# Climate factors and their relation regarding cone yield of stone pine (Pinus pinea L.) in the Kozak Basin, Turkey

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# Climate factors and their relation regarding cone yield of stone pine (*Pinus pinea* L.) in the Kozak Basin, Turkey

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**Abstract.** This study aims to reveal the factors that affect cone yield of both natural and planted stone pine (*Pinus pinea* L.) in Kozak Basin, Bergama, Izmir (Turkey). In the basin, productive and non-productive areas have been determined, according to long term observations. Topographical features of the basin, pollination properties and long term precipitation data have been analyzed. In addition, three meteorological stations have been established in places which can represent productive and non-productive areas of the basin. Productive areas have lower relative humidity and higher wind speed than non-productive areas. In non-productive areas the number of days in which the temperature falls below -10ºC and relative humidity rates surpass 70% is higher than in productive areas. It has been determined that during pollination period a wind speed higher than 3 m/s is very effective in pollination. Likewise it is understood that pollination also is influenced negatively from precipitation occurring during pollination period, high relative humidity of air and extremely high or low temperatures. In non-productive areas it is determined that there is a temperature difference, reaching to 22ºC, between day and night. All these clues show that non-productive areas have a very similar characteristics of a typical "frost hollow (frost pocket)".

**Keywords.** Kozak basin – Stone pine – Cone yield – Climatic factors – Frost hollow – Frost pocket.

***Les facteurs climatiques et leur relation pour la production de cônes du pin pignon* (Pinus pinea *L.) dans le bassin de Kozak en Turquie.***

***Résumé**. Cette étude vise à mettre en lumière les facteurs qui influencent la production de cônes à la fois pour des pins à pignons naturels et plantés (*Pinus pinea *L.) dans le bassin de Kozak, Bergama, Izmir (Turquie). Dans ce bassin, on a mis en évidence des zones productives et non productives selon des observations à long terme. Les caractéristiques topographiques du bassin, les propriétés de pollinisation et les données de précipitations à long terme ont été analysées. De plus, trois stations météorologiques ont été établies dans des lieux pouvant représenter des zones productives et non productives de ce bassin. Les zones productives avaient une humidité relative plus faible et une vitesse du vent plus forte que les zones non productives. Dans les zones non productives par rapport aux zones productives, il y avait un plus grand nombre de jours où la température tombait au-dessous de -10 $C^0$ et où les taux d'humidité relative dépassaient 70%. Il a été déterminé que pendant la période de pollinisation, une vitesse du vent supérieure à 3 m/s est très efficace pour la pollinisation. De même il est avéré que la pollinisation est également influencée négativement par des précipitations ayant lieu en période de pollinisation, par une forte humidité relative de l'air et par des températures extrêmement fortes ou faibles. Dans les zones non productives on a enregistré une différence de température, atteignant 22 $^0$C, entre le jour et la nuit. Toutes ces pistes montrent que les zones non productives ont des caractéristiques très semblables à celles d'une "cuvette de gel" typique (ou poche de gelée)".*

***Mots-clés.** Bassin de Kozak – Pin pignon – Production de cônes – Facteurs climatiques – Cuvette de gel – Poche de gelée.*

## I – Introduction

One-third of the total stone pine area in Turkey (16,000/50,000 ha) and two thirds of the national pine nut production (800 to 1,200 t/yr) are located in the Kozak basin, in the Aegean Bergama District near İzmir, a bowl shaped basin with granite bedrock. In spite of the importance of the

area for the Turkish pine nut production, stone pine growers in Kozak Basin have been complaining about low and irregular yields and extreme conelet loss. But most previous studies on the basin were about ecological adaptation and growth of stone pine (Fırat,1943; Akgül and Yılmaz, 1991; Kılcı *et al.*, 2000; Çukur *et al.,* 2005), whereas factors that affect cone yield have not been studied yet. In recent years, increased conelet losses have been observed in stone pine, and a study to uncover relations among cone losses and biotic factors and nutrition has been conducted by Aegean Forestry Research Institute.

According to the study, almost all of the cone losses happen in the first year. Almost all new born conelets fall off in July and August. According to the statistical analysis, there is no relation between amount of new born conelets and altitude, but there is a negative correlation between altitude and conelet losses. When altitude increases, conelet losses decrease (Özçankaya *et al.*, 2010). In the study, also diseases and pests causing cone losses have been determined, however, none of them have been found effective on conelet losses. The areas with 5-10 ripe cones per tree were accepted as unproductive, while those with more than 50 ripe cones per tree were accepted as productive. Besides, Özçankaya *et al.* (2010) reported that in a trial area only one new conelet out of 111 conelets survived at the end of September. This effect might be due to insufficient pollination caused by some climatic conditions. Roques (1977) also reports that cone losses due to various abiotic factors causing infertility. In this context, the aim of the present work was to study relations between location and climatic features of the basin and pollination success.

## II – Material and methods

Yield data have been gathered from local growers and cooperatives. Productive and non-productive areas have been also determined according to the information given by owners. In first place, areas with low and high yield within the basin have been marked on a topographic map, finding that areas with high cone yield are above certain altitude (500 m a.s.l.) (Özçankaya *et al.*, 2010). Afterwards, meteorological station locations in these areas and climatic factors have been evaluated. In the study, 1:25000 scale maps of DSI (State Directorate for Water Affairs) were utilized, as well as long term meteorological data of DMI (State Directorate for Meteorology) and data obtained from portable weather stations established in the basin.

Historic climate records showed an average precipitation of 939 mm in the village Yukarıbey [500 m a.s.l., 1963-1998] and 741 mm at Güneşli Station [700 m a.s.l., 1980-1994]. Although both station are located in the same basin and the distance between them is less than 10 km, there is a precipitation difference of nearly 200 mm, though the altitude difference between both is 200 m. The reason might be the prevalent north winds that leave more precipitation at windward mountains slopes than at lee (Anonymous, 2010). Occasional fog occurs in the basin in winter and autumn (Fig. 1).

**Fig. 1. Foggy Landscape of Upper Kozak Basin.**

For our study, three meteorological stations have been established in places which can represent the basin and its productive and non-productive areas: (i) Karaveliler village, at 587 m a.s.l. (in upper Kozak Basin, with high yield and altitude); (ii) Pompa, at 430 m (in upper Kozak Basin, with low yield and medium altitude); and (iii) Demircidere village, at 230 m (in lower Kozak Basin, low yield and altitude) (Fig. 2).

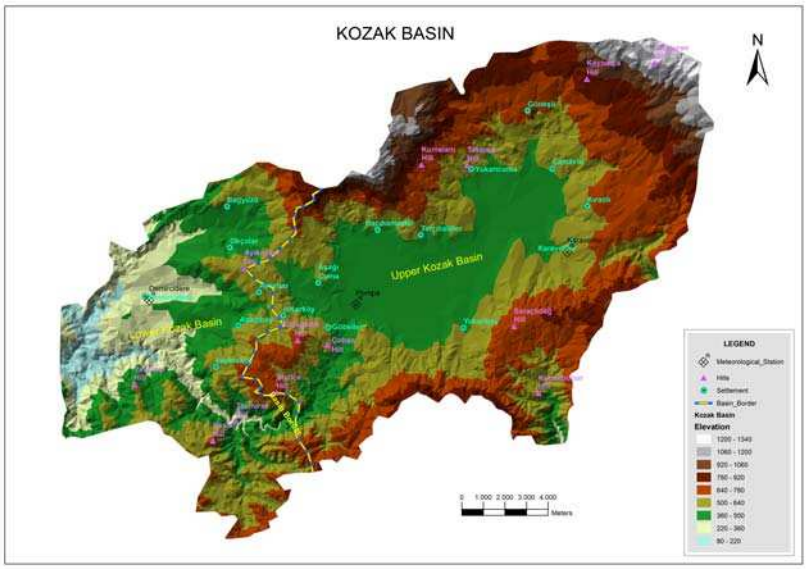


**Fig. 2. Kozak Basin Digital Elevation Model (DEM) and localization of the three weather stations (Karaveliler, Pompa and Demircidere).**

As the crow flies, distances between stations are almost equal (about 10 km). Each weather station registered hourly humidity, temperature and wind speed parameters during 2009 and 2010. Phenology and cone survival was monitored in both years, in order to evaluated recorded weather data during pollination period such as temperature, relative humidity and wind speed.

## III – Results

Observed pollination period in the basin varies from mid-May to early June, according to the observations for many years. It depends on altitude: between May 19 and 31 in the Upper Kozak Basin village Karaveliler, from May 28 to June 3 around Pompa, 12th and 20th may in Demircidere Village (Table 1). There were large differences between day and night temperatures in May in both years, 14°C in Karaveliler, 22°C around Pompa and 16°C in Demircidere. Average humidity was between 47-60% in Karaveliler, 77-85% in Pompa and 59% in Demircidere, and average wind speeds 1.45-0.94 m/s in Karaveliler and Pompa, 0.75-0.67 m/s in Demircidere (Table 1).

Although in both years average and maximum temperatures were similar among sites, minimum temperatures different clearly. Temperatures below 10°C occurred only once in Karaveliler in 2009, none in 2010, and six times (hours) in Demircidere in 2009, but 77 and 95 hours in Pompa in the two years.

On the other hand, during pollination period, the lowest average relative humidity was in Karaveliler, followed by in Demircidere and Pompa. Relative humidity over 70% occurred in

2009 only during 32 hours in Karaveliler, but for 150 in Demircidere and 294 hours in Pompa, and in 2010, 172 hours in Karaveliler versus 360 in Pompa. The average wind speeds during pollination period was highest in Karaveliler and lowest in Demircidere. Wind speeds faster than 3 m/s, considered effective for pollination, were never observed in Demircidere, in Pompa once, but 48 times in Karaveliler during the studied period in 2009, 20 times in Karaveliler in 2010, when in Pompa only 8 hours passed this threshold.

**Table 1. Climate data recorded during pollination period at the three meteorological stations**

| Locality | Pollination period | Year | Temperature (°C) | | | Relative humidity (%) | Avg. wind speed (m/s) | Wind >3m/sn (hours) | Humidity >70% (hours) | Temp. $<10^0$C (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Avg. | Max. | Min. | | | | | |
| Karaveliler (587 m) Prod. | 19-31 May | 2009 | 20.0 | 32.1 | 10.0 | 47% | 1,45 | 48 | 32 | 1 |
| | | 2010 | 18.5 | 32.4 | 7.4 | 60% | 0,94 | 20 | 172 | 0 |
| Pompa (430 m) Unp. | 28 May-3 June | 2009 | 17.5 | 29.8 | 1.7 | 77% | 0,75 | 1 | 294 | 77 |
| | | 2010 | 16.3 | 30.8 | -0.1 | 85% | 0,67 | 8 | 360 | 95 |
| Demircidere (230 m) Unp. | 12-20 May | 2009 | 20.6 | 31.4 | 8.3 | 59% | 0,39 | 0 | 150 | 6 |

## IV – Discussion and conclusions

Pollination period varied between 12th May and 3rd June due to altitude in both sub-basins. The observed difference among weather station allows relating cone setting with climate data. Pollination happens by means of wind in pine species (Anşin, 1988), and wind speed has an important role in burst of pollen strobili and airborne pollen transport to female conelets. Weak winds are inefficient not only for pollen shedding but also for its transfer; and a wind speed minimum of 3 m/s is required for moving the male branchlets swinging back and forth continuously (Öztürk and Seçmen, 2004). Moreover, relative humidity which has an inverse ratio with wind speed also affects negatively pollen shedding. Thus it seems that there is not sufficient wind speed and dry air conditions in Demircidere and Pompa, although all trees have both male and female flowers.

On the other hand, climate parameters recorded during pollination (19-31 May) period of 2010 substantially are different from that of 2009. Number of hours with wind speed (3 m/s or above) needed for pollination in 2010 were quite lower than in 2009 at Karaveliler, and also mean temperature and wind speed were lower, but precipitation was higher. These air conditions are considered to have negatively affected the pollination. Pollen transfer could be affected due to wind speed and excess humidity, cold and humid air might keep closed male and female flowers (Adkins *et al*., 2005). The negative impact of these climatic factors increased conelet losses in 2010. More loss than ordinary was also observed in Karaveliler village, located in Upper Kozak basin where conelet loss is minimum in normal years. That year, unusual conelet losses happened and it even continued in September while normally occurring mainly in June, July and August. It is also possible that unusual humic climatic conditions in 2010 might have triggered some fungal diseases.

Regarding wind speeds over 3 m/s during pollination period that are supposed to be very effective on pollination, only the upper basin sections with altitude over 500 m have enough wind, but lower basin does not. Again precipitation, high relative humidity and extreme temperatures have negative impacts on pollination during pollination period.

Moreover, stone pine stands in the Lower Kozak Basin are dense and overstocked, therefore there might not be sufficient air circulation for pollination, and interventions such as thinning and pruning are necessary. The sections between 430-500 m at the plain in Upper Kozak Basin

show characteristics of a frost pit. Therefore it is more appropriate to sustain traditional agricultural activities here rather than stone pine plantations for cone production.

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