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CONTENTS

THE USE OF MICROSPORE CULTURES IN VEGETABLE BREEDING IN TURKEY

Burcu TUNCER [1]

CHAPTER 1

[1] Assoc. Prof. Dr. Van Yuzuncu Yil University, Faculty of Agriculture, Department of Horticulture, 65080, Van, Turkey.

1. INTRODUCTION

The microspore culture is the method used in the isolation of microspore from anthers containing microspores at the late uninucleate stage of development and their development in a liquid medium under *in vitro* conditions and obtaining haploid embryos from these microspores. The microspore culture method is developed to eliminate some of the disadvantages of the anther culture method; it is a newly-developed technology and more complicated than the anther culture. This method eliminates the risk of regeneration from somatic tissues and the inhibiting substances in anther tissues are no longer a problem as this method removes these substances from the medium. Microspores are directly in contact with liquid mediums, and therefore, their nutrient intake is better. In addition, microspore cultures enable easier mutagenic applications and gene transfer studies and removing the mutagenic chemical compounds is easier with centrifugation (Bal, 2002).

In the international studies, microspore embryogenesis studies were carried out with vegetables of the *Brassica* group including rocket (Leskovsek et al., 2008), Chinese cabbage (Wusheng et al., 2005), head cabbage (Yuan et al., 2012), broccoli (Na et al., 2011), cauliflower (Gu et al., 2014) and vegetables of the *Solanaceae* group including pepper (Cheng et al., 2013), eggplant (Corral-Martinez and Segui-Simarro, 2012) and carrot, which is from the *Umbelliferae* family (Li et al, 2013), and they obtained haploid embryo, callus and/or haploid plant formation at rates depending on the species. In Turkey, the microspore embryogenesis studies are rather new and the number of the studies is limited.

This paper contains the protocol followed in our previous studies on the vegetables of the *Brassica* group, the use of the microspore culture technique in Turkey and information on the results obtained by the studies in Turkey.

2. MATERIAL AND METHOD

2.1. Plant Materials

The procedure, which was applied in our previous studies on the head cabbage (cv. Yalova-1, Ercis genotype, 177 C, 177 T, 531 C and 538 C breeding lines), kale (cv. Karadere 077, cv. Balkaya, cv. Yanmaz), F1 hybrid ornamental kale cultivars (cv.Red Pigeon, cv. Victoria Pigeon, cv. Red Chidori, cv. White Kamome, and cv. Pink Kamome) and radish (cv. Cherry Belle, cv. Burkır, cv. Bursiyah, cv. Boncherry F_1) from the *Brassica* species, is listed step by step below (Tuncer and Yanmaz, 2011a; Tuncer and Yanmaz, 2011b; Tuncer et al., 2016; Tuncer, 2017):

2.2. The Growing of the Donor Plants

Cabbage and kale seeds, during spring, and radish and ornamental kale seeds, during autumn, are planted in voils containing 1:1 peat:perlit mixture.

Then, when they reach the 3-4 leafed period, head cabbage and kale seedlings are planted at 60x80 cm intervals in the previously determined locations in a field (Figure 1a), while radish and ornamental kale seedlings are planted in plastic pots (50 x 29 cm) containing the same medium. In autumn, burned stable manure is fed 1-2 ton per a decare to the soil. The drip irrigation system is used to irrigate the plants. The N:P:K (6:4:6) fertilization is applied when necessary. In order to meet the cooling requirements of the plants, after the harvest of the heads from head cabbage and leafed-plants from kale, they are planted in trenches in a non-heated greenhouse with their roots and preserved during winter (Figure 1b); in order to meet the cooling requirements of radish and ornamental kale plants, they are placed in pots and, then, kept in low tunnels during winter. At the beginning of spring, rooted cabbage plants that are taken out of the greenhouse are planted in their designated locations in the field at 40x20-25 cm intervals and buds are harvested from healthy plants when the flowering begins (Figure 1c).

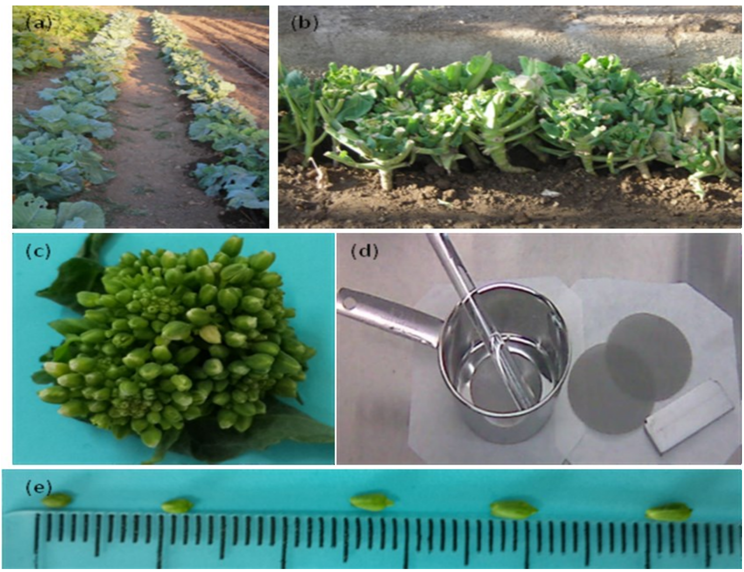

Figure 1: (a) The growing of the donor plants, (b) rooted cabbage and kale plants planted in the greenhouse to meet the cooling requirement, (c) flower buds, (d) the kit used in bud crushing, (e) cabbage buds classified by their sizes (Photographs: B. Tuncer)

2.3. The Determination of the Suitable Bud and Microspore Development Stage

The optimum bud harvest time is usually the time before without blooming any of the raceme and when the buds are arranged on a wide cluster in chains (Figure 1c). Buds are divided into five groups based on their development stages (Figure 1e). Five buds from each group is classified by their morphological properties. The DAPI (4′,6-diamidino-2-phenylindole) stock solution is used (1 mg DAPI/1 ml bidistilled water) to determine the microspore development stage. The solution is kept at +4°C and in darkness. The anthers are placed on a glass slide, the microspores are released by crushing with an arrow-headed needle and pliers and 1 µl of the stock solution is added to the glass slide. After covering the glass slide, preparations are covered with aluminum foil and kept in darkness for 10 minutes and, then, microspore development stages are examined under a fluorescence microscope. The uninucleate microspore development stage is the most appropriate stage for microspore culture (Figure 2a). If the examination of the behaviors of the microspores under *in vitro* conditions is required, 1 ml of the cultures can be placed on the glass slides and the preparations stained with DAPI can be examined under ultraviolet light (Figure 2b, 2c, 2d).

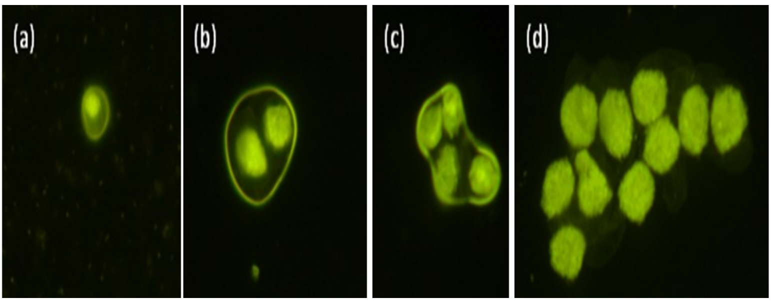

Figure 2: In the preparations stained with DAPI (a) uninucleate microspore, (b) symmetrical nucleus division, (c) multinucleated structures, (d) viable microspores at the 21st day of the culture (Photographs: B. Tuncer)

2.4. The Sterilization of the Buds and the Medium

The filter sterilization method is used in the sterilization of the isolation and culture mediums and sterilization is carried out in a laminar flow cabinet (Figure 3a). In order to minimize the variations due to plants, buds are collected from at least three plants. Buds at the uninucleate microspore development stage (2.5-3.5 mm length in head cabbage and radish, 4.0-4.5 length in kale and ornamental kale) are kept in Tween-20-dropped 10% sodium hypochlorite solution for 10 minutes, whereas in radish, they are kept in 5% sodium hypochlorite solution for 20 minutes. Then, they are washed while shaking with bidistilled water three times for 6 minutes each (Figure 3b, 3c).

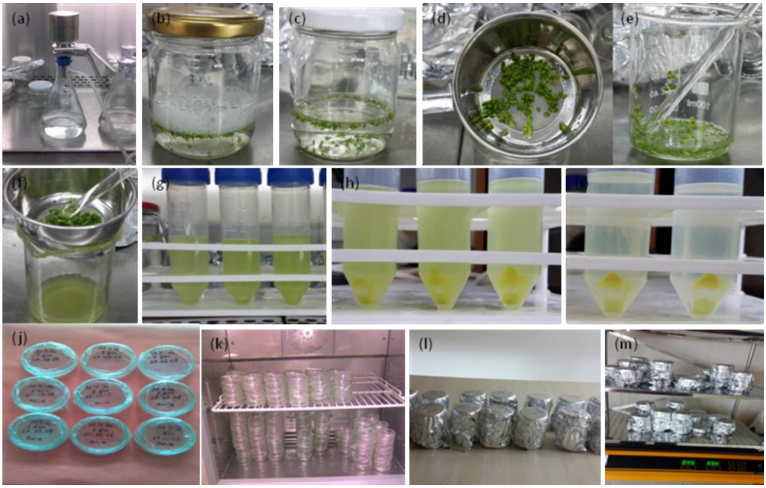

Figure 3: (a) The sterilization of the medium, (b, c) The sterilization of the flower buds, (d, e, f) the isolation of the microspores, (g, h, i) the stages of the microspore suspension centrifugation and the resultant microspore pellets, (j) the cultured microspores, (k) 1-2 day-long heat-shock treatment to microspores, (l) petri dishes kept at 25°C in darkness (m) petri dishes kept on an orbital shaker (Photographs: B. Tuncer)

2.5. Microspore Isolation

In head cabbage, kale and ornamental kale, liquid NLN-13 (Lichter, 1982) is used as the isolation medium, whereas in radish liquid, B5-13 medium (Gamborg et al., 1968) is used. Both mediums should be cold. 130 g/l of sucrose is added to the isolation medium. In this case, the mediums are called NLN-13, B5-13. The pH of the medium is adjusted to 6.1. Forty buds are used in each isolation. The amount of the buds can be increased to obtain more isolation in a single attempt; if that's the case, the amount of the suspension should also be adjusted based on the amount of buds. Forty buds are placed in a 50-ml beaker and crushed in 3.5-ml NLN-13 medium with a glass rod to release the microspores (Figure 3d, 3e). Then, the microspore suspension in the glass beaker is sieved with the isolation kit with 40-µm pores. The glass beaker and the sediment remaining in the sieve are washed with 6.5-ml isolation medium (Figure 3f). In order to obtain microspore sedimentation, the suspension is poured into centrifuge tubes and centrifuged at 900 rpm and 4ºC three times for three minutes. The fluid at the top of the tubes are removed after each centrifugation and microspores are re-suspended with a fresh isolation medium, which increases the microspore purity (Figure 3g, 3h, 3i).

2.6. The Procedure for Stress Treatments in Inducing Microspore Embryogenesis

2.6.1. High-temperature shocks

In the cabbage, kale and ornamental kale cultivars and breeding lines, the microspores cultured in petri dishes are kept darkness at 32°C and 35°C for 2 days (Tuncer et al., 2016) and the microspores of the radish cultivars are kept darkness at 32.5ºC for 1 day (Tuncer, 2017).

2.6.2. Colchicine treatments

The stock solution of 0.2% colchicine is prepared and sterilized with filters. Following the final centrifugation process, the desired volumes are obtained from the stock solution and added to the isolation medium containing the microspores in the centrifuge tubes. The microspores are treated with 50 and 100 mg/l of colchicine for head cabbage, kale and ornamental kale (Tuncer and Yanmaz, 2011a), and 10, 25, 50 and 75 mg/l of colchicine for radish (Tuncer, 2017); then, they are kept at 30ºC in darkness for 15 hours for cabbage and kale cultivars (Tuncer and Yanmaz, 2011a) and at 4°C in darkness for 2 days for radish (Tuncer, 2017). Microspores in the centrifuge tubes are then centrifuged 2 times at 4° C at 900 rpm to remove the colchicine from the medium.

2.6.3. Gama ray treatments

The buds containing uninucleate microspores are subjected to gamma ray treatment in a device that provides a dose of 0.938 KGy/hour-ray. 50 Gy, 75 Gy, 100 Gy and 300 Gy doses are used in ornamental kales. Following the gamma ray treatment, buds are kept at 4°C until microspore isolation (Tuncer and Yanmaz, 2011b). Prompt isolation of the microspores is important in microspore vitality.

2.7. The Cultivation of Microspores

Following the final microspore isolation process the resultant microspore pellet is suspended with the cold NLN-13 (cabbage and kale species) medium or 1/2 NLN-13 (radish cultivars) medium to obtain 40,000 microspore/ml (approximately 1 ml medium/bud). Five ml of the microspore suspension is distributed into each 6-cm glass petri dish and, then, are cultivated (Figure 3j). Following the high-temperature shock treatment, the petri dishes are kept at 25°C and in darkness (Figure 3l). When the embryo or callus pile are visible to the naked eye (11-12 days after isolation) the petri dishes are placed on an orbital shaker at 45 rpm in a climate chamber at 25°C (Figure 3m). In cabbage and kale species, embryos are counted 3 weeks after isolation (Tuncer and Yanmaz, 2011a; Tuncer et al., 2016), whereas in radish, callus colonies are counted 4-5 weeks after isolation (Tuncer, 2017).

3. RESULTS AND DISCUSSION

The studies carried out in Turkey by us or other researchers on microspore embryogenesis in vegetable species and their results are summarized in Table 1 and 2. The microspore embryogenesis studies in Turkey showed that, although at varying rates depending on the species and application, embryo and callus development were achieved in *Brassica* species (Table 1), whereas in the species from the *Solanaceae* family, the method failed and an effective procedure is yet to be established (Table 2).

In order to induce microspore embryogenesis, haploid embryogenesis can be induced with stress treatments that include heat-treatment, carbohydrate and nitrogen starvation, colchicine and gamma ray treatments to buds containing uninucleate microspores or to microspores isolated from anthers.

Heat-treatments are applied to flower buds or isolated microspores. High-temperature shocks are effective on the microspore embryogenesis in the *Brassica* species, while low temperatures can be used for the species of the *Solanaceae* family. Tuncer et al. (2016) studied the effects of high-temperature treatments (32 °C and 35 °C, 2 days) on the microspore embryogenesis in six white head cabbage (cv. Yalova-1, Ercis genotype, breeding lines: 177 C, 177 T, 531 C, 538 C), three kale cultivars (cv. Karadere 077, cv. Balkaya, cv. Yanmaz) from Turkey and on five commercial F1 hybrid ornamental kale (cv. Red Pigeon, cv. Victoria Pigeon, cv. Red Chidori, cv. White Kamome, and cv. Pink Kamome). The researchers reported that microspore-originated embryogenesis varied depending on the genotype and temperature and the highest embryo formation in head cabbage (cv.Yalova-1) and ornamental kale (cv. Pink Kamome F1) were 9.9 embryo/ Petri dish dish and 11.1 embryo/ Petri dish, respectively, and occurred at 32 °C, whereas the highest embryo formation in kale (cv. Karadere 077) was 5.6 embryo/ Petri dish and occurred at 35°C (Figure 4).

Table 1: The microspore embryogenesis studies conducted in Turkey on the vegetables from the *Brassica* species

Species	I.M.	C.M.	Stress treatment	E. or C/petri		Ref
B. oleracea var. *capitata* (Head cabbage)	NLN-13	NLN-13	32°C (2 day)	0 – 9.9	E	(Tuncer et al., 2016)
			35°C (2 day)	2.1 – 8.3	E	
B. oleracea var. *acephala* (Kale)	NLN-13	NLN-13	32°C (2 day)	1.9 – 3.6	E	
			35°C (2 day)	1.9 – 5.6	E	
B. oleracea var. *acephala* (Ornamental kale)	NLN-13	NLN-13	32°C (2 day)	1.9–11.1	E	
			35°C (2 day)	0.8 – 5.1	E	
B. oleracea var. *capitata* (Head cabbage)	NLN-13	NLN-13	32°C (2 day) + 50 mg/l colchicine/15 h	0.7 – 5.3	E	(Tuncer and Yanmaz, 2011a) [10]
			32°C (2 day) + 100 mg/l colchicine/15 h	2.0 – 3.5	E	
			35°C (2 day) + 50 mg/l colchicine/15 h	0.9 – 1.5	E	
			35°C (2 day) + 100 mg/l colchicine/15 h	3.4 – 4.0	E	
B. oleracea var. *acephala* (Kale)	NLN-13	NLN-13	32°C (2 day) + 50 mg/l colchicine/15 h	0.3	E	
			32°C (2 day) + 100 mg/l colchicine/15 h	4.2	E	
			35°C (2 day) + 50 mg/l colchicine/15 h	0.7	E	
			35°C (2 day) + 100 mg/l colchicine/15 h	3.4	E	
B. oleracea var. *acephala* (Ornamental kale)	NLN-13	NLN-13	32°C (2 day) + 50 mg/l colchicine/15 h	6.7	E	
			32°C (2 day) + 100 mg/l colchicine/15 h	0.2	E	
			35°C (2 day) + 50 mg/l colchicine/15 h	9.4	E	
			35°C (2 day) + 100 mg/l colchicine/15 h	0.2	E	

I.M.: isolation medium, C.M.: culture medium, E: embryo, C: callus

Table 1: Continued

Species	I.M.	C.M.	Stress treatment	E. or C/petri		Ref
B. oleracea var. *acephala* (Ornamental kale)	NLN-13	NLN-13	32°C (2 day) + 50 Gy gamma	3.42	E	(Tuncer and Yanmaz, 2011b)
			32°C (2 day) + 75 Gy gamma	1.87	E	
			32°C (2 day) + 100 Gy gamma	0.20	E	
			32°C (2 day) + 300 Gy gamma	0.32	E	
			35°C (2 day) + 50 Gy gamma	2.29	E	
			35°C (2 day) + 75 Gy gamma	2.50	E	
			35°C (2 day) + 100 Gy gamma	0.49	E	
			35°C (2 day) + 300 Gy gamma	0.42	E	
Raphanus sativus L. (Radish)	B5-13	1/2 NLN-13	32.5ºC (1 day) + 10 mg/l colchicine/2 day	1.6-3.8	C	(Tuncer, 2017)
			32.5ºC (1 day) + 25 mg/l colchicine/2 day	0.9-4.6	C	
			32.5ºC (1 day) + 50 mg/l colchicine/2 day	2.7-6.6	C	
			32.5ºC (1 day) + 75 mg/l colchicine/2 day	1.2- 4.4	C	

I.M.: isolation medium, C.M.: culture medium, E: embryo, C: callus

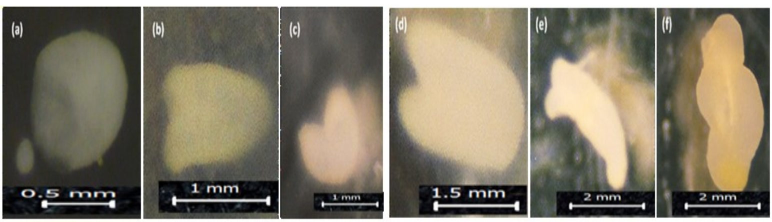

Figure 4: Embryo stages observed at 3 weeks after the isolation; (a) Globular embryo (35 °C, Karadere 077), (b)Heart - shaped embryo (Yanmaz, 35 °C), (c) Heart -shaped embryo (32 °C, 177 C), (d) Torpedo–shaped embryo (32°C, Yalova-1), (e) Torpedo-shaped embryo (35 °C, 538 C), (f) Embryoid (32 °C, Pink Kamome F_1) (Tuncer et al., 2016)

Colchicine treatments are stress treatments that mainly induce microspore embryogenesis in species of the *Brassicaceae* family. Tuncer and Yanmaz (2011a) investigated the effect of the combined application of colchicine and high-temperature treatments on microspore embryogenesis in different cabbage species. Their research showed that the 50 mg/l dose of colchicine yielded better results and the 32°C+50 mg/l and 35°C+50 mg/l colchicine treatments were more effective in head cabbage (cv. Yalova-1, 5.3 embryo/Petri dish) and ornamental kale (cv F1 Red Chidori, 9.4 embryo/Petri dish), respectively.

In another study conducted by Tuncer (2017) on four radish cultivars, the different doses of colchicine treatments (10, 25, 50 and 75 mg /l) to microspores showed that the most effective dose in all cultivars was 50 mg/l. The researchers also reported that the highest callus formations were observed in the large, round red radish cultivars (cv. Burkır) (6.63 calli/Petri dish) and the standard small rooted radish (cv. Cherry Belle) (5.73 calli/Petri dish.

Figure 5 shows the callus pile at the end of the cultivation period obtained by Tuncer (2017) with the colchicine treatments to radish cultivars. Ionized radiation may also be used to induce microspore embryogenesis (Table 1). Tuncer and Yanmaz (2011b) reported that different doses of gamma ray treatment to uninucleate microspores yielded differentiated formations at the end of the cultivation period in ornamental kale (Figure 6). The researchers also reported that applying intermediate-doses below 100 Gy to buds could be more beneficial in inducing microspore-originated embryogenesis.

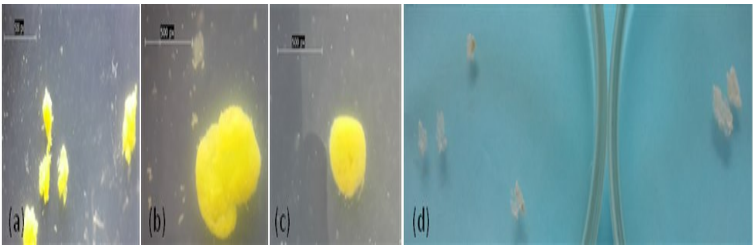

Figure 5: Callus colonies observed in Petri dishes, 4–5 weeks after the isolation: (a) 50 mg L^{-1} colchicine, (cv. Burkır), (b, c) 50 mg L^{-1} colchicine, (cv. Cherry Belle), (d) callus piles after transfer into the MS germination medium (Tuncer, 2017)

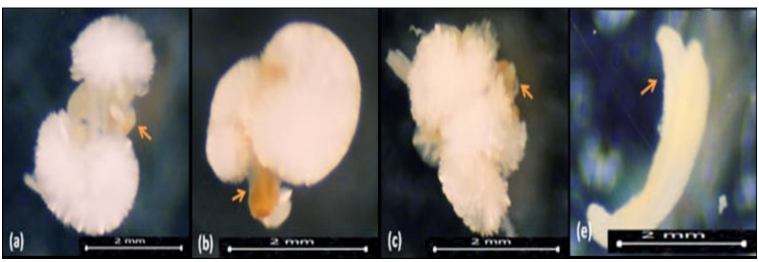

Figure 6: *In vitro* microspore embryogenesis (a, b, c) differentiated structures (32 °C + 50 Gy), (d) 12 daily late torphedo embryo (32 °C + 50 Gy) in ornamental kale (Tuncer and Yanmaz, 2011b)

For now, the method does not apply to the vegetable species from the *Solanaceae* group and an effective procedure is yet to be developed (Table 2).

In their study on pepper (*Capsicum annuum* L.), Bal et al. (2003) kept the buds that contain uninucleate microspores for 7 days at 10ºC in a medium containing mannitol; then, cultured the isolated microspores in the NLN medium that contain three different concentrations of sucrose (100 g/l, 130 g/l and 170 g/l). The researchers reported that, only in two petri dishes that contain 170 g/l of sucrose, 40.5% and 67% callus colony formations were obtained at the 30th and 60th days, respectively, while in the other treatments, the cultures were lost due to infection (Table 2).

Table 2: The microspore embryogenesis studies conducted in Turkey on the vegetables from the *Solanaceae* species

Species	Isolation medium	Culture medium	Stress treatment	Result	Ref
Capsicum annuum L.	40 g/l sucrose 50 mg/l ascorbic acid 400 mg/l L-proline 0.1 mg/l biotin 10 mg/l nicotinic acid	NLN-100 NLN-130 NLN-170 (150 mg/l L-glutamine, 15 mg/l L-proline, 100 mg/l L-alanine, 90 mg/l arginine)	Mannitol starvation (0.3 M) 10ºC (7 day)	30th days 40.5% callus colony 60th days 67% callus colony	(Bal et al., 2003)
Solanum melongena L.	B medium (1.49 g/l KCl; 0.25 g/l MgSO4.7H2O, 0.11 g/l CaCl2, 0.3 M Mannitol, 1 mM phosphate buffer of pH 7)	AT3 medium (13 mM KNO3,, 8.6 mM (NH4)2SO4, 2.9 mM KH2PO4, 1.1 mM CaCl2.2H2O, 0.7 mM MgSO4.7H2O, 10 mM MES Buffer, 8.6 mM glutamine, 0.25 M maltose and Fe-EDTA	Mannitol starvation (0.3 M) + 33°C (2 day)	multinucleate structures (19.4%)	(Bal et al., 2009)
Lycopersicon esculentum Mill	40 g/l sucrose 50 mg/l ascorbic acid 400 mg/l L-proline 0.2 mg/l biotin 10 mg/l nicotinic acid	NLN-17 + lactalbumin hydrolysate (2-4 ml/l) + BAP (0.5 mg/l) + NAA (0.5, 1.0, 1.5 mg/l) NLN-17 + BAP (0.5 mg/l) + NAA (0.5 mg/l) + casein hydrolysate (5 or 10 g/l)	Mannitol starvation (0.3 M) + 10ºC (7 day)	Symmetric nuclei dividing, multicellular structures	(Bal and Abak, 2005)

In their studies on tomatoes (*Lycopersicon esculentum* Mill), Bal and Abak (2005) reported that with the cultivation of the microspores obtained from the mannitol-starvation pre-treated buds in the NLN-17 + lactalbumin hydrolysate (2 or 4 ml/l) + BAP (0.5 mg/l) + NAA (0.5, 1.0, 1.5 mg/l) medium, symmetrical nucleus division occurred, while in the NLN-17 + BAP (0.5 mg/l) + NAA (0.5 mg/l) + casein hydrolysate (5 or 10 g/l) medium multinucleate structure formation occurred (Table 2).

4. CONCLUSIONS

In conclusion, with our studies conducted in Turkey on the head cabbage, kale, ornamental kale and radish, a procedure that can be applied to the vegetable species of the *Brassica* group was established. With our studies on the *Brassica* species, microspore-originated embryogenesis was achieved; however, transformation to plants did not occur. This may be due to the intense infection observed in the cultures: This caused embryos to fail to reach maturity and therefore, fail to transform into plants.

Moreover, the difficulty in applying the method may have caused the infection problem. In one of our previous studies results of which was not included in this paper, low doses of antibiotics were added to the mediums to solve the infection problem; however, it was observed that the antibiotics completely inhibited the embryo development. In the studies conducted in Turkey on the vegetables of the *Solanaceae* group, symmetrical nucleus division and multinucleate structure formation were observed but embryogenesis did not occur.

The future studies should focus on the prevention of the infection problem that hindered the progress of the microspore culture method as a priority. In addition, controlling the donor plant growing conditions and studying with genotypes with foreign origin are expected to positively affect androgenesis.

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DETERMINATION OF DISTRIBUTION AREAS, HARMFUL INSECTS AND MITE SPECIES IN VINEYARDS

Mehmet KAPLAN [1]

CHAPTER

2

[1] Asst. Prof. Dr., Department of Plant Protection, Faculty of Agriculture, Siirt University, Siirt, Turkey.

Introduction

Grape, which has a great importance in human nutrition, is a type of fruit consumed table and dry. It is also an important export product for Turkey's economy. Spain ranks first in the world in the list of vineyard areas in size; Italy, France and Turkey are to follow. The production of grapes, Italy, China, USA, Turkey ranks 6th after France and Spain (Anonymous, 2013).

Vineyard area in Turkey is 4,170,410 decares, while the amount of grape production is 3.933.000 tons. In the Southeastern Anatolia Region, Diyarbakır Province has an important place in terms of viniculture and 109,938 tons of grapes have been produced in 178,359 decares. Grapes are generally considered as table, dried and wine (Anonymous, 2018). The yield and quality in the vineyard area in Turkey has been found in many types of pests and diseases affecting negatively. These pests occasionally lead to economic losses above the economic loss threshold.

Materials and Methods

The main material of the study consists of vineyards in Diyarbakır and pests found in these areas, Japanese umbrella, vacuum insect collection device (D-vac) and various laboratory materials.

In order to determine the harmful insect species and their distribution areas in the years 2013-2015, Diyarbakır was carried out in the central, Dicle, Hani, Eğil, Kulp Ergani, Çüngüş, Çermik and Silvan districts. The studies were carried out between April and October in a total of 30 vineyards with a minimum of 50-70 omca every two weeks. In addition to the use of sex-specific sex traps, the method of impact, visual inspection, culture method, leaf and shoot method were used.

Results and Discussion

Types, distributions and densities of pests

As a result of this study, 14 harmful insect species belonging to 10 families connected to 4 teams and 1 species belonging to 1 family connected to 1 team were determined.From these identified species, *Lobesia botrana* (Denis & Schiffermüller) was seen as the main pest in the vineyards, while *Arboridia adanae* (Dlabola, 1957), *Haplothrips glabiceps* (Bagnall), and *Klapperichicen viridissima* (Walker) (Homoptera: Cicadidae). distribution and density were found to be important species. In addition to these species, *Arctia villica* (Linnaeus), *Anomala vitis* (Fabricius), *Tetranychus urticae* Koch and *Eriophyes vitis* (Pagenstecher) species were found to be low density pests in the vineyards. However, the determined species were determined to be harmful in the vineyards and their distribution by districts.

Table 1. Harmful insects and Mite species determined in the vineyards of Diyarbakır province in years 2013-2015.

ORDER	DISTRICTS	AREAS OF SPREADING									
		Merkez	Çermik	Çüngüş	Ergani	Dicle	Eğil	Hani	Kulp	Hazro	Silvan
	FAMİLYA-TÜR										
LEPİDOPTERA	**Tortricidae**										
	Lobesia botrana Den.& Schif.	+	+	+	+	+	+	+	+	+	+
	Arctia villica Linnaeus		+	+			+	+	+	+	
	Theresimima ampellophaga B.B.		+		+	+			+		+
HEMİPTERA	**Cicadidae**										
	Klapperichicen viridissima Walk.	+	+	+	+			+			+
	Cicadellidae										
	Arboridia adanae Dlabola	+	+	+	+	+	+	+	+	+	+
	Asymmetrasca decedens Paoli	+	+	+		+	+	+	+		+
	Empoasca decipiens Paoli	+	+		+					+	+
COLEOPTERA	**Curculionidae**										
	Ootiorhynchus sp.		+	+			+	+		+	
	Cerambycidae										
	Xylotrechus sp.	+	+		+					+	+
	Scarabaeidae										
	Anomala vitis (Fabricius)		+					+	+	+	+
THSANOPTERA	**Phlaeothripidae**										
	Haplothrips glabiceps Bagnall	+	+	+	+			+		+	+
	Thripidae										
	Anaphothrips vitis Priener,	+	+		+		+		+		
	Thrips tabaci Lind.	+	+		+		+		+		+
ACARİNA	**Eriophyidae**										
	Colomerus vitis Pgst.	+	+	+	+			+	+	+	+
	Tetranychidae										
	Tetranychus urticae Koch	+	+	+	+	+	+	+	+	+	+

Lobesia botrana were identified as main pests in the vineyard areas. It has been identified to damaged in the bud, flowers and grapes. As a matter of fact, it is the main pest of the vineyards both in the world and in our country because of the damage caused directly to the product (Kısakürek, 1972; Kaçar, 1982; Ataç et al., 1990; Altındişli and Kısmalı, 1996).

The larvae of *L. botrana* cause damage by feeding on the buds, flowers, greens and ripe grape grains in vinyards. During the bud and flowering period, larvae connects buds and flowers. The damaged buds and flowers are poured, resulting in sparsely grained clusters. The unripe grapes to nibble, drilling and creates losses by switching from one to another one. In the sweetening period of grapes, the larvae feed on multiple grains and cause the flow of sugary liquids and the proliferation of saprophyte fungi on these fluids and eventually the decay of the grape cluster (İyriboz, 1938; Sipahi, 1956; Anonymouus, 1999; Anonymous, 2008). Günaydın (1972) stated that *L. botrana* was determined as a result of his survey in the vineyard areas in Southeast and Eastern Anatolia regions; Karagöz (1988) reported that *L. botrana* was identified as the main pest in the vineyards of Edirne, Kırklareli, Tekirdağ between 1985-1986, and Guarıo and Laccone (1996) reported that found *L.botrana* in vineyard areas of Italy. Bigot et al. (2003), *L. botrana* was found to be the main harmfulin Gorizia in the northeastern part of Italy, Kovancı et al. (2005) stated that they found *L. Botrana* in İznik.

It was determined species of *A. adanae, A. decedens* and *E. decipiens* from the Cicadellidae family, as well as *K.viridissima* from the Cicadidae family in the vineyard areas of Diyarbakır province. Asena (1970), determined *A.adanae*'s wintering status, damage, spread in the region and number of offspring. Maçan (1984) stated that there are 16 insects and mite species, including *A. adanae* in the vineyards in the Southeastern Anatolia Region, examined the biology and spread of *K.viridissima*, *E. vitis* and *L.botrana*. Karagöz (1988) reported that *E. decipiens* were the major cause of damage in the vineyards of Edirne, Kırklareli, Tekirdağ between 1985-1986. Pavan et al. (1988) reported that *Empoasca vitis* Goethe gave three offspring per year in the northern part of Italy, and that the struggle for the first and second offspring should be done. Altınçağ and Akten (1995), as a result of their research on pests in the vineyards of the Aegean Region, have identified *A. decedens E. decipiens A. Adanae* and *Zygina nivae* Mulsant et Rey, only *A. decedens* is common, Bahadıroğlu and Avgın (2003), in various regions of the province of Kahramanmaras damage to the vine insect species belonging to Hemiptera, distribution, damage shape, biological characteristics, population densities and natural enemies as a result of their work they record *A. adanae*. Özgen and Karsavuran (2009), in Diyarbakır, as a result of their study to determine the degree of damage of A. adanae in different grape varieties. *A. adanae* has reported that all vine varieties have the most damage on the lower leaves, followed by the middle and upper leaves.

Otiorhynchus sp. (Cerambycidae), *Xylotrechus* sp. (Cerambycidae) and *Anomala vitis* Fabricius (Scarabaeidae) species were determined in the vineyard areas of Diyarbakır province. However, although these species are seen in the region's vineyards, they are not seen as prevalence and density. *Otiorhynchus peregrinus* Stierlin from the Curculionidae family is not common although it is detected. Iren (1972), *Otiorrhynchus* spp. such as pests can cause significant damages in the vineyards in the following years, Karagöz (1988), between 1985-1986 in Edirne, Kırklareli, Tekirdag province, O. peregrinus, *O. scitus*, *O. albidus' s* damages are important, Guario and Laccone (1996), in Italy, *Otiorhynchus* species are important pests, Bouchard et al. (2005) reported that they determined the *Madarellus undulatus* (Say), *Barypeithes pellucidus* (Boheman), *Otiorhynchus ovatus* (L.) and *O. sulcatus* species belonging to the family Curculionidae as a result of their survey in the vinyard areas of Canada.

Haplothrips glabiceps from the Phlaeothripidae family was found to be widespread in the vineyard areas of Diyarbakır province. On the other hand, *A. vitis* and *T. tabaci* species from Thripidae family were determined, although not intense in some areas. Iren (1972), in the study conducted to determine the pests of economic importance in the vineyard areas of Central Anatolia, small amounts and locally encountered thrips species, Schwartz (1988), in his study of table grape varieties in South Africa found *T. tabaci* in 1984-1985. Laccone and Guario (1997), in the vineyards of Italy, *F.occidentalis* did harm, Somma and Ruggeri (1998) reported that *F.ccidentalis* did a lot of damage in table grape varieties before flowering in the vineyards of Apulia in Italy. Abbruzzetti and Grande (1999), Ponti et al., (2005), reported that *F. occidentalis* have damaged the vineyards in Italy.

In the vineyard areas of Diyarbakir province, *T. urticae* from the Tetranychidae family belonging to Acarina, which is one of the harmful mite species was detected, but the pest was not widely seen. The reason for this can be explained by the use of sulfur in the fight against *Uncinula necator* (Schw.) by the vineyard producers in the region and the predator mite activity. In fact, Ho and Chen (1994), in the vineyards of Taiwan, found that red spider species *T. urticae* and *T. kanzawai* Lo. however, stated that these pests have an average rate of 10% on the leaves.

Conclusion

As a result of this study, 14 harmful insect species belonging to 7 families connected to 4 teams and 1 species belonging to 1 family connected to 1 team were determined.From these identified species, *L.botrana* was seen as the main pest in the vineyards, while *A. adanae H. glabiceps*, and *K. viridissima* distribution and density were found to be important species.

L.botrana as main pests in the vineyard areas has been identified to damaged in the bud, flowers and grapes. *A. adanae*, *A. decedens* and *E. decipiens* were identified from the species belonging to the Cicadellidae family, which are indirectly pests that adversely affect the development of vineyard areas. A. adanae is seen as a common and dense of in the vineyard areas, As a result of the feeding of the damaged leaves, grape grains are exposed to sunburn, resulting in loss of yield and quality. However, *K.*

viridissima from the Cicadidae family has been shown to be widespread in recent years. *H. glabiceps* from the Phlaeothripidae family was found to be widespread and intense in the vineyard areas of Diyarbakır province. The greatest damage of this species in May and June is caused by feeding in flowers.

As a result, most of the producers in the region are unaware of these harmful species, which significantly affect the development and yield in the vineyards where the study is conducted. In these areas where the chemical struggle is applied very little and the natural balance is preserved, the density and damage of pests vary from year to year. For this reason, in the fight against pest should be given importance to cultural struggle by avoiding the chemical struggle. In cases where the chemical struggle is necessary, the natural enemy species should be made at a time when the population density is low before flowering. The chemical drugs to be used must be selected from those that have the lowest impact on the specific, environmental and natural enemies that are licensed against pests.

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A GEOGRAPHIC INFORMATION SYSTEMS (GIS)-BASED MULTI-CRITERIA EVALUATION FOR GREENHOUSE SITE SELECTION. A REGIONAL SCALE APPLICATION IN EASTERN MEDITERRANEAN BASIN, TURKEY

Burak SALTUK [1]

Ozan ARTUN[2]

CHAPTER 3

[1] Asst. Prof. Dr. Siirt University, Agriculture Faculty, Biosystem Engineering Department, 56100 Siirt-TURKEY.

[2] Dr., Cukurova University, Karaisali Vocational School, Department of Architecture and City Planning, 01770 Karaisali, Adana, TURKEY.

INTRODUCTION

The increase in consumption of plant and animal products due to the world population rate has made it necessary to find new agricultural techniques and production areas. The greenhouses are the plant production structures where inappropriate climatic and topographical conditions can be controlled and inspected by human intervention. As an industrial branch of agriculture, greenhouse is gaining importance in the world and increases its popularity day by day. Today, while agricultural biotechnology researchers conduct studies on genetic engineering (selection, DNA isolation, etc.), biosystem engineering researchers are working on appropriate conditions (climate, topography, irrigation, etc.) for the creation of new production areas. Increasing the consumption of basic plant and animal foods on earth that required for life by human beings leads to the emergence of new agricultural techniques and increasing new production areas. The rapid increase of the population in the world in the 21st century, increases the necessity of plant and animal food needed for life. The difficulties facing the world (climatic changes, pollution, industrialization, environmental impacts, etc.) prevent human beings from reaching enough food and their alternatives are decreasing day by day. Therefore, the amount of product quantity taken from the unit area should be increased and new production areas must be established.

30.8 million tons of vegetables were produced in Turkey in 2017. 23.4 million tons of this production were produced in open areas and 7.4 million tons of it was produced under cover. Today, the total amount of lentils has reached to 737,177 hectares. We are among the first four countries in the world in terms of greenhouse presence and in Europe, we share the first place with Spain. In the last decade, the average size of greenhouse business has increased from 2 decares to 4 decares in our country. In recent years, the greenhouse enterprises that produces under modern conditions are rapidly increasing with the supports provided by the Ministry of Agriculture and Forestry and the other relevant institutions. The average size of the greenhouse enterprises in Turkey is 27 decares and the total value of the greenhouse production is approximately 10 billion TL. In greenhouse production, Antalya province takes the first place in Turkey (51%) (3.2 million tons / year). This province is followed by Mersin (18%) (1 million tons / year), Adana (11%) (670 thousand tons / year) and Mugla (9%) (527 thousand tons / year) respectively. The total greenhouse production (5.4 million tons/year) in these four provinces, constitutes approximately 90% of the total greenhouse production in Turkey (Anonymous, 2017).

Mediterranean Region located in the southern part of Turkey is a suitable area for cultivation in terms of geographic and climatic conditions. The region is also suitable for greenhouse cultivation. Nevertheless, it has difficulty in meeting the increasing demand of the population and the export potential. Therefore, it is necessary to determine the appropriate geographic and climatic characteristics individually for greenhouse cultivation based on the literature and select the suitable areas by cost analysis.

In 2011, greenhouse production covered 51 provinces in Turkey, afterwards it is carried out in 70 provinces by 2014. The increase rate in the last 4 years is 72% and this is above the average annual growth rate of 15% (Doğaka, 2015). Greenhouse cultivation in Turkey, covers production in greenhouses and plastic tunnels. As of 2011, the undercover agricultural areas have reached 60000 hectares and 32000 hectares of these are the greenhouses. Modern greenhouse cultivation, which has been developing rapidly with the introduction of big investor groups in the sector, has shown a great improvement in the last decade and has reached 1000 ha levels. Approximately 150-200 ha of land is added to this number each year. Today, 3% of the greenhouse areas have modern greenhouses. This share is expected to reach 15% in the next decade (Eker, 2012).

The greenhouse is one of the most important income generating branches of crop production. The need for food, which is the basic need of people, increases with the increasing population. The expectations of agriculture cannot meet, due to the inadequate production of agricultural land and the inability to implement modern agricultural techniques. Therefore about 795 million people are undernourished globally, down 167 million over the last decade, and 216 million less than in 1990–92. The decline is more pronounced in developing regions, despite significant population growth. In recent years, progress has been hindered by slower and less inclusive economic growth as well as political instability in some developing regions, such as Central Africa and Western Asia (Anonymous, 2015).

Greenhouses are the production structures that need to be kept under control therefore the researchers stated that when temperatures fall below 12 ° C or exceed 30 ° C, the quality, yield and growth of greenhouse fruits and vegetables are affected (Castilla & Hernandez, 2007). In addition, it is known that the humidity values in the greenhouse increase the fungal diseases. Hence, since, air temperature and humidity are the two major parameters affecting thermal comfort significantly, and only sensible load can be handled by an evaporative cooling system, the conventional evaporative cooling system is suitable for dry and temperate climate where the humidity is low (Costelloe & Finn, 2003).

Indoor greenhouse conditions must keep the temperature and humidity values suitable for the plants. Daily radiation requirements are approximately 6 hours for plants to make sufficient photosynthesis within the greenhouse. In the northern hemisphere, in November, December, and January and in the southern hemisphere in May, June and July there is a need for 500 - 550 hours of insolation. Greenhouse interior temperatures should not be below 12 ^{0}C and above 32 ^{0}C for the growth, yield and quality of fruits and vegetables in the greenhouse (Nisen, et al., 1988).

Many studies are carried out on the greenhouse cooling systems, and energy efficiency value is an important factor to ensure optimum climate conditions in the greenhouse. In the study conducted by (Heidarinejad G., et al., 2009), cooling performance of two-stage indirect/direct evaporative cooling system is experimentally investigated in the various simulated climatic conditions. For this purpose, a two-stage evaporative cooling experimental setup consisting of an indirect evaporative cooling stage (IEC) followed by a direct evaporative cooling stage (DEC) was designed, constructed and tested. Due to the wide variety of climatic conditions in Iran, two air simulators were provided to simulate outdoor design condition of different cities in primary and secondary air streams Heating is done in the greenhouses that were built in recent years in Turkey. Heating in greenhouses increases product yield, quality and quantity. Especially in the Mediterranean coastline, two-fold increase in productivity can be achieved in heated greenhouses. However, the heat energy requirements increase in greenhouses where heat protection measures are not taken and average 100 kWh. $m^{-2}a^{-1}$ heat energy is needed during the production period, depending on the climate values of the region (Baytorun & Gügercin, 2015).

The greenhouse indoor temperature can be kept at the desired level during the winter months only by heating. In the calculation of the heating load in greenhouses, regional long-term climate data, type and quality of greenhouse covering material, heat curtain usage, heat curtain type, heating system, greenhouse sealing condition, plant species to be grown, solar radiation, wind, lighting etc. Many different parameters such as play important role. At the same time, the calculated heating load is the main parameter in determining the heating power of the system to be designed (Cayli & Temizkan, 2018).

In Kırsehir province, it has been reported that it is very important to use a double layer instead of single layer cover material and to make the installation of heat curtains on the side walls are very important in increasing the amount of energy saved. From this point of view, in Siirt province, the use of heat curtains in greenhouses and shortening of ventilation times, and also the use of double layer PE or Polycarbonate cover materials with low heat conduction coefficient instead of single layer PE can be effective in reducing production costs (Boyacı, 2018)

Site selection is crucial for profitable and sustainable greenhouse production. The climate influences the type and level of greenhouse technology (structure and internal equipment for climate control) and subsequent crop production conditions, which in turn influence product cost and quality. The distance to markets, especially in export-focused production, can be a limiting factor in the profitable greenhouse cultivation (Castilla & Baeza, 2013).

The multifunctional applications of GIS make it possible to analyze spatial data, consolidate the information obtained from these analyzes, and store them. GIS helps to decide on the processing and distribution of agricultural land and can be used for administrative purposes. Decreasing and pollution of natural water resources gradually as a result of global warming forces growers to use marginal quality waters in irrigated agriculture (Sonmez & Sari, 2004).

Multi-criteria Decision Analysis (MCDA) is a solution applied in situations where more than one criteria must be evaluated together. The basic method of solving the problem is to divide the problem into small, simple and understandable pieces so that a meaningful result can be obtained from these pieces On the other hand, MCDA provides a rich collection of techniques and procedures for structuring decision problems, and designing, evaluating and prioritizing alternative decisions. At the most rudimentary level, GIS-MCDA can be thought of as a process that transforms and combines geographical data and value judgments (the decision-maker's preferences) to obtain information for decision making. It is in the context of the synergetic capabilities of GIS and MCDA that one can see the benefit of advancing theoretical and applied research on GIS-MCDA (Malczewski, 1999; 2006). Scientists focused on the combined use of geographic information systems (GIS) and spatial multi-criteria decision analysis, aiming to provide a decision tool for planning at the regional level. This procedure has been developed by means of various criteria (known as siting criteria), which were used either as constraints and/or as evaluation factors in order to identify first the potential/appropriate sites for installation. The proposed decision tool is thus able to get the optimal locations for future projects, as well as the suitability score of the already licensed projects (Latinopoulos & Kechagia, 2015).

In the study, it is aimed to determine the potential areas of the East Mediterranean basin for greenhouses. In this context, climate (maximum temperature of the warmest month, the minimum temperature of the coldest month and annual precipitation, wind direction and speed, topographic characteristics (Elevation, slope, aspect), soil types, land cover/land use, distance to geothermal fields data of the study area have been used. These data were the main material of the work. Also, it is aimed to remind the importance of greenhouse cultivation of the region to the producers and also to investigate the impact of the geothermal water usage in greenhouse heating, on the environment and the energy costs.

The study covers 4 provinces (Adana, Osmaniye, Hatay and Kahramanmaras) of the Eastern Mediterranean basin. A Geographic Information System (GIS) -based Multi-criteria evaluation for greenhouse site selection were applied in 4 provinces (Adana, Osmaniye, Hatay and Kahramamaraş) of the Eastern Mediterranean basin using these data. The suitable, nonsuitable or partially suitable areas for greenhouse siting in the basin were determined in terms of GIS, for guidance to producers and researchers in the future.

MATERIALS AND METHODS

The Eastern Mediterranean Basin is located in the Mediterranean Region of Turkey (Figure 1). The study was carried out in the Eastern Mediterranean region of Turkey and it covered four provinces (Adana, Hatay, Kahramanmaras and Osmaniye) (Fig.1). Adana province is located in the northeast of the Mediterranean region and has a surface area of 13,844 km^2.

Hatay province is located at the eastern end of the Mediterranean region and is the border province of Syria. The surface area of Hatay province is 5,867 km^2. The northern part of the province of Kahramanmaras is quite mountainous and has a surface area of 14,525 km^2. Osmaniye province is surrounded by Amanos Mountains in the east and southeast and Taurus Mountains from the west to the north. The surface area of Osmaniye province is 3.215 km^2 (Anonymous, 2019).

Figure 1. Map of Turkey and the Study Area

Greenhouse cultivation is seen as the most important income generating activity in today's agriculture. However, in the selection of the greenhouse location, especially if the climatic and topographic characteristics of the region are not taken into consideration, it is seen as the enterprises which are completely unproductive rather than generating income. In our study, 7 different factors were evaluated in the study area by making use of both literature and expert opinions. Besides the greenhouse soil, land topography is also effective in the selection of the greenhouse location. If the greenhouse construction areas are very inclined, greenhouse construction can cause difficulties in terms of greenhouse construction, irrigation and soil work. Due to the lack of drainage of excess water, the greenhouse areas should not be selected in the rainy and very flat areas where drainage of drainage water cannot be drained. If there is a need to establish a greenhouse in flat areas, it is desirable to have sufficient slope in the greenhouse. If the greenhouse is installed on sloping terrain, the terrace has to be built. Since the construction weights of plastic covered greenhouses are lighter than glass covered greenhouses, they have facilities for installation on slopes. However, if the greenhouse is to be installed in a place with a high slope, it is absolutely necessary to do terracing. The most suitable land slope for greenhouses is 0.5-1%.

In the study, we tried to identify the criteria that are capable to describe various constraints related to greenhouse site selection, and then we created individual map layers corresponding to each constraint criterion. In this context, we divided the study area into 30 m. - 30 m. grid cells, each cell representing an alternative location for a greenhouse site. The factors accepted to be effective in the selection of greenhouse construction sites are determined by the impact and weight values within the framework of the field studies and the criteria mentioned in the related literature (Table 1.).

Figure 2 Map of Turkey and the Study Area

Table 1 Environmental data set used for MCDA modelling. (Worldclim, 2018), (GTOPO, 2018), (Didan, 2015).

Parameters		Description
1.	Elevation	Altitude from the sea level (m)
2.	Slope	Slope in degrees obtained from altitude (%)
3.	Aspect	Aspect in degrees obtained from altitude (Direction)
4.	BIO5	Max temperature of warmest month (°C)
5.	BIO6	Min temperature of coldest month (°C)
6.	BIO12	Annual precipitation (mm)
7.	Wind	Wind direction and speed (m/s)

In the study, climatic data layers representing annual precipitation, maximum temperature of the warmest month, the minimum temperature of the coldest month with a a spatial resolution of about 1 km^2 were collected from Worldclim global database and resampled to 30 m. resolution (Worldclim, 2018). Elevation, slope, aspect was derived from ASTER Global Dem V.2 with a resolution of 30 m. (GTOPO, 2018). The land cover coverage was taken from the Modis MODIS/Terra Vegetation Indices 16-Day L3 Global

250 m SIN Grid V006 (Didan, 2015). with 1 km. resolution and resampled to 30 m. resolution. Wind data are taken from the Turkey wind energy potential map prepared by the General Directorate of Renewable Energy (GDRE) and resampled to 30 m. resolution .

After collecting and evaluating the related data, Multi Criteria Decision Analysis method was used with Geographic Information Systems (GIS) supported by ArcGIS 10.3 package program. According to MCDA method, generally accepted factors in the literature and field studies that are effective in choosing the greenhouse construction site has appointed as impact factors and weight values (Table 2.).

The wind speed values of the study area are collected in 3 groups (<4.5 m/s, 4.5-5.5 m/s. and 5.5-6.5 m/s). 10 impact factor value is given to the places where the wind speeds are <4.5 m/s. . 9 and 8 impact factor values are given to the places where the wind speeds are 4.5-5.5 m/s and 5.5-6.5 m/s respectively. 10 weight value is given to wind speed.

Maximum Temperature of Warmest Month (BIO5) values of the study area are collected in 5 groups (18^0-22^0, 22^0-26^0, 26^0-30^0, 30^0-34^0, 34^0-38^0). 10 impact factor value is given to the places where the temperature is between 18^0-22^0. 9, 8, 5 and 4 impact factor values are given to the places where the temperature is between 22^0-26^0, 26^0-30^0, 30^0-34^0 and 34^0-38^0 respectively. 7 weight value is given to Maximum Temperature of Warmest Month.

Minimum Temperature of Coldest Month (BIO6) values of the study area are collected in 7 different groups (-20^0- -16^0, -16^0- -12^0, -12^0- -8^0, -8^0- -4^0, -4^0- 0^0, 0^0-4^0, 4^0-8^0). 8 impact factor value is given to the places where the temperature is between 4^0-8^0. 7, 5, 4, 3, 2 and 1 impact factor values are given to the places where the temperature is between 0^0-4^0, -4^0- 0^0, -8^0- -4^0, -12^0- -8^0 , -16^0- -12^0 and -20- -16 respectively. 10 weight value is given to Minimum Temperature of Coldest Month.

Annual precipitation (BIO12) values of the study area are collected in 4 different groups (300-500 mm, 500-700 mm, 700-800 mm and >800 mm). 10 impact factor values are given to the places where the precipitation is between 500-700 mm. 8 impact factor values are given to the places where the precipitation is between 300-500 mm. 7 impact factor values are given to the places where the precipitation is between 700-800 mm. 4 impact factor values are given to the places where the precipitation is >800 mm. 7 weight value is given to annual precipitation.

Elevation values of the study area are collected in 7 different groups (0-300 m, 300-600 m, 600-900 m, 900-1200 m, 1200-1500 m, and >1500 m). 10 impact factor values are given to the places where the elevation values are between 0-300 m. 9 impact factor values are given to the places where the elevation values are between 300-600 m. 6 impact factor values are given to the places where the elevation values are between 600-900 m. 4 impact factor values are given to the places where the elevation values are between

900-1200 m. 9 impact factor values are given to the places where the elevation values are between 300-600 m. 2 impact factor values are given to the places where the elevation values are >1500 m. 8 weight value is given to elevation values (Table 2).

Aspect values of the study area are collected in 6 different groups (North, Northeast, East, Southeast, South, Southwest, West- Northwest). 10 impact factor values are given to the places located in the Southeast and Southwest. 8 impact factor values are given to the places located in the south. 7 impact factor values are given to the places located in the east and west. 5 impact factor values are given to the places located in the northeast and northwest. 4 impact factor values are given to the places located in the north. 8 weight value is given to aspect values (Table 2).

Slope values of the study area are collected in 7 different groups (0^0-1^0, 1^0-8^0, 8^0-16^0, 16^0-32^0, 32^0-50^0, 50^0-75^0, >75^0). 10 impact factor value is given to the places where the slope is between 0^0-1^0. 6 impact factor value is given to the places where the slope is between 1^0-8^0. 5 impact factor value is given to the places where the slope is between 8^0-16^0. 1 impact factor value is given to the places where the slope is between 16^0-32^0, 32^0-75^0 and >75^0. 6 weight value is given to slope values (Table 2).

The obtained factors were evaluated in a GIS environment and all the raster data resampled to 30 m. resolution. The Weighted Sum analysis of the Spatial Analyst Tool in the ArcGIS program is used for creating the suitability maps for the greenhouse siting (Figure 2.). The validity of the created map was checked by the land controls.

Table 2 The categorization of the factors affecting the greenhouse site selection

Wind Speed (m/s)	Max. Temprature of Warmest Month (^{o}C)	Min. Temperature of Coldest Month (^{o}C)	Annual Precipitation (mm)	Elevation (m)	Aspect (Directiton)	Slope (^{0})
≤4.5	18-22	-20 - 16	0-100	0-300	North	0-1
4.5-5.5	22-26	-16 - -12	100-300	300-600	Northeast	1.-8
5.5-6.5	26-30	-12 - -8	300-500	600-900	East	8.01- 15
6.5-7.5	30-34	-8 - 4	500-700	900-1200	Southeast	16 -32
7.5-8.5	34-38	-4 - 0	700-800	1200-1500	South	33 - 50
8.5-10.00	38-42	0 - 4	800-≥	1500-≥	Southwest	51-75
10- ≥	42-46	4 - 16			West- Northwest	75-≥

RESULTS AND DISCUSSION

In our study, we have investigated the suitability for greenhouse siting in the 4 provinces of the Eastern Mediterranean basin. In this context, 7 criteria that could be effective in the construction of greenhouses were considered where greenhouses were built more. Adana province is considered to be the closest province to in terms of the appropriateness of greenhouse due to climatic and topographic conditions. Toros Mountains are located in the north of Adana. Seyhan and Ceyhan Plains as well as two large streams are also located in Adana. Hence Adana is the fertile land where irrigated agriculture is made. With its fertile soil, suitability for irrigated agriculture, annual rainfall, wind speed and minimum temperature values, Seyhan and Ceyhan plains are seen as a suitable area for greenhouse cultivation. In Adana, the percentage of areas suitable for greenhouse siting, partially suitable and unsuitable were determined as 37.06%, 45.58% and 17.36%, respectively (Figure 3a). When Figure 3a is examined, agricultural areas, especially in Seyhan and Ceyhan districts, are suitable for greenhouse cultivation. For the year 2019, the Ministry of Agriculture and Forestry is selected Adana province, as the area of application in the organized agriculture and livestock. The main reason for that is the region has a very suitable climate for greenhouse cultivation. Field farming is done throughout the province. While industrial plants are grown, profitability rates may be low in terms of both labor and input costs in large areas. Increasing the income from the unit area does not mean manufacturing only in season.

Increasing the revenue obtained from the unit area does not only mean production during the season. Fruit and vegetable production at the beginning of the season should be encouraged and be demanded, especially in the countries considering exportation. The Karataş and Yumurtalık districts are in the southern part of the Mediterranean coast. Therefore, it is easy to export the products to the world markets from the International Mersin Port (Free Zone) located in the southwest (30 nautical miles) of this area. Our study covers the province of Adana and its 14 districts. 9 districts and villages of the province, except Feke, Saimbeyli, Aladağ, Pozantı and Tufanbeyli districts, were seen as suitable areas for greenhouse cultivation (Figure 3a). Since Adana and Hatay provinces have appropriate land, air and sea routes, it is very easy to deliver the produced product to the market in need. The products obtained from greenhouses to be established in Adana and Hatay provinces will be able to reach every point of Turkey. At the same time, these greenhouses will potentially be able to export to the Middle East and Russian market. Greenhouse cultivation is carried out in the coastal areas of Hatay province. The Nur (Amanos) Mountains are an extension of the Taurus Mountains. It is an outer line formed by the mountains extending in the direction of Hatay - Kahramanmaraş. Since these areas are areas with high wind speeds, it should not be made greenhouses in these areas. There are currently 10 wind power plants in the Belen and Nurdağı sections, which are located in the wind corridor. These areas are not considered suitable especially for greenhouse cultivation. The energy provided from the wind power plants established in the high parts of Samandağ, Belen and Yayladağı districts may be useful in providing energy to the greenhouses to be established in areas such as Amik plain. The wind map of the province of Hatay and the produced map of the study area shows the intersection at the same points, and this confirms our study.

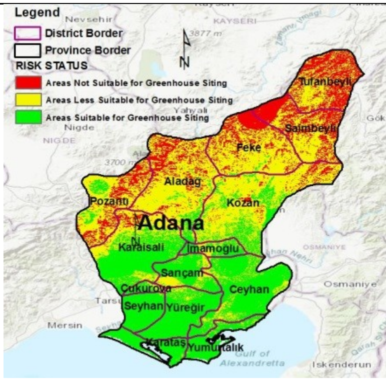

Figure 3a Suitable areas for greenhouse cultivation in Adana

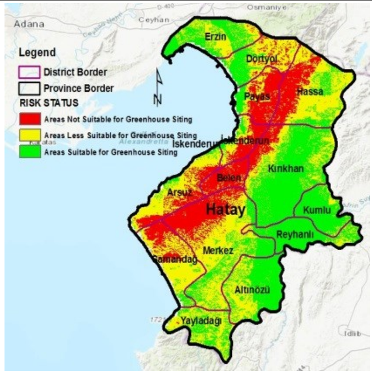

Figure 3b Suitable areas for greenhouse cultivation in Hatay

Although the province of Kahramanmaraş is located in the Mediterranean region, its climate is characterized by continental climate. In the region, especially fruit growing and field cultivation is done, and it is not considered as suitable for greenhouse cultivation. Andırın, Türkoğlu and Pazarcık districts are located in the southern part of the Kahramanmaras Province and on the Osmaniye border. In the southern part of these districts, there are 7.8% partially suitable areas for greenhouse cultivation (Figure 3c). There are currently 2 wind power plants in the province. The province is not recommended for greenhouse cultivation due to the high altitude of the region and unsuitable climate data. The preference for fruit growing business in this area would be a more appropriate decision. In the district of Türkoğlu, Kadıoğlu neighborhood, 500 thousand square meters of greenhouse area has been producing since 5-6 years. This area has been a source of hope for local producers. In our study, this field is also seen as a suitable area for greenhouse cultivation (Figure 3c). In the Mediterranean region, fall production starts in September and lasts until the end of January and spring production starts in February and takes place until the end of May. However, it is very difficult to observe these production periods in K.Maras. The reason for this is the winter months are cold and rainy. Therefore, heating in the cold season can be a major problem for manufacturers. It is foreseen that the potential could be increased by making the greenhouse in the geothermal areas (Onikişubat and Dulkadiroğlu). In addition, it can be foreseen that, the potential may be increased by pulling production periods 2-3 weeks forward (Figure 3c).

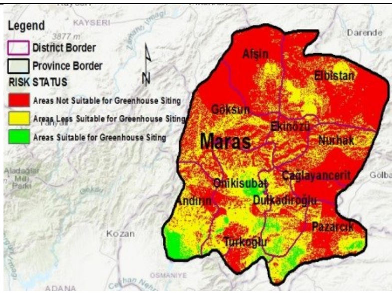

Figure 3c Suitable areas for greenhouse cultivation in K.Maraş

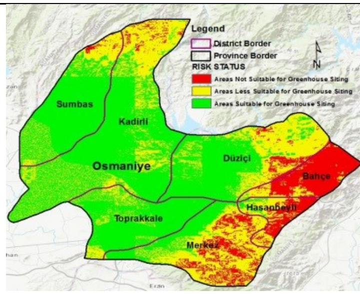

Figure 3d Suitable areas for greenhouse cultivation in Osmaniye

In the study, the majority of Osmaniye province, which has a Mediterranean climate, has been determined as suitable areas for greenhouse cultivation. On the contrary, Bahçe and Hasanbeyli districts in the southeastern part of the province are not suitable for greenhouses due to high wind speeds. When Turkey wind energy atlas is analyzed, there are currently 3 wind power plants in Bahce and Hasanbeyli districts. In Osmaniye province, 26.43% of the province is considered suitable for greenhouse cultivation. Greenhouse cultivation in Osmaniye is an income generating activity for the province and it will be beneficial in the development of the region. It will also be able to create new jobs for refugees who migrated to Osmaniye due to the civil war in Syria (Figure 3d).

As a result, in the study area, covering 4 provinces in the Eastern Mediterranean basin, the appropriate greenhouse siting areas were determined by MCDA analysis using the ArcMap 10.2 software. The relationship between the criteria which are effective in the selection of greenhouse sites compare with this method and it is aimed to have knowledge about the region. When the region is evaluated on the basis of provinces, greenhouse enterprises belonging to the study area; Adana, Hatay and Osmaniye Provinces and their districts and villages are seen as profitable but a very sensitive selection is required for K. Maras province (Figure 3e).

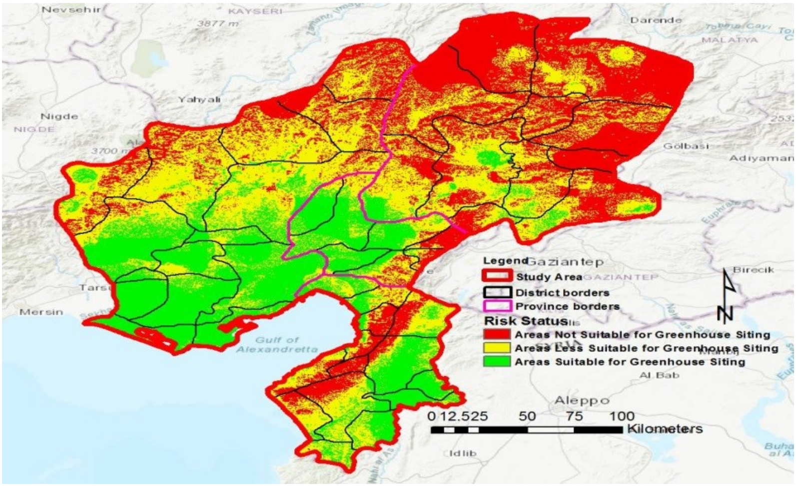

Figure 3e. Suitable areas for greenhouse cultivation in Eastern Medıterranean Basın, Turkey.

CONCLUSION

In this study, 7 parameters which will be preferred for the establishment of greenhouses are evaluated by MCDA method. The suitability maps were created with ArcGIS to determine the appropriate, partially suitable or inappropriate areas for the greenhouse cultivation in the study area. According to the results of the study, these recommendations should be given to producers and responsible institutions:

a) It is very important to obtain the long-term climatic values of the places where the greenhouse will be established.
b) In the projecting and implementation stages, the greenhouse model specific to Mediterranean climate should not be selected for all locations. The specific greenhouse type and equipment suitable for the selected location should be preferred. This will also be beneficial to our national economy, especially if the greenhouse construction manufacturers choose the robustness and project models rather than the cost factor.
c) The regional agricultural organization should activate the control mechanism for the greenhouses in the region. Even if demand from the producers is demanded, it is necessary to disseminate planned, projected and licensed greenhouses that contain suitable places for the greenhouse location rather than random planning.
d) Employing agricultural engineers who have the technical knowledge to perform expertising within the agricultural insurance companies, will minimize the damage dimensions.

e) The greenhouses, which are either awarded or granted by the Ministry of Agriculture and Forestry, should be established as planned and licensed in the organized agricultural regions.
f) Greenhouse manufacturers should not recommend a greenhouse model to producers without considering climatic conditions or static-strength calculation.
g) In the region, the data bank should be created in accordance with the criteria of the greenhouse locations and should be designed by means of Greenhouse Production Programs. Within this program, ArcGIS and Construction (Static, Strength) Programs should be able to work in coordination.

According to the results of this study, it is thought that both our producers can benefit and increase the export potential of the region by encouraging the licensed greenhouses which are suitable for the local climatic conditions and have sufficient qualifications in terms of construction.

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ADDITIVES USED IN WOOD PLASTIC COMPOSITE MANUFACTURING

Fatih MENGELOĞLU [1]

Vedat ÇAVUŞ [2]

[1] Kahramanmaraş Sütçü İmam Üniversitesi, Orman Fakültesi, Orman Endüstri Mühendisliği Bölümü.

[2] İzmir Kâtip Çelebi Üniversitesi, Orman Fakültesi, Orman Endüstri Mühendisliği Bölümü.

1. Introduction

Wood Plastic Composites (WPCs) are the general name of composites which are produced by mixing of lignocellulosic materials, plastic materials and additives (Matuana and Heiden, 2004; Çetin et al., 2014; Özmen et al., 2014; Çavuş and Mengeloğlu, 2016). Term wood is used as lignocellulosic materials in general. WPCs are manufactured using similar production techniques to filled or unfilled thermoplastic polymers (Hietala, 2013).

Lignocellulosic filler usage in WPC production has some advantages over inorganic fillers such as providing lightweight products and lover wear resistance during processing. Lightweight is one of major driving force for choosing fillers in outomotive and packageging industry (English and Falk, 1995). The density of lignocellulosic fillers is around 1.3– 1.4 g /cm^3 while inorganic fillers like calcium carbonate and fiberglass are nearly 2.9 and 2.5 g/cm^3, respectively. WPC can be tilized as floor coverings, stair rails, door and window frames (Hietala, 2013; Clemons, 2002; Mengeloğlu and Karakuş, 2008), walking trails, outdoor furniture, marinas, pools and spas (Clemons, 2002).

The most important advantages of WPCs are their low energy consumption, low corbon emission, recyclability, less waste production (Youngquist, 1995), ease of processing, degree of hardness, high dimensional stability and low specific weight (Bledzki and Sperber, 1999). In addition, WPCs may provide low cost, durability against chemicals, corrosion and weather conditions, and low production time for complicated parts decreasing the mounting time (Mengeloğlu et al, 2002). Dispite these advantages, WPCs has also some drawbacks like higher cost of thermoplastic matrixes, higher brittleness and lower impact resistance of resulting composites compared to unfilled counterparts, and longer drying time of fillers (Mengeloğlu et al., 2002; Karakuş and Mengeloğlu, 2015).

The production of WPC is not an easy and trouble free process. Majors problems associated with it are adhesion problems caused by incompatibility between polar wood and nonpolar plastic matrix, and friction problems resulting pressure and temperature increase in extruder. WPC performances may change the source, type, size and aspect ratio of wood wood/fiber, type, structure and molecular weight of the plastic, and additives used (Mengeloğlu, 2006). Through the use of various additives in WPC formulatins, expected lifetime, physical, mechanic and chemical properties of the WPCs can be improved and their application areas can be expanded.

2. The Additives Used In The Production Of Wood Plastic Composites

During manufacturing, various additives are added into WPC formulations. This provide necessery product properties such as resistance against physical and chemical effects and wheather conditions, and appealing aesthetic appearances. During additive selection, performance and cost should be taken under consideration. In production of WPCs, many additives are used. The most important ones are coupling agents, antioxidants, antistatic agents, adoptive agents, foaming agents, plasticizers, colouring agents, UV stabilizer, viscosity reducers, nonflammability materials (Clemons, 2002; Rowell, 2006; Ashori, 2008; Rude, 2007; Gardner et al., 2015).

2.1. Coupling Agents

One of the major problems associated with WPC is lack of interaction between hydrophilic wood filler and hydrophobic polymer matrix resulting poor ahesion and lowered properties. In general, the strength of the adhesion between two materials depends on the mechanisms occurring and contact area between them. These mechanisms can be dispersion forces (London wan-der Waals forces), electrostatic forces, diffusive forces, and inter linlinking at a micro-rough interface (Bahners et al., 2018). In WPC system, the major factor is belived to be the dispersion forces so that the surface energies of the materials involved and the interfacacial energy determines the work of adhesion.

One of the most important additives used in WPCs production is coupling agents/compatibilizers. Maleic anhydride grafted polymer use in polyolefin based WPCs is a common approach affecting interfacial interaction and enhancing fiber-matrix adhesion (Bahners et al. 2018; Felix and Gatenholm 1991; Huber and Müssig 2008; Joseph et al. 2002).

Among maleic anhyride grafted polymers, maleated polyolefins are the most widely used coupling agents. They contain one polyolefin domain (high density polyethylene or polypropylene) to form entanglements with polymer matrix, and maleic anhydride domain to strongly interact with cellulose fiber at extrusion temperatures. Maleated polyolefins contains 1-6% (w/w) of the covalently attached anhydride onto the polymer backbone after grafting via radical reactions (Klyosov 2007).

During the WPC production, the anhydrite of the maleated polyolefins (MAPP or MAPE) reacts with hydroxyl groups on wood surface generating an ester linkage. Thus maleated ends of MAPP/MAPE bond to wood fillers. After bonding, wood filler entangled with melted thermoplastic and a mechanical bonding occurs between hydrophilic wood flour/fiber and hydrophobic thermoplastic (Kattas et al., 2000; Rowell, 2006; Yang et al., 2007). Ester bonds formed between the hydroxyl groups of the filler and the hydride carbonyl groups of coupling agent provide significantly improved adhesion (Adusumalli et al.2010; Gaasan and Bledzki 2000; Botros, 2003; Silva 2003). The proposed reaction of MAPP with hydroxyl group on the wood fiber by Takase and Shiraishi (1989) is shown schematically in Figure 1.

Effecttiveness of nine different maleated polypropylene (MAPP) copolymers in agrofiber/polypropylene composites was investigated by Snijder and Bos (2000). They found that on coupling efficiency, molecular weight of MAPP had more important role than maleic anhydride (MA) content in MAPP. The interfacial adhesion of the composites improved by the backbone structure of MAPP because of their miscibility in the PP matrix. It is also reported that optimum concentration of MAPP for improvement of hemp fiber/PP adhesion is found to be 2 and 4 wt% (Mechraoui et al., 2007). Effects of filler nature (flour vs fiber) and 3% MAPP coupling agent on the mechanical properties of 40% wood flour/fiber filled PP composites were also investigated (Stark ve Rowlands, 2003). Compared to non-coupled composites, both composites having 3% MAPP provided better results both with wood flour and wood fiber usage. It should also be noted that wood fiber used composites provided higher properties.

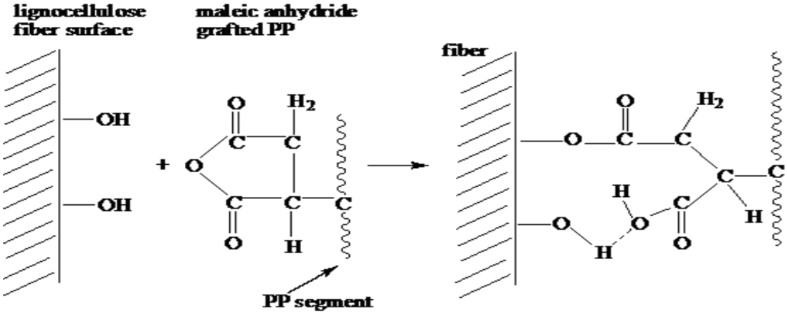

Figure 1. The reaction of MAPP with hydroxyl group on the wood fiber (Takase and Shiraishi, 1989).

Several studies conducted to find alternative coupling agents in WPC formulations. Silanes, iscoyanates, alkali treatmens etc., were studied for chemical modification (Mengeloğlu et al. 2000). Corona and plasma treatments were also investigated as physical initiated surface modifications (Wolf, 2010; Liston, et. Al. 2016).

Maleated polyolefins are currently the major coupling agent in commercial WPC manufacturing. WPC manufactures usually consumes about 1-5wt % maleated polyolefins as a coupling agent in their formulations (Klyosov, 2007). It is also stated that effect of coupling agent can be more pronounced in industrial manufacturing compared to laboratory ones. Mixing is more intense and more dispersive in small-scale laboratory tests. That is why; the dispersing effect of the coupling agents is minimal (Klyosov, 2007). During maleated couping agent usage, attention should be paid to choosing right lubricant systems (non-metallic ones), keep coupling agents in dry conditions, and protect from air moisture.

Table 1. Some mechanical features of wood plastic composites (Stark ve Rowlands, 2003).

Composite	Specific gravity	Bending Resistance (Mpa)	Tensile Strenght (Mpa)	Impact Resistance (J m^{-1})	
Polypropylene (PP)	0.90	28.5	38.30	Notched	Un-notched
PP + 40% wood flour	1.05	25.4	44.20	20.9	656
PP+40% wood flour + 3% MAPP	1.05	32.3	53.10	22.2	73
PP + 40% wood fiber	1.03	28.2	47.90	21.2	78
PP+40% wood fiber + 3% MAPP	1.03	52.3	72.40	23.2	91

2.2. Lubricants - Sliders

Polymers are made of long chain molecules of varying sizes and distributions. Over their melt temperature, tthey become relatively viscous and “Sticky”. During processing, frictional forces found between Polymer/Polymer, Polymer/Metal, Polymer/ Filler, filler/filler, and filler/metal were lessened by lubricants (URL2). Lubricants can surve two different main purposes and be named as external and internal lubricants. External lubricants typically provide lubrication between the polymer and the metal surface of the processing equipment. Polyethylene waxes, oxidized polyethylene waxes, praffins, metal soaps, esters (high esterification), amides, fatty acids, etc. are used as external lubricants. Internal lubricants, on the other hand, are semi-soluble plasticizers and typically reduce bulk viscosity through partial compatibility with the polymer. Soluble component of lubricant opens polymer chain providing intermolecular lubrication with the less soluble portion of the molecule. Fatty alcohols, esters (low esterification), EVA wax, etc. can be listed as internal lubricants (URL2).

Wax, antistick, slip, release agent, and flow modifiers terms can also be used interchangeably with term “lubricant” (Rowell, 2006). Lubricants ease the flow of the composite through the process in the machine (Harper, 2006), enhance the surface appearance of the product and let the product leave the mould easily. Using lubricants as additive decreases the melting viscosity which decreases energy consumption and friction in the hive (Kattas et al., 2000). The choice of lubricant depends on thermoplastic polymer and filler used (Rowell, 2006). As a lubricant, the use of highly acidic lubes degrades cadmium pigment. Also zinc stearate usage yellows the Red 2B pigments.

WPCs application areas are expanding and they are becoming more engineered materials. To improve the product deficiensies required in certain applications, formulas containing more additives are started to be utilized. This increases the need for the improved dispersion provided by lubricants (Markarian, 2002).

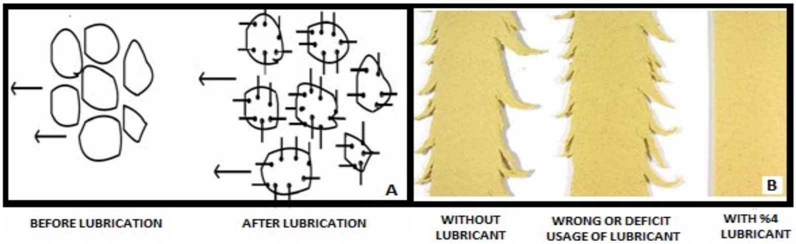

Figure 2. The schematical image of the movement of polymer molecules with and without lubrications and images of right and wrong usage of lubricant in wood plastic composites (URL, 1).

Effect of lubrication in WPC manufacturing was studied by several researchers (Rowell, 2006; Fras et al., 1999; Gächter and Müller, 1993). Internal lubricants affect the sliding mechanism of chains and decrease the friction between molecules. At high temperature, lubricants penetrate to the polymer matrix with thier polar parts. In this way the Wan-der Wall's gravitation between molecules is decreased and the chains slide over each other (Figure 3) (Fras et al., 1999; Gächter and Müller, 1993). Internal lubricants decrease the friction between molecules by taking part in plastic molecules abolishing the cracking or breaking problems by increased viscosity of melt (Rowell, 2006).

Lubricants are generally added into composites as 0.1-3.0wt % (Kattas and et al, 2000). Lubricants have positive effects on both the flow and physical features of the product. With lubricant use, finished products with shiny and smooth surfaces are produced (Gächter and Müller, 1993). The effect of right lubricant application on WPC appearances is presented in Figure 3.B. Formulation of WPC in this image had 70% wood flour, %23 polypropylene, 3%coupling agent and 4% lubricant.

In WPC production, commonly used lubricants are paraffin wax, saponifiers, amides and esters, metallic stearate (calcium stearate, sodium stearate, zinc stearate), ester type lubricants, vegetable oils, floroelastomer, ethylene bis stearamid (EBS) oxidized polyethylenes and conbinations of these with different proportions. It should be noted that most lubricants can provide a combination of internal and external effects. Overall effectiveness of the lubrican rely on the balancing of these effects in the formulation. Lubricants may show different performance in different polymer compounds due to chemical solubility. Solubilities change relative to polymer chemistry and other additive chemistries (URL2).

2.3. Colourants and UV Stabilizators

The other additives used in the production of WPCs are colourants and ultraviolet stabilizators. Colourants are materials used to color the composites and create an aesthetic appearance. Colourants are divided into to; soluable dyes and insoluable pigments. First one preferably used in textiles, leather and paper while pigments are mostly used in plastics, coatings, and printing inks (Murphy, 1996). In the production of WPCs, pigments are mostly used instead of paints (Kattas et al., 2000). During pigment use, manufacturers should keep an eye out for handling. This is necessary not simply because of the cost of the pigment, but also because it may present a dust hazard (Murphy, 1996). That is why the general rule is safe and dust-free formulations for the processors. Since they have so many priorities during processing, many of them now prefer to buy ready-coloured material (Murphy, 1996).

Pigments can be organic or inorganic in nature. Organic pigments can give more colour but provide less coverage compared to inorganic pigments (Kavak, 2006). Colourants are usually added into the mixture as 0.1-0.25% in composite production. List of plastic colourants is presented in Table 2 (Anapa, 2003).

Selection of lubricants plays key role in pigments appliacations. Lubricants should provide optimum dispersion, processability, and color development/dispersion and stability in the end use. Lubricants also do not interfere with the function of the colorant. Most common used ones EBS (Acrawax C, Advawax 280, TR-EBS, etc.), Stearates and Hydrocarbon waxes (Klysov, 2007).

Table 2. Plastic Colourants (Anapa, 2003)

Colour	Chemical Material Used
White	Titanium dioxide, barium sulfate, zinc oxide, lithophone
Silver Gray	Thin aluminium powder
Yellow	Titanium yellow, chrome yellow, cadmium yellow
Blue	Phthalocyanine green, chrome green
Red	Cadmium red, iron oxide (Fe2O3), lead molybdate
Black	Carbon black
Glittering Appearance	Mica, lead corbonate
Others	Copper, bronze, brass and zinc powders

UV stabilizers are used against plastics oxidation coused by UV lights. They perform by blocking harmful UV radiation, or removing any oxidized components. The UV part of sunlight causes photodegradation, which is the process of UV light breaking down the chemical bonds in a polymer. UV stabilization may affect mechanical properties, resistance to ageing, colouring, outdoor/weathering properties and appearance. UV screening pigments (carbon black, calcium carbonate, titanium dioxide), benzophenones/benzotriazoles, nickel stabilizers, hindered amines (HALSs), and polymeric stabilizers are utilized as UV stabizers (Murphy, 2003).

WPCs are mainly used in outdoor applications. For this reason, they are under exposure of UV lights while in service and require UV stabilisation for optimum overall performance. WPCs faces disruptive outdoor conditions like water, air and ultraviolet rays. Some producers use gray pigments to decrease colour changing or cover WPCs with a second layer of ultraviolet stabilizer (Rowell, 2006). Wood flour or fibers used in the production of WPCs may be deformed by the ultraviolet rays. In order to prevent or decrease the deformation, ultraviolet stabilizators should be used. Ultraviolet stabilizators not only protect the products against the deforming effects of ultraviolet rays but also protect the colour of the composites, which increases the lifetime of the products (Rowell, 2006). These are the examples of UV stabilizators: aryl esters, tetramethyl piperidine, benzophenone, esters of benzoic acids, resorcinol monobenzoate and benzotriazole. Depending on the kind of the plastic, 0.5-2.0% of UV stabilizators can be used (Anapa, 2003).

2.4. Antioxidants

Antioxidants are used to prevent oxidative degradation in a great variety of polymers. Action of highly reactive free radicals caused by heat, radiation, mechanical shear, or metallic impurities does initiate degradation. Once the first step of initiation occurs, propagation follows. A peroxy radical is formed with the reaction of free radicals and an oxygen atom. Unstable hydroperoxide and another free radical are formed when peroxy radical reacts with an available hydrogen atom within the polymer. Without antioxidant presence, this reaction continues and drives to degradation of the polymer. Role of antioxidant is to prevent the propagation steps of oxidation. They are classified as primary or secondary antioxidants Primary antioxidants donates their reactive hydrogen to the peroxy free radical so that the propagation of subsequent free radicals does not occur. Secondary antioxidants, on the other hand, retards oxidation by preventing the proliferation of alkoxy and hydroxy radicals by decomposing hydroperoxides to yield nonreactive products (Harper, 2006).

Antioxidants are also needed in WPC formulations to abolish or decelerate the negative effects of atmospherical oxygen over the polymeric material. With the addition of antioxidants, both the plastic is preserved during the processing at high temperatures, and are protected the damaging effects of sunlight, air oxygen, water, pollutants, and other elements (Klyosov, 2007).

The most commonly used antioxidants are phenolics, phosphates and thioesters (Rowell, 2006). The proportion of antioxidants in the composite can be changed depending on the polymeric matris (Kattas et al., 2000). The primary antioxidants are phenols, aromatil amines and salts, and condensation products made by aldehyde, ketone and thio compounds of amine and aminophenoles (Anapa, 2003).

2.5. Antistatic Agents

Antistatic additives can be classified by application method and by chemistry. First one is internal and external while secon one is anionic, cationic, and non-ionic additives. Internal agents are normally compounded at 0.1-3.0% by weight and have a slight compatibility with the polymer (Murphy, 2003). Antistatic agent help both dissipating or reducing electrostatic charge and improving promote the decay of static electricity. A secondary benefit of antistic agent incorporation into polymer is improved processability, mold release and lubrication (Kattas et al., 2000; Murphy, 2003).

Antistatic agents can be in liquid (quaternary ammonium, polymeric anti-statics), solids (carbonblack, coated metal particles, glass spheres), and intrinsically conductive polymers (polyanilines). Some of the disadvantages of the antistatic agents are possible effect on surface, and susceptibility to moisture (Murphy, 2003).

Static agents used in the production of WPCs are additive preventing static electiricity which occurs in the production and the usage of the composites. The static electricity gathering over the plastics causes electric shock, burning or explosion, gathering of dust, dirt, foreign matter and etc. on the material. Thus the antistatic agents added into composites relieve the gathered static electricity or prevent electrostatic charge. Antistatic agents are either directly added into produced pellet or superficially sprayed with the proportion of 0.1-2% (Kattas etal., 2000; Kylosov, 2007). In WPC applications, commercial available blends are used. They have the combination of hindered phenolic antioxidant and phosphite (Klysov, 2007).

2.6. Plasticizers

Plasticizer, mainly used with PVC and cellulosics, is added to polymer to make a compound more flexible and easier to process (Murph, 2003). Plasticizers are additives which decrease the glass transition temperature, make the plastic softer, decrease fragility and enable the plastic to be processed more easily. Plasticizers are chemical materials changing the physical and mechanical features of plastic objects (Kattas et al., 2000).

The glass transition (Tg) of commonly used plastics is higher than room temperature. The polymers under the Tg are glassy and fragile. Over Tg, polymers generally show behaviour of rubberish and have high impact resistance. Cellulosics, vinyls, acrylics and etc. are used plasticizers to reduce the Tg of polymers (Pişkin, 1987).

Plasticizers are organic liquids having high boiling point or solids having low melting point. The plasticizers which are used through the polymer syntheses are called internal plasticizers while the plasticizers are added into the polimer structure in time of process are called external plasticizers. It is expected that plasticizers should have no toxicicity, noninflammable, and long-lasting effect (Pişkin, 1987). Commonly used plasticizers are these:

phthalates (dioctyl phthalate, dop oil), sebacates (dibutyl sebacate), chloric paraffins, phosphates (various alkyl aryl phosphates), epoxy plastizicers, aliphatic esters (glycol benzoate esters, mellitic esters), polymeric plastizicers (Kattas et al., 2000).

Plasticizer should also provide following features; low cost, low evaporation rate, provide effectiveness over a wide concentration range, low water absorption, stability during processing, and resistance to UV light (Saçak 2005).

2.7. Foaming Agents

The term “foaming agent” and “blowing agent” are generally used interchangable. Foaming agents are inorganic or organic substance that used in polymeric materials to produce a foam structure. They can be either physical or chemical foaming agents (Kattas et al., 2000). Physical foaming agents mostly used for thermosetting polymers. Major ones are carbon dioxide, nitrogen, and air. In liquid form, partially halogenated chlorofluorocarbons are preferred as physical foaming agents.

Chemical foaming agents (CBAs) generate gas as a result of chemical reaction or degradation when they are heated (Pişkin, 1987). Exotermic and endotermic foaming agents are two majör types of CBAs. Exothermic foaming agents release energy during decomposition, while endothermic foaming agents require energy during decomposition. In general, endothermic CBAs generate carbon dioxide as the major gas. Commercially available exothermic types primarily evolve nitrogen gas, sometimes in combination with other gases. Endotermic foaming agents are sodium borohydride (NaBH4), sodium bicarbonate (NaHCO3), and polycarbonic acid while endotermic foaming agents are azodicarbonamide (AZ), modified AZ, Sulfonyl hydrazides Sulfonyl semicarbazides, and Dinitropentamethylene tetramine (DNPT) (Kattas et al., 2000).

In the production of WPCs, foaming agents are used to make composite lightweight and cost less (Rowell, 2006). A high content of lignocellulosic material in plastics, makes the composite material much less suitable for foaming. Foaming significantly decreases the composite’s flexural strength and flexural modulus (Klyosov, 2007; Yetgin and Ünal, 2008). Foaming agents in the range of 0.1-1.0% are used for injection and extrusion process while 5.0-15.0% are utilized for pressure molding (Kattas and et al, 2000). Most foamed plastics are polyurethane (PU), polysytrene (PS), polyethylene (PE), polyprophylene (PP), polyvinylchloride (PVC), polycarbonate (PC).

In the production of plastic composites, rigid and flexible foams can be accomplished using foaming agents. The density of foam material is generally 15-60 kg/m^{3}. The commonly used foaming agents are pentane, toluen, trichloroethylene and azo carbonamid (Gua et al., 2007). Foams are divided into two classes considering cell morphology: closed-cell foams and open-cell foams (James et al., 2005).

2.8. Fire/Flame Retardants

Plastics used in transportation, building, appliance, and electronic industries require flame-retardant (FR) additives to prevent human injury or death and to protect property from fire damage. Ignition smoke generation and rate of burn of plastics may be control by FRs use in formulations. Organic and inorganic FRs typically contain either bromine, chlorine, phosphorus, antimony, or aluminum materials in their composition. FRs can also be classified as being reactive or additive. “Reactive” flame-retardants chemically bind with the host resin while “Additive” types are physically mixed with a resin without chemically binding with the polymer. FRs concentrations can be a few percent to more than 60% of the total weight of a treated resin. Flame retardants try to minimize fire to exist by controlling fuel, heat energy, and oxygen. They also may be classified as “Char formers” (phosphorus compounds), “Heat absorbes” (metal hydrates such as aluminum trihydrate (ATH) or magnesium hydroxide), “flame quenchers” (bromine or chlorine-based halogen systems) and “Synergists” (usually antimony compounds). The use of formulas with multiple flame-retardant types (a primary flame retardant and synergist) is common to enhance overall flame-retardant efficiency at the lowest cost (Kattas et al., 2000).

In WPCs applications, FRs should be added according to the type of the plastic matrix in the composites (Çavdar, 2005; Bryson and Craft, 2009; Jang and Lee 2001; Klyosov 2007; Sain et al., 2004; Kurt and Mengeloğlu, 2011).

2.9. Heat Stabilizers

Polymers can bring up against heat (thermal) energy during polymer processing or service life at application site. Tempreture that polymers starts to degrade is just around the their maximum use (service) temperatures. In polymer formulations, heat stabilizer are being utilized to reduce/prevent thermal decomposition of polymers (Saçak, 2005).

Heat stabilizers are additives used for preventing or decelerating the degradation of plastic materials or losing some properties. Generally, lead stearate, barium stearate or zinc stearate and phenolates are used (Murphy, 1996).

2.10. Bio Fixers/Biocides

Bio fixers are used to protect organic fibers in the WPCs against the attacks of microorganisms. When the WPC used in outdoors and exposed to damp, a suitable environment is set for the growth of microorganisms. The microorganisms, in the structure of organic fibers, may damage the composite. Thus antimicrobial additives are added into the composite. There is no need for antimicrobial additieves in formulations when there is short and temporary applications. Antimicrobial additives, on the other hand, are needed for composites contacting with soil or used in a humid contitions. Bio fixers which were used for this aim, can be divided two category such as organic and inorganic materials (Rowell, 2006). Usually, zinc borate is utilized as preservative additive. It is affordable preservative additive and can be added (2-3%) into the composite formulation. Zinc borate doesn't easily dissolve in the water and it is more resistant to leaching and heat compared to other preservatives (Klyosov, 2007). Borates like boric acid, borax and disodium octaborate tetrahydrate are commonly used as wood preservative chemicals. They are generally effective against fungal decay. They are ineffective against mold and coloration (Klyosov, 2007).

2.11. Mould Covering and Viscosity Reducing Additives

The other additives used in the production of composites are mould covering and viscosity reducing additives. Mould covering additives are used through the process of moulding the polymers in order to disable the plymer melts to stick the surface of moulds and thus they let the mould leave the product easily (Pişkin, 1987). The best examples of mould covering materials are waxes and silicons.

Viscosity reducers are additives which reduce the viscosity of liquids they are added into. The most important applications of these materials in plastic industry are vinyl plastisols. They are used for reducing the viscosity without increasing plasticizing level. Ethoxylated fatty acids can be an example for viscosity reducers (Saçak, 2002).

3. Result

In WPC production, additives are selected based on the target product properties, type of filler and processing techniques used. For this reason, it is important to know additives, their correct concentration and their suitability to WPCs productions. Right formulation in WPCs may affect production process, the physical, mechanical, chemical, burning and morphological properties of the final product, service time of final product and aesthetic properties of the product.

Application area and expected final products properties should be known before formulating WPCs. If the additives are used properly, the elements limiting the use of WPC can be abolished. In parallel with the developments in the materials and technologies, the application areas of WPCs can be increased as an alternative to traditional metal, wood and plastic materials.

In short, expected final product properties, cost of additives, suitability of WPCs, and complience to legislations should be taken into consideration while choosing additives.

WPC productions are quite new compared to other traditional materials. On the other hand, major Research and Developement (R&D) studies both in academia and industry provides oppurtunities for new and expanding application areas.

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A GEOGRAPHIC INFORMATION SYSTEMS (GIS) - BASED APPROACH FOR EVALUATING THE POTENTIAL OF BIOGAS PRODUCTION FROM LIVESTOCK MANURE AT A REGIONAL SCALE: A CASE STUDY FOR GEDIZ BASIN

Ozan ARTUN [1]

Burak SALTUK [2]

[1] Dr., Cukurova University, Karaisali Vocational School, Department of Architecture and City Planning, Karaisali, Adana, TURKEY.

[2] Asst. Prof. Dr. Siirt University, Agriculture Faculty, Biosystem Engineering Department, Siirt-TURKEY.

INTRODUCTION

One of the most important branches of agricultural production is animal (meat and milk) production. Although the main output of intensive production in bovine livestock facilities is seen as meat and milk, the manure and wastes that animals give to the environment can accumulate in the storage structures and the energy can obtain from this manure. The manure released uncontrolled to the external environment causes soil and water pollution. It also causes the loss of energy (biogas) that can be obtained by recycling of these wastes. Biogas is one of the most advantageous methods to eliminate and recycle waste from livestock.

Turkey is a country of agriculture and livestock. Studies on biogas began in Turkey in 1957. Soil and water institution worked on biogas production after 1975. In 1980's General Directorate of Rural Services continued to study on biogas production. In 1987, these studies were discontinued for an unclear reason. Turkey's biogas potential is estimated as 17.3 million TEP / year (Öztürk, 2005).

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic material and is a type of biofuel. The continuing use of fossil fuels and the effect of greenhouse gases (GHGs) on the environment have initiated research efforts into the production of alternative fuels from Bioresources. The amount of GHG emissions in the atmosphere is rising, with carbon dioxide (CO_2) being the main contributor. In addition, the global energy demand is increasing rapidly, with approximately 88% of the energy produced at the present time being based on fossil fuels (Anonymous, 2014, 2015).

Biogas is primarily composed of methane and carbon dioxide, contains smaller amounts of hydrogen sulfide and ammonia, and is saturated with water vapor. Biogas must be desulfurizated and dried before utilization to prevent damage of the gas utilization units. (Schneider et all, 2002).

Anaerobic digestion (AD) is expected to meet with increasing success due to the low cost of available feedstocks and the wide range of uses for biogas (i.e., for heating, electricity, and fuel). Biogas production is growing in the European energy market and offers an economical alternative for Bioenergy production. A study by (Achinas et all, 2017) provide an overview of biogas production from lignocellulosic waste, thus providing information toward crucial issues in the biogas economy.

Gas produced by biogas production is not a pure gas. The content of this gas is approximately 55 - 75% CH4 gas, 25-45% CO2 gas, 1-10% hydrogen gas (H2), 0 - 0.3% nitrogen (N2) gas and 0-3% hydrogen sulfide gas (H2S) (Weiland, 2010).

Our country has a rich potential in terms of biomass resources and organic waste resources. However, our country is a country that consumes almost three times the energy it produces. For this reason, our dependence on external energy needs is over 70%. Also biogas potential of Turkey is equivalent to 88% of the current natural gas usage of our country (Kumbur, et all., 2015).

Since the acquisition of biogas is mainly based on the decomposition of organic substances, vegetable wastes or animal fertilizers can be used as the main ingredient. Today, biogas production has a wide range of diameters. It can meet the heating and kitchen expenses of a single house and electricity generation can also be done with the help of generators (Anonymous, 2018c). According to the data of 2018 in Turkey, there are 68 plants working with biomass energy (Anonymous, 2018a). The amount of manure from animals varies according to the type of animals.

According to this;

- 3,6 tons/year wet manure is obtained from cattle
- 0,7 tons/year wet manure is obtained from ovine
- 0.022 tons/year wet manure is obtained from poultry.

Based on these values,

- 33 m^3/year biogas can be obtained from a ton of cattle manure
- 58 m^3/year biogas can be obtained from a ton of ovine manure
- 78 m^3/ year biogas can be obtained from a ton of poultry manure (Koçer, 2006).

Waste and biogas are produced as a result of decay of manure and other substances by microorganisms. Biogas consists of a mixture of methane, carbon dioxide and other gases. Biogas and natural gas are similar. Biogas; can be used as fuel in heating or electricity production. The heating requirement depends on the season, not comparable to the production of fertilizers and biogas. Therefore biogas is frequently used in electricity production. The electricity produced is used on the farm and surplus electricity is sold to electricity (Öztürk, 2017). Biogas production is an excellent way of using organic waste for energy generation, followed by the recycling of the digested substratum (digestate) as fertilizer (Comparetti et all, 2013)

In a study carried out by Işın (2018), in Izmir, where agriculture and animal husbandry is intensively carried out, the impacts of the wastes generated by the agriculture and livestock activities on the environment and the disposal of these wastes and / or their conversion into a reusable structure were evaluated. As a result of the evaluation, it is suggested that the biogas plants, should make the obtained processing result wastes, usable in agriculture. Also, the conversion of biogas to electrical energy in this process and its current gains are discussed.

Biogas; is a cheap, environmentally friendly energy and fertilizer source. Provides waste recovery. As a result of biogas production, weed seeds that can be found in animal manure lose their germination. After biogas production, wastes are not destroyed and they are transformed into a more valuable organic fertilizer (Gizlenci & Acar, 2008).

Through biogas; natural balance is maintained by preventing soil, water and air pollution. In addition, wastes from biogas production are used as fertilizer in agriculture (Çanka Kılıç, 2011).

MATERIALS AND METHODS

Manure and wastes obtained from cattle can be an important source of income when evaluated for biogas production, while leaving them to arbitrary land or water resources can lead to pollution. According to diffuse pollution load calculations made in Turkey, when TN (as total nitrogen) load distribution is analyzed, the highest share with 35% is due to the use of fertilizer for agricultural purposes. It's followed by land use with 33%. Animal husbandry constitutes 21%, atmospheric transport constitutes 7%, septic tank constitutes 3% and leachate constitutes 1%. When the distribution of TP (Total Phosphorus) loads was examined, it was seen that most of the load was from fertilizer use (54%). It is observed that livestock (23%) and land use (14%) are the following agricultural activities. The distribution of septic and leachate TP loads is 8% and 1%, respectively. When searching for the distribution of the distributed load of the Gediz basin, it appears to be parallel to the overall Turkey. In the Gediz Basin, the spread TN burden from livestock activities is 3.150 tons/year and TP load is 272 tons/ ear. When the distribution in the settlements is considered, the districts with the highest nitrogen and phosphorus loads are Salihli with 411 tons/year TN and 40 tons/year TP, Akhisar with 258 tons/year TN and 26 tons/year TP and Kemalpaşa with 198 tons/year TN and 21 tons/year TP (Anonymous, 2017). This study was carried out in 4 provinces (Manisa, İzmir, Uşak ve Kütahya) in the Gediz basin. It is aimed to determinate the areas where animal waste-based biogas plants can be made also it is a known fact that the non-assessed animal wastes cause effective pollution of water resources.

Gediz Basin is located in the Aegean region of western Turkey. It empties the waters into the Aegean Sea through Gediz and its tributaries and covers the area between the North Aegean, Susurluk and Küçük Menderes Basins. The basin is geographically located between 38^{0} 04'39''. 13 north latitude and 26_{o} 42'29''. 45 'east longitude (Figure 1.).

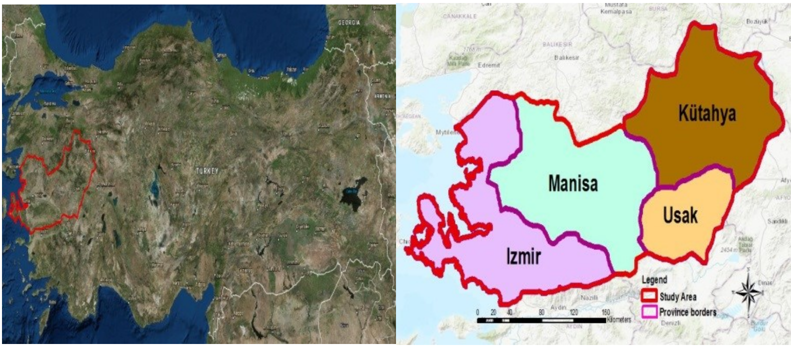


Figure 1. Map of Turkey and the Study Area

As mentioned above, the study was carried out in the Gediz basin and it covered four provinces (Manisa, İzmir, Uşak ve Kütahya) (Fig.1). The areas suitable for biogas energy production and the obtainable biogas energy amounts in the study area were examined. Furthermore, the number of animals in the region and the amount of animal waste and biogas were determined. The number of cattle in four provinces and their districts was taken from the Turkish Statistical Institute in 2018 and the literature data for the Gediz Basin (Anonymous, 2018b). In this study, Geographic Information Systems (GIS) were used to find cattle and animal waste and biogas amounts in the provinces and districts of the Gediz basin. GIS technologies are applications useful for capturing, storing, manipulating, analyzing, managing, and presenting all types of spatial and environmental data that are associated with them (Glass, 2001). For this purpose, all the related places of the basin were digitized in the GIS environment as a polygon first within the limits of the province and then the district boundaries. The UTM map projection and WGS 84 datum are selected as a reference system and all maps and data were transferred to the chosen projection and datum by using ArcMap 10.3 software (ESRI, 2010).

In order to make an examination of each province independently of other provinces, all boundaries were divided on the basis of the provinces as a separate layer. Similarly, the districts of each province were divided in the form of district boundaries as a separate layer. The database was prepared for each feature by entering the number of cattle.

For this purpose, these places were digitized in the setting of GIS as polygons based first on province borders and then district borders. ArcMap 10.3 software was used for this purpose. The topographic base map within the said software was used. Since the program works based on layers, any qualification obtained was considered as a layer. First, the borders of the study area were digitized by making geographical corrections. The whole boundary was divided into a separate layer on the basis of the provinces in order the inquiries for each province to be carried out independently of other provinces (ESRI, 2010).

Similarly, the districts of each province were divided into separate layers based on the borders of the districts. Evaluating the present bedding materials and identifying the water resources of the region, they were digitized as a separate layer.

In this study, the areas suitable for establishing biogas units were determined and shown on the maps created. The animal waste and biogas amount were determined on the basis of the districts by benefiting from the present cattle number for 2018 (Anonymous, 2018b). According to Hill (1982) and Ekinci et al. (2010), it is very important to determine the capacity before projecting biogas facilities. The calculation of biogas production quantities was performed taking into account the use of whole manure produced in the study area. For the calculation of the amount of manure, an average amount of 43 kg·day-1 of manure obtained from mature cattle can be taken as a basis. While producing the prediction map of the study area, the districts with cattle between 0 and 1000 heads were determined to be the areas not potential for biogas and coloured in orange ( ), and the districts with cattle between 1000 and 10000 heads were determined to be potential biogas production areas and coloured in yellow ( ). Again, the districts with more than 10000 heads of cattle were determined to be high-potential biogas production areas and coloured in green ( ). The prediction map of the suitable biogas production areas of the study area was created in relation to these animal numbers. The number of cattle in 2018 was evaluated within 3 layers and shown on the map of the basin with different colouring (Table 1).

Table 1. Representation of the cattle number on the study area map

Cattle Number in Enterprises	Display Colour on the Map
1-1.000	
1.000-10.000	
10.000-10.000+	

RESULTS AND DISCUSSION

The study area is located in the Aegean Region. It is seen as a more suitable area for livestock enterprises due to the climatic conditions in the inner parts of the basin (Uşak and Kütahya) where the potential areas of irrigated agriculture and fruit growing are located. In addition, there are facilities for processing animal products (leather, clothing) in Uşak. The tourism potential of the region is concentrated especially in the coastal areas and there are no livestock farms in these areas. The livestock enterprises, which are mostly located in the inner regions, continue their activities as an income generating agricultural arm. Both the difficulties in labor costs and the financial problems caused by cattle breeding indicate that the last 5 years of livestock potential in this region has decreased (Figure 2.).

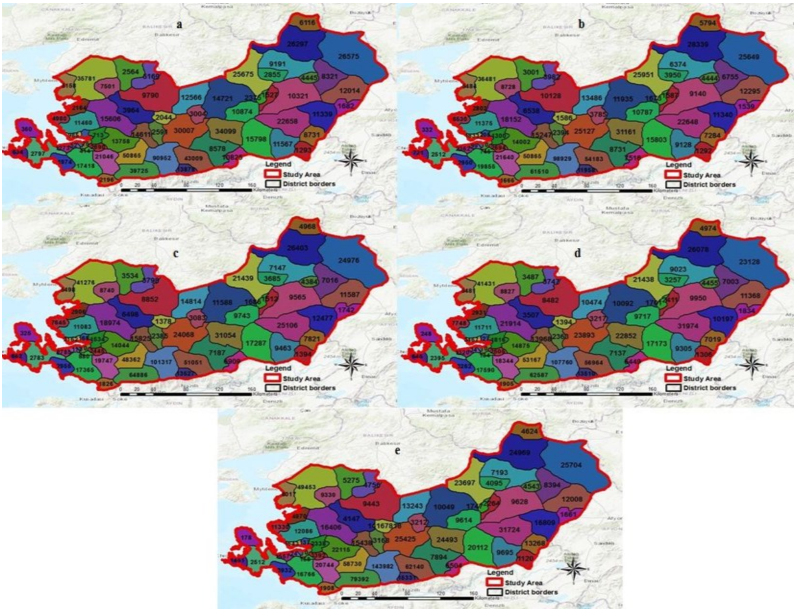
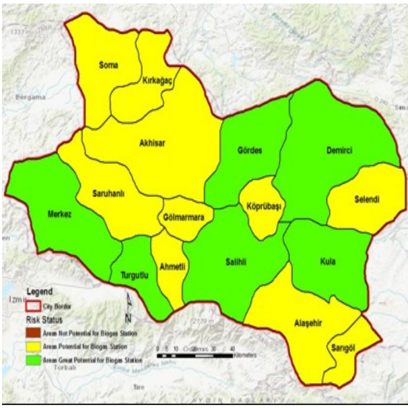


Figure 2. General view of the study area, according to the number of cattle (a. 2013, b. 2014, c. 2015, d. 2016, e. 2017)

When the provinces included in the study were compared, it was observed that Manisa has an important place in the research area both as a territory and as animal presence. It is observed that animal husbandry is an important activity in the villages of Manisa, especially in the villages close to water resources. It is seen that the enterprises in the region do not carry their manure and wastes for storage purposes, they do not give importance to storage structures and they are not very sensitive about the environment (Figure 3.). In the province of Manisa, 10 out of 16 districts were found to be partially suitable areas for setting up a biogas plant. In addition, the total number of cattle in 6 districts determined to be suitable for biogas plant is sufficient to establish a biogas plant, especially in this area. State-owned enterprises or enterprises in the form of cooperatives belonging to the village legal entity in certain areas can have a significant effect on energy acquisition in the region where cooperatives are widely practiced. According to 2018 renewable energy sources list, there is a geothermal power plant in Manisa province. According to the data for 2018 across Turkey there are 86 biomass sourced energy facilities. These facilities' resources are plant, animal wastes and waste disposal. In this context, it is thought that biomass energy potential of Manisa province could be improved. Biomass energy facilities that can be established in Soma, Ahmetli, Alaşehir and Gördes districts in Manisa province or in the villages of these districts can serve the whole of the province. In addition, the remaining pulp after obtaining the biogas energy can also benefit in agricultural fertilization. The main water sources of Manisa province are Gediz River and Bakırçay which are passing near Kırkağaç and Soma. The Gediz River flows into the Aegean Sea after passing the plains of Salihli, Turgutlu, Manisa and Menemen. Most of the rivers in the province of Manisa collect in the Gediz basin and only a small part of them are collected in the Aegean basin. It is foreseen that environmental pollution caused by manure can be prevented in the case of the establishment of biogas plants in Manisa province. In addition, businesses in the countryside close to the Gediz River, but far from the center, spread the manure to the surrounding land. Manure and waste streams in these areas are spread to the environment together with precipitation. Especially in the summer they show themselves with odors and directly or indirectly pathogens (malaria, dysentery, amoebic).



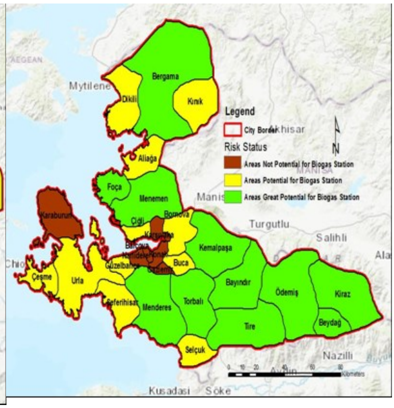


Figure 3. Figure 4.

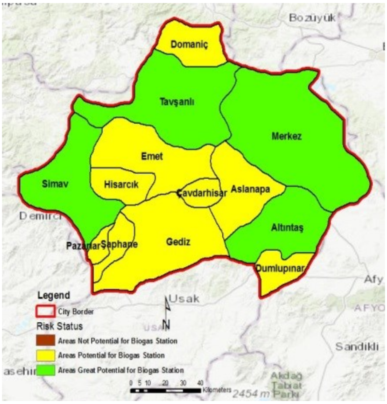
Figure 3. Potential Biogas Energy Fields in Manisa province for 2017

Figure 4. Potential Biogas Energy Fields in İzmir province for 2017

It is seen that İzmir province is second in the basin both as a field and as animal presence. İzmir has integrated meat facilities and it is one of the most important cities of the region with its export potential. According to the data of 2013, there are 373210 cattle in İzmir province and according to 2017 data the number of cattle in the province is 534018. The total number of cattle in the region has increased by 69.89% in the last 5 years. In Izmir there are energy facilities that use renewable energy sources. These facilities produce hydraulic, geothermal and wind energy. In case of establishing energy from biomass in İzmir, it will be appropriate to prefer internal regions. In the whole province, coastal areas are not preferred for livestock because of the tourism activities in these regions (Işın, E.O., (2018). Livestock enterprises are more preferred in domestic areas (Figure 4.). Renewable energy potentials of the province, where agriculture and industry integration can be made, can be increased with biomass plants. Suitable locations for biogas stations in Izmir are shown in Figure 4.

While Gediz River was the first cause of pollution in İzmir Gulf, after the river bed was changed, increasing industrialization and urbanization were the sources of pollution in the Gulf (Turgay, 2017). The Gediz River, which is considered to be the most important source of water in the Aegean region, passes through the entire basin as it flows into the Aegean Sea and the basin is therefore exposed to both diffuse and spot pollution. For this reason, it is very important to protect the Gediz river from point origin animal or industrial pollution. In the study area, establishment of biogas plants in the region or encouraging them within the scope of incentives is required.

The province of Kütahya is located in the Gediz Basin and the name of the Gediz River comes from this province. The Gediz river is the second largest in the region after the Büyük Menderes River, and it is borned from the Murat Mountain of Gediz district and is meets the sea in the Menemen district of Izmir province. The river is 401 km long and passes through the Gediz basin. The fact that Kütahya is located in the inner region causes it to be preferred in terms of cattle breeding. In addition, the province of Kütahya is very important as it is necessary to take into account the source and pollution of the Gediz River. The potential biogas areas of the province are shown in Figure 5. Simav, Central, Tavşanlı and Altıntaş districts and affiliated villages were determined as suitable locations for biogas stations. The other districts and their villages are partially suitable. Especially in areas where the Gediz River passes, livestock enterprises should be installed very carefully and the pollution caused by water should be prevented at its source. In addition, since the province of Afyon locates in the east of Kütahya and the province is very developed in terms of animal husbandry, the biogas plants that can be established here will be at the level of service to the whole region. Since the province has a border with Kütahya province, cattle manure may be redirected to Afyon province rather than establishing a new biogas plant.



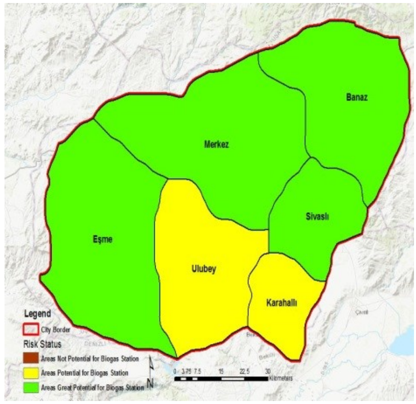


Figure 5. Figure 6.

Figure 5. Potential Biogas Energy Fields in Kutahya province for 2017

Figure 6. Potential Biogas Energy Fields in Usak province for 2017

Uşak province is highly developed in terms of animal husbandry and it is particularly strong in terms of processing animal products t and present them to the market. However, both pollutants originating from leather processing plants and animal manure are considered as a continuous source of pollution. Especially in the local press, pollution-related news are frequently included. According to Anonymous (2017), water, soil and air are polluted in Usak province due to insufficient and occasionally unworked treatment facilities. It is stated that the pollution caused by industrial wastes continues to contaminate Ulubey Canyon and the wastes of Usak Combined Leather Organized Industrial Zone were left to Dokuzsele Creek without any processing. It is seen that the province is suitable for the biogas plant, especially if it is established in Ulubey district and its related villages, pollution will be prevented and economic benefit will be provided (Figure 6.).

CONCLUSION

In this study, the cattle potential of 4 provinces in Gediz basin was evaluated and mapped with Geographic Information Systems (GIS). The appropriate biogas production sites were trying to be determined in the study area for the years 2013-2017, using the ARCMAP 10.3 software. In the determination of these areas, potential biogas energy obtained from cattle manure and wastes is taken into consideration. Reducing the pollutant effect to Gediz basin and especially water resources are considered as a secondary benefit. In this context the given number of cattle and their wet manure production values are used. As a result, the regions, where the number of cattle is high, are identified as the areas suitable for potential biogas production. In addition, the amounts of biogas energy per year 2013-2017 are calculated from the existing cattle numbers in these years, in the Gediz Region.

Nowadays, energy is one of the basic needs of societies. Obtaining energy from available facilities and especially to benefit from renewable energy is very popular issues today.

According to the results of the study, Gediz basin is very important both in terms of biogas energy potential and environmental pollution. There are 1 large capacity biogas plant and 1 composting facility in İzmir province. Other than that, animal wastes are not stored properly in the districts and villages.

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SOME GEOPHYTES OF IBRADI (ANTALYA) FOREST PLANNING UNIT

Mustafa KARAKÖSE [1]

[1] Dr. Lec. Giresun University, Espiye Vocational School, Giresun, TURKEY.

Introduction

Turkey, due to its location, is one of plant biodiversity centre in the world (Terzioğlu et al. 2009). Of the 374000 (Christenhusz and Byng 2016) plant taxa accepted in the world, 12816 (4040 endemic plant taxa) plant taxa are found within our country (Güner et al. 2012; Özhatay et al. 2013; 2015; 2017). Geophytes are an important part of these beauties. The Danish botanist Raunkiaer (1934) first used the term geophyte. Raunkiaer prepared a plant classification system based on the location of dormant buds in relation to growth habit and location relative to the ground. Geophyte (*hidden plants*) is the name given to herbs, which stay dormant underground for the large part of the year and have specialised food-storing underground-metamorphosed stems such as bulbs, corms, rhizomes and tubers (Ekim et al. 1991). For the development of metamorphosed stems of geophytes, hot and dry weather in summer and cold and snowy weather in winter are unfavourable periods. These plants pass these unfavourable months underground as dormant (Koyuncu 1994). Dormancy is a common adaptation in plant taxa subjected to unfavourable season in some species containing lots of geophytes (i. e. Alliaceae, Orchidaceae, İridaceae, Liliaceae) exposed to semi-arid Mediterranean climates (Volaire and Norton 2006). Therefore, Geophytes are mostly found in spring and autumn. Geophytes are found in almost all parts of the world, but most of them originate in the Mediterranean basin (Ekim and Koyuncu 1991). Anatolia is one of the major geophyte centres, with about 2500 taxa (including such as Pteridophyta section, Ranunculaceae, Liliaceae, Amarylidaceae, Iridaceae, Orchidaceae, Araceae) distributing naturally (Demir and Eker 2015).

The Mediterranean basin has arid and semi-arid climatic conditions. Ecosystems in these regions are quite fragile with their extreme climatic conditions, which have low precipitation, high temperatures and evaporation rates (Çalışkan and Boydak 2017). Today, with the global warming, the habitats of geophytes have become a more important issue. Urbanization, improper land use, overgrazing and collection put these habitats in danger. Conservation of these areas is necessary (Özhatay et al. 2013). Geophytes; in the Netherlands, Germany, England, the United States, and in return, exports to our country every year about $ 2-2.5 million in foreign exchange (Özhatay et al. 1997). Among the countries that export flower bulbs, our country has an important place. However, this contribution to the economy, rather than production is carried out by removing the mostly from natural habitats. This poses a great risk for the future of nature and plant biodiversity.

In Turkey, the export of geophyte plants goes back to 15th century with Tulip's bulbs (Ekim et al. 1992). These exports were made with geophytes from the natural habitats until the 1980s (Ekim et al. 1997). From this date, Turkey has decided to take some protective measures. By the government of Turkey, were adopted in rules of Biodiversity Conservation, CITES and Bern, in 1992, 1996. After that, in 2004, regulation on collection, production and marketing of natural flower bulbs was accepted in order to prevent and protect against damage to bulbous plants. The collection amounts of plants mentioned in this regulation are updated every year. Although this regulation seeks to control, prohibit and limit the export of many species, sufficient results cannot be obtained. In addition to this, a geophyte garden was opened to make *ex-situ* conservation and horticulture at Yalova city, in 2014 (Kaya 2014). In the garden, there are 100.000 geophyte samples belonging to 850 plant taxa.

On the other hands, geophytes have been an important symbol of Anatolian culture from past to present. Due to various use areas (daily routine, food, medicine, horticulture) of geophytes, they are important plant groups in terms of economically and traditionally. Geophytes are important as plants that have many characteristics such as flowering in winter and early spring, having aesthetic and decorative values and gaining attraction to parks and gardens in landscaping arrangements (Ekim et al. 1991). Among the geophytes, tulip is the prominent species in the Anatolian culture. Tulip was a mythical ornamental flower during the Great Seljuk Empire, Anatolian Seljuk Empire and Ottoman Empire. Tulip is the most used prevalent figure in miniatures, carpets, wall tiles, and the works of poets as well. Many geophytes were often seen in the gardens of the Ottoman Empire. As is known, many species of tulips were transferred from Turkey to Europe. The beginning of the 18th century was known as the *Tulip Era* of the Ottoman Empire (Baktır 2013).

One of the most important features of geophytes is that they are used in the medical field because of the active substances they contain. Some geophytes belonging to the genus such as *Galanthus, Anemone, Ornithogalum, Ruscus, Colchicum, Iris, Orchis, Ophrys and Cyclamen* are used as medicinal and aromatic plants in medicine and beekeeping. The rhizomes of *Ruscus aculeatus* are used as a diuretic and antipyretic agent because of its essential oils and saponin alkaloids (Baytop, 1999). Geophytes occur as part of the daily life of the Anatolian people. In Anatolia, mostly rural areas, most of geophytes are the part of the eating habits. Bulbs, flowers, seeds and leaves are often preferred in the construction of food, sahlep, pickles and cheese. Another example in traditional routine; *Colchicum speciosum* (called as *Vargit* in Turkish) is an autumn plant distributed in the Black Sea Region. This geophyte is the harbinger of the winter season. Local people start to prepare for migration from pastures to city with the appearance of this plant.

Material and Method

The material of the study consists of geophyte plants obtained from field studies conducted between the years of 2008-2009. Geophytes were collected from the research area within the vegetation period in accordance with the plant collection rules. The location of the specimens collected during the field studies, the characteristics of the habitat, altitudes and collection dates were recorded. These plants were identified using the Flora of Turkey and the East Aegean Islands (Davis, 1965-85; Davis et al. 1988; Güner et al. 2000). Scientific names of geophytes were checked according to Turkish Plant List (Güner et al. 2012). The usage areas and the organs of the species were determined by using previous studies (Çakır 2017; Kayıran and Özkan, 2017; Korkmaz and İlhan 2015; Mükemre et al. 2015; Korkmaz et al. 2014; Ertuğ 2014; Sargın et al. 2013; Koçak and Özhatay, 2013; Seyidoğlu et al. 2009; Ertuğ 2004; Baytop 1999; Yeşilyurt et al. 2017; Uysal et al. 2010; Bokov 2019; Mükemre et al. 2016; Tuzlacı and Doğan 2010).

Results

In this study, 49 geophytes, which belong to Pteridophyta and Spermatophyta sections, were identified. Of the 49 geophytes, 36 geophytes were introduced, and habitat features, parts used and use purposes were given as well (Table).

Table: Some geophytes of the İbradı Forest Planning Unit

	*Ranunculus ficaria* L. subsp. *ficariiformis* Rouy & Foucaud (Ranunculaceae) Description: Herbaceous perennial with tuberous plant and reaching a height of 20-cm. Rosette leaves ovate-orbicular-deltoid in shaped. Bulbils absent in the leaf axils. Petals yellow coloured. Flowering time: March-April Habitat: Hillsides, field margins, stream edges, 1-800 m Used part: Tuber Uses: Wound, haemorrhoids, eczema

Gagea peduncularis (C.Presl) Pascher (Liliaceae)

Description: Bulbous plant with a blackish-brown tunic. New bulb forms
Near the old one. Basal leaves 2 (-3), linear, glabrous. Perianth segments yellow, narrowly ovate or oblanseolate.

Flowering time: February-April

Habitat: Limestone rocks, *Pinus* forests, 10-1300 m

Used part: Bulb

Uses: Ornamental

Romulea bulbocodium var. *crocea* (Boiss. & Heldr.) Baker (Iridaceae)
Description: Herbaceous, perennial plant. Corm asymmetrical, tunic brown. Leaves up to 7 and scape 1-6 flowered. Perianth segments yellow.

Flowering time: February-June

Habitat: Rocky, sandy places, 0-900 m

Used part: Corm

Uses: Ornamental, food

Muscari armeniacum Leichtlin ex Baker (Asparagaceae)

Description: Perennial bulbous plant leaves 3-5, linear-lanceolate, scape up to 40 cm, perianth segments pale blue with white lobed.

Flowering time: March-May

Habitat: Forest, macchie, open areas, 02750 m

Used part: Bulb, flower

Uses: Ornamental, dye, nectarious, cosmetology food wound healing

Muscari aucheri (Boiss.) Baker (Asparagaceae) - Endemic

Description: Perennial bulbous plant, leaves 2-3, oblanceolate, scape up to 30 cm, perianth segments pale blue with white lobed.

Flowering time: April-June

Habitat: Stony slopes, limestone scree, 1000-3000 m

Used part: Bulb

Uses: Ornamental

Bellevalia clusiana Griseb. (Asparagaceae) - Endemic

Description: Perennial bulbous plant, leaves 3-4, oblanceolate exceeding inflorescence, scape up to 35 cm, perianth brownish with pale green lobes.

Flowering time: April-May

Habitat: Marshy ground, fallow fields, 880-1200 m

Used part: Bulb, leaves

Uses: Food

Fritillaria pinardii Boiss. (Liliaceae)

Description: Perennial plant with 3 cm diameter bulb. Stem up to 20 cm, leaves 3-8, glaucous, widely lanceolate, flowers 1-2, purplish outside, yellowish-orange inside.

Flowering time: April-June

Habitat: Rocky hillsides, steppe, 1000-2500 m

Used part: Bulb

Uses: Ornamental, food, wound healing

Fritillaria elwesii Boiss. (Liliaceae)

Description: Perennial plant with 3 cm diameter bulb. Stem up to 30 cm, leaves 4-6, linear, flowers 1-4, brownish-purple.

Flowering time: March-May

Habitat: *Pinus brutia* edges, macchie, 10-1200 m

Used part: Bulb

Uses: Ornamental

Fritillaria whittallii Baker (Liliaceae) -Endemic

Description: Perennial bulbous plant, stem 10-20 cm, leaves 6-7 linear to lanceolate.

Flowering time: April-June

Habitat: *Cedrus libani* forest, 1500-2000 m

Used part: Bulb

Uses: Ornamental

Ornithogalum oligophyllum E.D.Clarke (Asparagaceae)

Description: Perennial bulbous plant, stem 4-15 cm, leaves 2-3, broadening to upwards. Raceme cylindrical with 25-75 flowers.

Flowering time: April-July

Habitat: Grassy and rocky slope, 700-3000 m

Used part: Bulb, leaves, shoot

Uses: Food

Ornithogalum umbellatum L. (Asparagaceae)

Description: Perennial bulbous plant, stem 30 cm, leaves linear and exceeding scape. Raceme corymbose with 6-20 flowers.

Flowering time: March-May

Habitat: Field, water meadow, scrub, 1-1500 m

Used part: Bulb, leaves

Uses: Food, acne, burn

Ornithogalum nutans L. (Asparagaceae)

Description: Perennial bulbous plant, stem 60 cm, leaves several, linear and as long as with scape. Raceme cylindrical with 9-15 flowers.

Flowering time: March-May

Habitat: Slope, field, roadside, meadows, 1-1950 m

Used part: Bulb

Uses: Ornamental

Corydalis erdelii Zucc. (Papaveraceae)

Description: Perennial tuberous plant, stem erect and up to 12 cm, leaves opposite, biternate, infloresence 1-7 flowered, flowers pink.

Flowering time: April-July

Habitat: Stony slopes, 1300-2800 m

Used part: Whole

Uses: Ornamental

Corydalis wendelboi subsp. *wendelboi* Lidén (Papaveraceae) - Endemic

Description: Perennial tuberous plant stems ascending with scale-leaf, leaves alternate and biternate, corolla whitish-purple.

Flowering time: April-June

Habitat: Scrub, Cedrus forest, 900-2000 m

Used part: Whole

Uses: Ornamental

Galanthus elwesii var. *elwesii* Hook.f. (Amaryllidaceae)

Description: Perennial bulbous scapose plant, leaves narrowly oblanceolate, scape up to 28 cm, outer perianth segment convex, inner flat.

Flowering time: February-April

Habitat: Pinus, Juniperus forest, phrygana, 900-1800 m

Used part: Tuber

Uses: Ornamental, abscess

Crocus chrysanthus (Herb.) Herb. (Iridaceae)

Description: Perennial plant with corm. Corm tunic membranous splitting at base, leaves 3-6, perianth segments yellow.

Flowering time: February-April

Habitat: Open hillsides, *Cedrus* forest, 1-2200 m

Used part: Corm

Uses: Food, ornamental

Crocus biflorus subsp. *isauricus* (Siehe ex Bowles) B.Mathew (Iridaceae) Endemic

Description: Corm tunic membranous or coriaceous, entire or toothed rings at base, leaves 4-7, perianth segments white-lilac.

Flowering time: February-June

Habitat: Conifer forest, rocky slopes, scrub, alpine, 200-3000 m

Used part: Corm

Uses: Food, ornamental

	*Crocus danfordiae* subsp. *danfordiae* Maw (Iridaceae)-Endemic Description: Perennial plant with corm. Corm tunic membranous splitting at base, leaves 3-7, perianth segments yellow or white. Flowering time: February-March Habitat: Cedrus, Pinus nigra forest, hillsides, scrub, 950-2000 m Used part: Corm Uses: Food, ornamental
	*Orchis simia* Lam. (Orchidaceae) Description: Perennial tuberous plant, stem up to 45 cm, with 3-5 oblong-lanceolate rosette leaves, spike ovoid to conical, labellum pinkish-purple with purple spots, 3-lobed; lateral lobes linear. Flowering time: April-May Habitat: Grassy hilldies, scrub, 1-1200 m Used part: Tuber Uses: Diabetes, cough, food

Orchis anatolica Boiss. (Orchidaceae)

Description: Perennial tuberous plant, stem up to 40 cm, with 2-4 linear rosette leaves, spike lax cylindrical 5-10 flowered, flowers rose-purple with purple dots, labellum ovate, 3-lobed.

Flowering time: March-May

Habitat: Pinus forest, macchie, 1-1650 m

Used part: Tuber

Uses: Food, ornamental

Dactylorhiza romana subsp. *romana* (Seb.) Soó (Orchidaceae)

Description: Perennial tuberous plant, up to 40 cm, mature tubers shortly lobed, linear leaves, spike cylindrical, flowers red, and labellum stretched forwards.

Flowering time: April-June

Habitat: Macchie, Quercus scrub, conifer, 1-2000 m

Used part: Tuber

Uses: Ornamental, food

Geranium tuberosum L. (Geraniaceae)

Description: Erect, perennial rhizomatous plant, up to 30 cm. Basal leaves palmatisect, stem pubescent, flowers pink, with 2 flowered peduncle.

Flowering time: April-June

Habitat: Stony slopes, fallow fields, 1-2500 m

Used part: Rhizome

Uses: Food, fodder, ornamental

Valeriana dioscoridis Sm. (Caprifoliaceae)

Description: Perennial rhizomatous herbaceous plant with simple stem. Basal leaves pinnate, 3-9 lobed, cauline leaves few, pinnate. Fragrant flowers pink coloured.

Flowering time: February-May

Habitat: Rocky slopes, scrub, 1-1500 m

Used part: Fresh stem

Uses: Food, digestive problems, nausea, liver problems

Doronicum orientale Hoffm. (Asteraceae)

Description: Perennial rhizomatous herbaceous plant, up to 60 cm in height. Basal leaves petiolate ovate-elliptic, cauline leaves sessile. Flowers yellow, peduncle glandular-hairy and pilose.

Flowering time: March-July

Habitat: Shady areas in forest and scrub, 50-1900 m

Used part: Flower, leaves

Uses: Fodder, infertility

Limodorum abortivum var. *abortivum* (L.) Sw. (Orchidaceae)

Description: Perennial rhizomatous saprophytic leafless plant, up to 80 cm in height. Stem thick, violet. Spike extended to 35 cm, flowers 4-25, violet. Hypochile whitish, epichile violet with dark lines.

Flowering time: May-July

Habitat: Coniferous and mixed forest, 350-2300 m

Used part:

Uses: Food, ornamental

Anemone blanda Schott & Kotschy (Ranunculaceae)

Description: Perennial tuberous plant, up to 25 cm, basal leaves trisect, flowers solitary, lavender-blue coloured.

Flowering time: March-April

Habitat: Rocky slopes, scrub, 150-2600 m

Used part: Tuber

Uses: Ornamental, diuretic, expectorant, food

Asplenium ceterach L. (Aspleniaceae)

Description: Perennial rhizomatous plant, up to 20 cm in height, leaves pinnatifid, sori linear, indusium absent.

Spores ripes in April

Habitat: Dry walls, limestone rocks, 10-1300 m

Used part: Leaves, spores

Uses: Diuretic, constipation, hemorrhoids

Ruscus aculeatus L. (Asparagaceae)

Description: Perennial rhizomatous evergreen plant, stem branched up to 50 cm in height, cladodes spinose, broadly ovate-acuminate, flowers adaxial.

Flowering time: February-May

Habitat: Quercus forest, limestone slope, 10-1000 m

Used part: Rhizome, fruit

Uses: Ornamental, food, diuretic, antipyretic, appetizer

Cephalanthera damasonium (Mill.) Druce (Orchidaceae)

Description: Perennial rhizomatous plant, up to 50 cm in height, leaves few, distant, lower ovate, upper oblong, spike 3-12 flowered, and flowers creamy-white.

Flowering time: May-July

Habitat: Decidous and coniferous forest in montane, 0-1800 m

Used part: Rhizome

Uses: Ornamental

	*Cephalanthera rubra* (L.) Rich. (Orchidaceae) Description: Perennial rhizomatous plant, up to 60 cm in height, stem leafy, pubescent above leaves linear 3-8, spike lax, and flowers bright rose. Flowering time: May-July Habitat: Pinus brutia, macchie, Quercus scrub, 0-2000 m Used part: Rhizome Uses: Ornamental
	*Cyclamen cilicium* Boiss. & Heldr. (Primulaceae) Description: Perennial tuberous plant, leaves showing up in autumn, corolla pale pink, lobes 15-18 mm. Flowering time: September-November Habitat: Pinus nigra, Abies forest, 700-2000 m Used part: Tuber Uses: Ornamental, food, fodder, laxative, emetic, stimulant, women disease

Dioscorea communis (L.) Caddick & Wilkin (Dioscoreaceae)

Description: Perennial tuberous climber plant, stem to 4 m, leaves alternate ovate-cordate-shaped, flowers greenish-yellow, berry red coloured.

Flowering time: April-June

Habitat: Shady riverside, Abies-Fagus forest, 20-1600 m

Used part: Tuber, leaves

Uses: Food, emetic, laxative, diuretic, wound healing, rheumatism

Smilax aspera L. (Smilacaceae)

Description: Perennial dioecious tuberous climber plant, stem usually woody, thorny below, leaves alternate rounded to cordate, hastate or sagittate base, flowers 1-6, berry red or black.

Flowering time: April-June

Habitat: Macchie, ravines, limestone slope, 50-700 m

Used part: Fresh shoots

Uses: Food, fodder

Eranthis hyemalis (L.) Salisb. (Ranunculaceae)

Description: Perennial rhizomatous herbaceous plant, up to 16 cm in height, basal leaves petiolate pinnate, cauline leaves sessile arranged verticillate, flowers solitary and yellow.

Flowering time: April-May

Habitat: Open areas, 1300-1800 m

Used part: Rhizome

Uses: Ornamental

Tulipa armena var. *armena* Boiss. (Liliaceae)

Description: Perennial bulbous herbaceous plant, tunic papery, leaves 3-4 mostly undulate, flowers crimson to scarlet.

Flowering time: April-June

Habitat: Rocky slopes, screes 1000-2750 m

Used part: Bulb

Uses: Ornamental

Gladiolus anatolicus (Boiss.) Stapf (Iridaceae)

Description: Glabrous perennial with symmetrical corm, up to 40 cm, tunic papery, leaves 3-4 wide, perianth segments mauve-purple.

Flowering time: March-May

Habitat: Macchie, Pinus brutia forests 1-1400 m

Used part: Tuber

Uses: Ornamental, food

Conclusion

Geophytes have economic importance due to usage in various industry sector such as medicine, floriculture, food, perfumery and cosmetic. However, due to several reasons such as over-picking, excessive pasturing, developments in tourism and transportation, industrialization and land conversion, geophytes are under pressure in their natural habitats. Especially underground organs, which have been removed for exportation, have been damaged commonly. Impact of humankind on natural habitats has increased distinctly and poses a dangerous threat to the natural balance of ecosystems during the recent years. The most damage has occurred in *Orchis* spp. for making sahlep in Turkey.

As a result, in order to protect the geophytes, necessary measures (conservation their habitats, *ex-situ* techniques, development of production methods, prevention of bio smuggling, educational activities to increase public awareness) should be taken and economically high value-added products should be produced.

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DETERMINATION OF BIOGAS PLANT LOCATION BY CLUSTERING METHOD

Onur İNAN [1], Kazım KUMAŞ [2],
Hasan Hüseyin AKSU[3], Afşin GÜNGÖR[4]

1 Öğr. Gör., Burdur Mehmet Akif Ersoy University, Bucak Emin Gulmez Vocational School of Technical Sciences, Burdur, Turkey.
2 Öğr. Gör., Burdur Mehmet Akif Ersoy University, Bucak Emin Gulmez Vocational School of Technical Sciences, Burdur, Turkey.
3 Dr. Öğr. Üyesi., Burdur Mehmet Akif Ersoy University, Bucak Emin Gulmez Vocational School of Technical Sciences, Burdur, Turkey.
4 Prof. Dr., Burdur Mehmet Akif Ersoy University, Bucak Technology Faculty, Burdur, Turkey. - (Akdeniz University, Engineering Faculty, Antalya,Turkey).

Introduction

The fact that the fossil energy resources, which are used extensively in meeting the energy needs of the world, cannot meet the energy needs in the coming years has accelerated the opening of renewable energy resources for use [1]. The amount of waste generated and the energy requirement in proportion to the increase in the population increase continuously. The use of fossil fuels to cause air pollution, acid rain and global warming, and the depletion of this type of fuel in the near future has increased the interest in alternative energy sources [2].

Biogas production from organic wastes has great importance in alternative energy sources. With the use of organic wastes in the production of biogas, an effective waste management will be carried out both in the production of energy from waste and in waste disposal [3]. The use of fossil resources and the amount of waste will be reduced by the development of technologies used to generate energy from waste. However, the leachate formed by the degradation of the storage areas will be prevented from contaminating the surface and groundwater. In addition, environmental problems such as the emission of hazardous gases to the atmosphere will be minimized. Biomethanation technology is a good alternative in the evaluation of the organic fraction in the waste [4]. Thanks to biomethanation and composting methods for the recovery of animal and similar organic wastes, an important step will be taken in reducing waste amount and preventing soil, air and water pollution.

Biogas energy, which has a wide usage area, has an important place in heat and electricity production as well as to prevent climate change. In addition, soil fertilizers as a result of increasing biogas productivity are gaining importance. While the production of energy crops contributes to regional development and rural development, biogas production contributes to the economy thanks to the marketing of the product obtained as a result of collecting and processing the waste. Moreover, its use in fuel oil makes biogas production attractive [5].

Depending on Turkey Statistical Institute TUIK data Onurbaş and Türker determined by utilizing the number of chicken in the year 2009 is estimated to be 390 million m^3 of biogas potential [6]. Altıkat and Çalık specified the annual biogas energy potential for animal waste originating from Iğdır province is estimated to be 21.441 million m^3 [7]. In their study, Koçer and Kurt have determined the average thermal value of biomass in Malatya in a year. As a result, in the case that animal manure is used in biogas production facilities, 87.645 m^3 / day biogas production can be done [8]. Zan Sancak et al, in their study, have investigated the production of biogas in Turkey with the number of animals in general. In Turkey, in case of use in biogas plants of cattle manure 2.533.487.544 m^3 / year biogas production and this production can be made with the 11.9 billion kWh of electricity can be obtained [9]. According to the data of TUIK, Yürük and Erdoğmuş, in their study, have calculated the biogas potential from animal wastes in Düzce and its districts and divided these facilities into clusters by K-means clustering. When the cluster K is clustered with a single cluster and all facilities are considered, the sum of the Euclide distances determines the closest plant location to all facilities [10]. In the study conducted to determine the biogas potential in Çanakkale, Ilgar calculated the amount of fertilizers of these animals by using the number of cattle, sheep and poultry and showed a total of 96.934.753 m^3 of biogas could be obtained annually [11]. In this study, it was aimed to determine the biogas potential obtained from cattle, sheep and poultry manure of Gümüşhane city center and districts and to determine the most suitable plant location by K-means clustering method. In this respect, the biogas potential and the most suitable plant location which can be obtained from animal fertilizers based on the data on the number of cattle, sheep and poultry obtained from TUIK in Gümüşhane province in 2018 have been determined.

K-Means Clustering Method

Clustering is the process of separating pieces of data that are similar to each other. By combining similar elements in the same cluster, homogeneity in clusters and heterogeneity between clusters are ensured. Therefore, elements closer to each other in space will be located in the same cluster.

The clustering algorithm required is selected depending on the intended use and data type. Major clustering algorithms are classified as partitioning, hierarchical, density-based, grid-based and model-based [12]. In addition to this, the distance criteria such as Minkowski, Euclide, Pearson, Manhattan and Canberra are used to calculate the distances between the elements [13].

In clustering process, while the elements in the cluster are very close to each other, the distance between the clusters is too high. In such problems, partitioning algorithms are preferred. One of the unsupervised learning methods, the K-means algorithm, is a sharp clustering partition algorithm that allows each data to belong to only one set [14]. Via K-means algorithm, a data set consisting of n data items is divided into a number of k input parameters. In this way, it is ensured that the intra-cluster similarities are maximized and the similarities between the clusters are minimum. While running the algorithm, the clusters are continuously renewed and the cycle continues until the optimal solution is reached [15].

The performance of the algorithm is determined by the number of k clusters, the values of the initial cluster centers and the criteria for similarity measurement. As a result of the determination of these criteria, it is tried to obtain the k number of cluster as intensively and separately as possible. Algorithm tries to determine the k number of piece to reduce the squared-error function. As a result, the K-means algorithm divides the data set consisting of n pieces of data into k number of clusters by means of the k parameter given by the user [16].

K-means clustering method is evaluated mostly with squared error criterion SSE. Clustering with the lowest SSE gives the best result. With SSE, the sum of the squares of the distances of the elements to the center points of the cluster is calculated. Squared Error function is calculated as follows:

$$SSE = \sum_{i=1}^{K} \sum_{x \in C_i} dist^2 \left(m_i, x \right) \tag{1}$$

where x is an element of C_i cluster and m_i is indicating the center point of C_i cluster.

The process steps of the K-means algorithm are as follows:

I. Assigning cluster centers by selecting the random number of elements with the number of sets among the items or by determining the center points by taking the average of all items
II. Calculating the distance of each item from the selected center points, all items are placed in the cluster closest to them
III. The new center points of the resulting clusters are replaced by the average value of all items in that set
IV. Finally, steps 2 and 3 are repeated until the center points remain fixed user [17].

Material and Method

In this study, cattle, sheep and poultry number data of Gümüşhane province in 2018 obtained from TUIK have been used. By TUIK Cattle are classified as domestic, buffalo culture and hybrid cattle. On the other hand, sheep are classified as merino, domestic sheep, hair and Angora goat. Finally, in the scope of poultry, eggs and meat chicken, duck, turkey and goose are located [18]. According to the data of TUIK in 2018, the number of cattle, sheep and poultry in Gümüşhane province center and districts is given in Table 1.

Table 1. Number of animals in the center and districts of Gümüşhane province

Location	**Cattle**	**Sheep**	**Poultry**
Merkez	8650	10631	78206
Kelkit	33450	10849	9095
Köse	6738	1560	4992
Kürtün	8503	1896	751
Torul	8000	3283	3009
Şiran	16861	9120	11630
Total	**82202**	**37339**	**107683**

The amount of fertilizers obtained from animals varies according to the type of animals. Accordingly, the following method was used to determine the amount of fertilizer and biogas [19].

- From 1 cattle 3,6 tons / year wet fertilizer,
- From 1 sheep 0,7 tons / year wet fertilizer,
- From 1 poultry 0,022 tons / year wet fertilizer on average is assumed to be obtained.

Based on these values, the amounts of biogas are determined as follows:

- From a ton of cattle manure 33 m^3/year biogas,
- From a ton of sheep manure 58 m^3/ year biogas,
- From a ton of poultry manure 78m^3/ year biogas production results could be reached.

Research and Results

According to 2018 TUIK data there are 227224 animals in total in Gümüşhane province. The distribution of animal numbers is given in Table 1 in detail on a district basis. Total animal stock in Gümüşhane province is composed of %47.39 poultry, %36.18 of cattle and %16.43 of sheep. The percentage distribution of total animal numbers by districts is Central District 42.9%, Kelkit 23.5%, Köse 5.85%, Kürtün 4.91%, Torul 6.29% and Şiran 16.55%.

Considering the animal types of districts of Gümüşhane, the amount of wet manure and biogas production according to the number of animals has been calculated. The calculated values are detailed in Table 2.

Table 2. Amount of animal waste and biogas production in central district and districts of Gümüşhane

Location	Animal Type	Number of Animal	Amount of Fertilizer (tons/year)	Amount of Biogas (m^3/year)	Amount of Total Biogas (m^3/year)
Central District	Cattle	8650	31140	1027620	1593439,94
	Sheep	10631	7441,7	431618,6	
	Poultry	78206	1720,53	134201,34	
Kelkit	Cattle	33450	120420	3973860	4429936,42
	Sheep	10849	7594,3	440469,4	
	Poultry	9095	200,09	15607,02	
Köse	Cattle	6738	24256,8	800474,4	872376,36
	Sheep	1560	1092	63336	
	Poultry	4992	109,82	8565,96	
Kürtün	Cattle	8503	30610,8	1010156,4	1088422,56
	Sheep	1896	1327,2	76977,6	
	Poultry	751	16,52	1288,56	
Torul	Cattle	8000	28800	950400	1088852,62
	Sheep	3283	2298,1	133289,8	
	Poultry	3009	66,19	5162,82	
Şiran	Cattle	16861	60699,6	2003086,8	2392852,56
	Sheep	9120	6384	370272	
	Poultry	11630	249,92	19493,76	

According to Table2, a total of 324427.57 tons of fertilizer is obtained annually from 227224 animals. 324427,57 tons of animal waste distribution according to the type of animal is 91.22% cattle, 8.06% sheep and 0.73% poultry. The percentage distribution of animal waste on the basis of districts are %12.42 central district, %39.52 Kelkit, %7.85 Köse, %9.85 Kürtün, %9.61 Torul, %20.75 Şiran. The total amount of biogas achieved from animal waste in Gümüşhane province is 11465880 m^3 per year. The majority of the annual biogas value is obtained from Kelkit, Şiran and central district. This study, which was conducted to determine the biogas potential that can be produced from animal wastes, shows that there is an important biogas potential achieved from cattle waste in Gümüşhane province.

Determining Most Appropriate Plant Locations by K-Means Clustering

The location of 150 facilities for Gümüşhane province was determined. In case of establishing a model for the detection of the facility closest to these positions, a problem with 150 variables occurs. The practical solution of the problem is very difficult in terms of working time. For this reason, it is aimed to find the most suitable positions by K-means clustering.

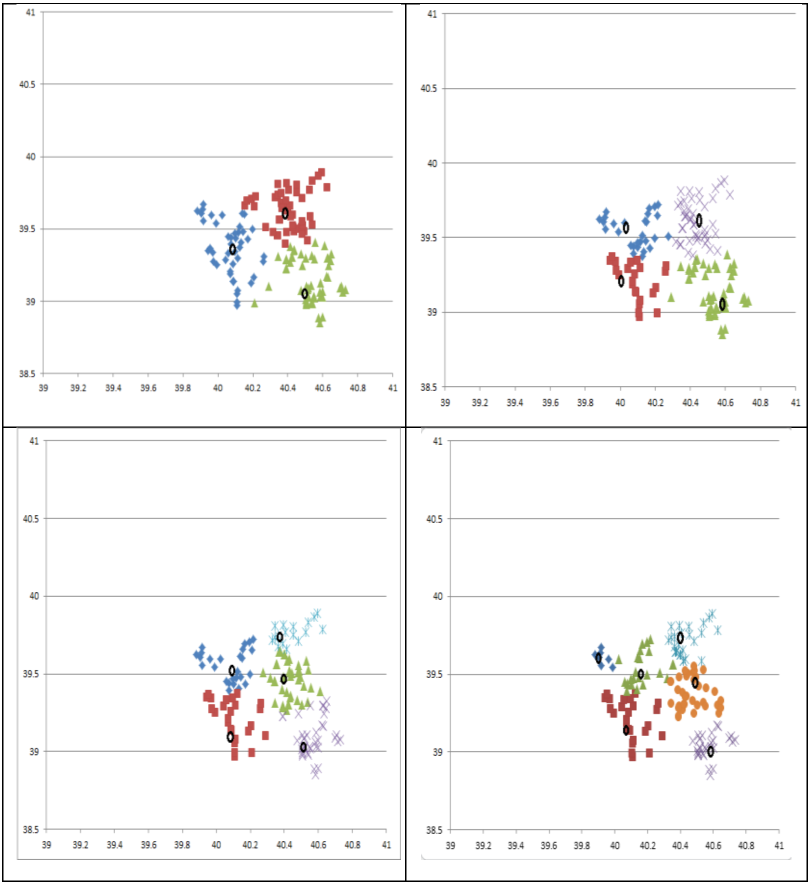

Fig. 1. Clusters obtained by K-means algorithm from the top left

k = 3, 4, 5 and 6 respectively.

Using this coordinate information, k=3, 4, 5 and 6 values were taken for cluster number and 200 iteration were used for each clustering. The following sets and mean set values were obtained respectively in Fig. 1 and Table 3.

It is seen that there are more or less the same location has been found in these four different classifications. This location is the approximately best position of a biogas plant likely to be installed. However, this location has been obtained without considering capacities. The most suitable plant location could be achieved by considering capacities.

Table 3. Cluster centers obtained by K-means algorithm

Number of Clusters	Cluster No	Cluster Centers		Number of Elements in Cluster	Average of Cluster Centers	
		Latitude	Longitude		Average Latitude	Average Longitude
k=3	1	40.52719	39.15275	54	40.3265	39.4217
	2	40.40092	39.64835	51		
	3	40.05145	39.46382	45		
k=4	1	40.08438	39.24638	24	40.3217	39.4119
	2	40.13712	39.56819	28		
	3	40.58505	39.17648	51		
	4	40.4806	39.65646	47		
k=5	1	40.56877	39.09383	38	40.3211	39.4283
	2	40.46173	39.81837	18		
	3	40.42989	39.46413	42		
	4	40.06615	39.20874	26		
	5	40.07845	39.55649	26		
k=6	1	40.47503	39.37638	38	40.2657	39.4115
	2	40.10198	39.20743	25		
	3	40.57277	39.03866	29		
	4	40.16768	39.53635	23		
	5	40.44521	39.75050	27		
	6	39.83141	39.55958	8		

Conclusion

Biogas technology has become more important in the production of renewable energy by processing and disposing of the wastes that cause environmental problems and making them use energy. Although there is enough potential for the evaluation of organic waste in Turkey, it is not utilized in the desired level. Moreover, energy investments based on organic waste hasn't been seen enough demand in Turkey.

According to TUIK 2018 year data in Gümüşhane province, there are 227224 animals in total including cattle, sheep and poultry. It is estimated that 324427.57 tons of fertilizer can be obtained from these animals annually. The amount of biogas that can be achieved from these wastes is 11465880 m^3. Therefore, for the biogas plant, which is likely to be installed in Gümüşhane province, the most appropriate location information that maximizes energy production should have determined.

In this study, the annual amount of animal waste was determined according to the animal species of the central districts and districts of Gümüşhane province and the biogas potential which may occur from this waste amount was calculated. In addition, it was aimed to specify the most suitable location for a biogas plant in which animal wastes could be evaluated. For this reason, using the K-Means clustering algorithm, the location information of the plant that will meet the optimum biogas production has been tried to be obtained. As a result of four different classifications, almost the same position information was obtained. However, this location information was attained without considering capacities. In another study, considering the capacities, the location information of the plant which will supply most suitable biogas production will be calculated.

As a result, the underground waters of Gümüşhane will be kept clean by the production and use of biogas and the greenhouse gas emissions from fossil fuels will be reduced. In addition, biogas production from animal wastes will increase the life quality of individuals interested in agriculture and livestock and positively affect the employment in Gümüşhane province.

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