



Stubble burning and wildfires in Turkey considering the Sustainable Development Goals of the United Nations

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Abstract

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There is a worldwide risk of fire spread due to the mismanagement of stubble in agricultural land. In 2019, 3.6% of the forest area was damaged by fires in Turkey due to stubble burning. The burning of agriculture residues negatively affects soil properties, air quality and water resources. This finally threatens humankind sustainability. However, there is a lack of information analyzing this problem from the current policies in Turkey. Therefore, this paper reviews the legislation currently applied to understand the specific competencies to achieve sustainable fire and forest management. A holistic analysis of the legal regulations and practices to prevent stubble burning in Turkey shown here the farmer's perception of the use of fire as an agriculture tool and the relevance of stubble burning to explain the location and recurrence of wildfires. Then, we discussed the relevance to shed light on how effective are the laws to avoid stubble burning and its impact on the environment. We claim for an update of the legislation to allow the farmers to manage the stubble and encourage the policymakers to develop new strategies to compost the stubble and achieve sustainable management within the Sustainable Development Goals of the United Nations that will contribute to achieving the Land Degradation Neutrality Challenge.

Keywords: Legal measures, people awareness, stubble burning, stubble management, wildfires

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Introduction

In 2019, approximately 15.4 million hectares of land, excluding fallow, are cultivated in Turkey. Among them, 6.8 million hectares of wheat, 2.9 million hectares of barley, and 0.6 million hectares of corn (TUİK, 2020) are cultivated. Rooted stems that remain in the field after the crops are harvested and defined as stubble. In Turkey, it is very common that farmers burn stubble considering a correct habit (Gursoy, 2012). Approximately 40% of the grain field in Turkey are exposed to stubble fire every year, and this fire results in the extinction of 10 million tons of stalks and straw (Temiz and Olgar, 2017). This is because farmers assume that fire provides convenience in tillage results and reduce diseases and pests, which allow obtaining higher crop yields, and reduce the economic costs to be transported (Korucu et al., 2007). There is a lack of suitable tools, equipment and financial support to process the stubble and the clogging of the sowing machines during planting which leave fire as a unique solution to the stubble burning by the Turkish farmers (Yilmaz et al., 2014). Another reason for burning stubble is that the stubble remaining on the soil surface causes

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Zabrus spp. beetle and plant root rot (Budak and Gunal, 2018). The perception of the farmers is that fire is positive to enhance their fields because the decomposition of the stubble will last for years and they need to plough the soil for the next harvest. Burning of agricultural residues is a harmful process in several ways but it is common in paddy, cotton, and cornfields, mainly cultivated with wheat in the United States (McCarty et al., 2009), New Zealand (Williams et al., 2020), Australia (Smith et al., 2007) or some countries of Asia (Mittal et al., 2009).

Stubble burning harms the soil in many aspects such as water-repellent conditions (Flow, 2016), changes in the water cycle by enhancing the runoff generation and reducing the infiltration capacity of the soils (Vermeire et al., 2004; McCarty et al., 2009), increasing the risk of soil erosion (De Bano et al., 1998), a greenhouse gas emissions rise (Venkataraman et al., 2006; Hemwong et al., 2008; Huang et al., 2012; Ravindra et al., 2019; Beig et al., 2020), and duplicating the nutrient losses (Fynn et al., 2003; Heard et al., 2006). Also, biodiversity is highly affected. For instance, many small reptiles and mammals, such as lizards or vole, whose value for the soil or life cycle is not fully appreciated by farmers, are also adversely affected by stubble fires (Akman, 2019). However, there are some contradictory results in this respect. For example, Christian et al. (1999) concluded that the burnt field's yield is higher than the yield from the unburned field.

Researchers explained this contradiction by the fact that yields are strongly affected not only by fire but also by soil, climate, and other environmental factors. In a study investigating the effects of forest fires on the biochemical properties of the soil (Kaptanoglu and Namli, 2019), it was concluded that low and moderate forest fires positively affected some chemical (pH, CaCO₃, Ca and P₂O₅) properties of soils, and negatively affected some biological properties (β-D glucosidase, urease enzyme activities). Burning the stubble left at the end of the harvest causes many risks besides its damage to the soil. These risks involve the emergence of acute respiratory diseases caused by smoke during and after stubble burning (Batra, 2017). Also, telephone and energy transmission lines can be damaged, traffic accidents due to fog formation can occur, fire splashes to neighbouring unharvested fields are registered (Korucu et al., 2005).

Wildfires also closely affect sociocultural life. Using data from the fires that occurred in Turkey between 1995 and 2004, Koulelis and Mitsopoulos (2007) found significant relationships among the population density of these years, the number of fires, the gross domestic product, and the width of the burning area. A large portion of forest fires in Turkey (93%) is removed by people, among them, negligence and carelessness forest fires are an important place (Inanc and Aydin, 2019). In Turkey, the primary starting point for forest fires is the agricultural area near or in the forests (Baltaci and Yildirim, 2021). According to the data of 2019, a total of 2698 forest fires broke out in Turkey, and 184 of these fires were reported to have occurred due to stubble burning. According to provinces, forest fires caused by burning stubble were located in Trabzon (28), Sakarya (27), Giresun (20), and Eskişehir (18). In 2019, the total size of the area damaged by forest fires was determined as 11332.44 ha. It was summarized that 406.45 ha was estimated to be burnt due to stubble burning. Forest areas damaged by stubble burning are registered in Trabzon (76.78 ha), Kahramanmaraş (67.45 ha), and Mersin (53.87 ha) (Anonymous, 2020a). Figure 1 shows different visuals from the stubble burning processes in Central Anatolia in October and November 2020.



Figure 1. Different visuals from the stubble burning processes in Central Anatolia in October and November 2020

Efficient and widespread training activities are required to prevent stubble burning. To date, various legal regulations have been developed in different countries to accomplish results in the short-term, in which policymakers are conscious of the enormity of the situation (Agudo-Gonzalez, 2010; Galiana-Martin et al., 2011; Montiel-Molina, 2013). In the European Union, the cross-compliance rules of the Common Agriculture Policy (CAP) regulates the management of agricultural residues according to the Council of the EU regulation no 73/2009, 6 (1) and it has prohibited the burning of stubble in EU member countries (Searle and Bitnere, 2017). Although there are many legal regulations and measures in the European Union countries, paradoxically, there have been severe wildfires in Europe (Fernandez-Anez et al., 2021), possibly, due to this fact (Xanthopoulos et al., 2006; San-Miguel-Ayanz and Camia, 2010; Mierauskas, 2012). However, a holistic analysis of the legal regulations and practices to prevent stubble burning in Turkey is scarce. Therefore, the main goals of this review are to describe: i) farmer's perception; ii) wildfires in Turkey due to stubble burning; iii) and what can be considered to make the current laws effective to face this issue.

Legal measures in Turkey

Developing legal measures to face wildfires is essential to focus on fire prevention measures (Mavsar et al., 2013). In this sense, high-risk seasons and practices carrying a significant wildfire risk should be regarded when preparing laws and land management plans (Pausas, 2004; Pausas and Keeley, 2014). The burning of stubble and agricultural residues, particularly after harvest, coincides with the months when the air temperature is high (Erdal et al., 2016). During the next growing period coinciding with soil preparation, stubble burning can cause severe forest fires (Velez, 2010; Montiel-Molina, 2013).

According to official statistics, 3.6% of the forest area affected by fires in 2019 in Turkey are due to stubble burning (Anonymous, 2020a). While determining legal measures, deliberate forest burning and carelessness, such as stubble burning and forest burning by negligence, are separated. According to Forest Law No. 6831 of the Turkish Government, Article 76 "d). It is forbidden to burn stubble or similar vegetation within the villages' boundaries within the scope of articles 31 and 32 of this law or at a distance of four kilometers to forests". According to Article 110 of the same law, "Those who cause forest fires contrary to the obligation of attention and care are punished with imprisonment from two to seven years". Still, suppose the intention of the act of burning is determined; in that case, it is said that "the person who deliberately burns the forest is punished with imprisonment not less than ten years and a judicial fine up to ten thousand days". It is stated in the same law that "a person who burns the state forests within the framework of the activities of an organization established to commit crimes against the security of the state is punished with life imprisonment and a judicial fine of up to twenty thousand days". According to the 18th Article of the Forestry Law No. 6831, no activities other than forestry activities are allowed in forests exposed to fire (Anonymous 2020b).

In general, wheat straw in Turkey uses to be incinerated with maize, cotton, and sunflower residues to be favoured (Yilmaz et al., 2014). Barley lot and residues are nutritious and easy to digest for livestock and have a short growth cycle in the field against wheat growth; mainly used for livestock. In addition, since the amount of stubble on the field surface after the harvest of barley is low, the rate of burning is significantly lower (Gursoy et al., 2013). Depending on the harvesting height of the grain crop (i.e., barley and wheat), 3500 kg ha⁻¹ for incineration of all crop residues and 1000 kg ha⁻¹ for residues other than herds disappear without being added to the soil (Temel, 2012).

The preservation of agricultural lands and pastures in Turkey is also guaranteed by Article 44 and Article 45 of the Republic of Turkey's Constitution in 1982. Nowadays, Turkish policymakers continue to work on a new Constitution. In this new document to be prepared, the laws for protecting natural assets will undoubtedly be included. Currently, efforts are made to find a solution against stubble fires by applying penal sanctions (Dilber and Guler, 2015) by the Environmental Law No. 2872 (Anonymous, 1983), Forest Law No. 6831 (Anonymous, 1956), the Provincial Administration Law no 5442 (Anonymous, 1949) and the relevant articles of Turkish Penal Code No.5237 (Anonymous, 2004) and the circulars issued on this subject, through the Ministry of Agriculture and Forestry, the Ministry of Environment and Urbanization, the Ministry of Internal Affairs, Governorships, Municipalities, and related security units.

According to Article 76 of the Forest Law, it is forbidden to burn stubble and similar vegetation at a distance of 4km to the forest or within boundaries of forest villages, whose description is determined by law. This act is considered a forest crime. According to Article 110 of the Forest Law, people who commit the act mentioned above are sentenced to imprisonment for one to three years, and a fine is imposed. In the calculation of fire damage, the value of entirely burned trees, the decrease in the value of partially burnt trees, the damage, and efficiency losses in the substrate are taken into account (Anonymous, 1956).

Governorships in Turkey also publish notifications on this subject. The purposes of these rescripts are to take the necessary measures for the sustainability of the soil fertility in natural balance by protecting the soil's biological, chemical, and physical structure and the environment. This is the primary source of agricultural production to determine alternative measures to prevent stubble burning after the harvest in cereal agriculture. It considers the damage to the soil structure and the environment to train technical staff and farmers, and ensure that the public is sensitive to stubble fires.

Under subparagraph (I) of the Ministry of Environment and Urbanization's Communiqué numbered 2019/1 published in the Official Gazette dated 31 December 2018 and numbered 30642, subparagraph (I) of the 20th article of the Environment Law numbered 2872, those who burn stubble will be fined 60.11 TL (Approx. € 6.83) administrative fine for each decade. If the stubble burning is acted in areas adjacent to forests and wetlands and residential areas, the penalty is raised five times. On the other hand, in the regions where the second crop is planted, controlled stubble burning is permitted under the responsibility of the Governorships within the framework of the action plan prepared by the Governorships. Still, almost all governorships do not apply this provision in their provinces and do not allow stubble burning, including controlled stubble burning. Besides, a fine of 320 TL (Approximately € 35.00) is fined for 2019, according to Article 32 of the Misdemeanor Law No. 5326, along with the penalties accrued for those who act against this notification published by the Governorship (Anonymous, 2005). Provincial Agriculture and Forestry Directorates carry out the execution. Besides, the relevant institutions' responsibilities for stubble burning are also plainly declared in the rescripts mentioned above. The order not to cause any malfunctions in practice by closely monitoring the issues specified in the rescript by the relevant Public Institutions and Organizations (Anonymous, 2020d).

Responsibilities of institutions and organizations for the prevention of burning stubble

Public institution's and organizations' responsibilities in Turkey concerning the prevention of stubble burning are also clearly stated in the relevant rescripts. According to one of these rescripts (Anonymous, 2020c), the responsibilities of the relevant public institutions and organizations are given in articles:

The responsibilities of the Provincial Directorate of Agriculture and Forestry and the Presidencies of the Chamber of Agriculture confirm that: i) stubble fires will be included in farmer training programs extensively, and their damages will be explained in detail; ii) environmental awareness by providing the contributions of local government and non-governmental organizations in the training-publication activities; iii) public awareness will be raised with posters and brochures to be prepared; and, iv) with other public institutions and organizations to make more effective measures against stubble burning. Training requests from the Agricultural Chamber Presidencies will be fulfilled immediately by the Provincial Directorate of Agriculture and Forestry.

The Highways Branch Directorate's responsibilities clarify that stubble fires that pollute the air occasionally diminish visibility on highways, which causes traffic accidents and loss of life and property. Thus, weeds on the road slopes will be removed and flammable material too. Moreover, warning signs will be fixed on the roadside concerning the damages of stubble fires.

The responsibilities of the Provincial Gendarmerie Command and Provincial Security Directorate affirms that: i) control and patrol duty will be increased before, during, and after harvest; ii) vehicle and personnel will support in the transportation of living and non-living things affected by fire in case of fire and if desired; and, iii) despite the measures and announcements taken, the official reports and all evidence regarding the fire will be sent to the Provincial Directorate of Environment and Urbanization. This institution will take legal actions against those who begin stubble fire. In addition, the responsibilities of the Directorate of National Education claim for children and young people to better understand the harmful effects of stubble fires, education on stubble fires and their damages will be included in the education curriculum.

Also, the responsibilities of the Regional Directorate of Forestry/Forestry Operation Directorates and Chief Offices are planned. Firstly, farmers in the settlement where burning stubble is prohibited under the Forest Law's relevant articles will be informed about forest fires that may occur due to stubble burning. The technical staff of the Provincial/District Agriculture and Forestry Directorates will also participate in this information to be made in the form of neighbourhood meetings. Before, during and after harvest, inspections will be increased by making fire announcements and legal actions will be taken against those who cause fires. Also, between the agricultural areas and forest areas in fire-sensitive areas, lanes will be opened with a grader in a way to prevent fire. However, despite the measures and announcements taken, if the stubble fire is closer than 4 km to the forest area, criminal action will be applied to those who cause the stubble fire under the relevant provisions of Forest Law No. 6831. In this case, the official reports taken for legal action

and all evidence regarding the fire will be sent to the Provincial Directorate of Environment and Urbanization.

Responsibilities of the Municipalities: i) announce the notification issued by the Provincial Governorship to inform the public and the concerned parties, regarding the prevention of stubble burning, ii) provide the intervention of the fire department units to extinguish the stubble fires within the boundaries of the municipality adjacent areas.

Responsibilities of the Neighborhood Mukhtars i): they will announce this notification published by our Provincial Governorship to inform the public and the concerned parties to prevent burning of stubble, ii) by determining those who cause stubble fires as soon as possible, informing relevant authorities immediately, iii) the time and place of training and activities related to stubble fires will be announced to the public.

The responsibilities of the Provincial Directorate of Environment and Urbanization: i) by making fire announcements before, during, and after harvest, inspections will be increased, legal action will be taken against those that cause fires, ii) studies will be carried out in coordination with the relevant institutions to prevent stubble fires, iii) will duly apply fines under the relevant laws.

Responsibilities of Provincial and District Mufti Offices: i) sermons on the prevention of stubble fires in mosques will be shared by mufti offices.

Responsibilities of combine harvester owners/operators in related rescripts on preventing stubble burning

Worldwide, various methods have been developed for the management of stubble left after wheat harvest. These are i) the stubble shredders separate from the combine harvester or the stubble shredder and spreader systems attached to the back of the harvester during harvesting, ii) collecting the stubble in the field during or after the harvesting process with the appropriate equipment, and making hay, iii) collecting bales iv) burying the stubble in the soil with tools such as a plough that tills the soil, v) performing stubble sowing directly with sowing machines (Erdal et al., 2016). One of the essential points in the correct control of the stubble is that the combine harvester operators performing the appropriate application. The responsibilities of the combined harvester owners/operators in the related communiqués regarding the prevention of stubble burning are listed in items (Anonymous, 2020d,e): i) those who do not have a G-class Driving License or Combine Harvester Operator's License will not be able to work as a harvester operator and cannot be operated by combine harvester owners Authorized operators will use combine harvesters. ii) harvester owners and operators will not exceed a 1.5% crop loss rate during harvesting within the provincial property borders for 2020. Product loss index values will be taken into consideration according to the land situation. iii) combine harvester owners shall not operate combine harvesters without two 6-kg fire extinguishers. iv) combine harvester owners and combine harvester operators are obliged to present their identification if requested by the authorized controllers. v) the combined header must be dismantled when they are travelling on highways. vi) in cases where the stalks left in the form of a barrel on the field during harvesting with a combine harvester are not counted as bales of straw, the straw chopper (harvester), which is attached to the straw hopper of the combine harvester and shreds the straw into the field by using a handle or chops the straw into a trailer attached to its back (combine harvester) schemes need to be installed and used on combines vii) the existing combine harvester owners, and the ones who come to the province from outside shall inform the Provincial or District Agriculture and Forestry Directorates about the combine harvester and the operator to be operated before starting the harvest. viii) harvester owners or operators are obliged to attend the training to be organized. ix) the combined harvester operator and owners will pay attention to the inspectors and law enforcement officers' warnings. x) all kinds of safety precautions will be taken in place and on time against fire hazards by those concerned not to damage the harvested product and the environment. xi) drivers with operator certificates will reap the crops from the most suitable height that will not allow the stubble's burning, taking into account the field and product condition and the land structure.

Responsibilities of field owners and villagers in the related communication on preventing stubble burning

If an effective struggle against stubble burning is desired, it is impossible to achieve success without the field owners and villagers involved in this struggle. Figure 2 shows some photos of the stubble burning in Ethiopia (Bahir Dar area, Nile) in January 2018. The responsibilities of the field owners and the local people in the related communiqués concerning the prevention of stubble burning are listed in items (Anonymous, 2020d): i) crop owners and mukhtars will ensure the formation of an 8-10 meters wide ploughed line,

cleared from combustible materials (stubble) after harvest, in the grain fields adjacent to the forest, they will prevent the burning of stubble, grass, and bushes in the fields in and around the forest, and the mukhtars will notify the Gendarmerie Command or the Forest Management Directorate of those who act contrary. ii) under Forestry Law No. 6831, it is prohibited to spend the night in the state forests other than the accommodation places determined, burning all fires other than the quarries and burning stubble or similar vegetation. This issue will be followed by the Neighbourhood Mukhtar, Forest Management Directorate, the relevant Municipality, Gendarmerie Command, and the Police Department. iii) the control officers will make the necessary warnings to notify the public and the Neighbourhood Mukhtar, the prohibition of burning stubble and cleaning the field, starting fires, accommodation and overnight stays outside the forest picnic-promenade and being cautious in the forest areas.



Figure 2. View of the stubble burning in Ethiopia (Bahir Dar area, Nile) in January 2018.

Discussion

Stubble burning is not a Turkey issue as it is widespread around the world. Turkey can be considered a laboratory to understand the use of stubble burning as has a long tradition of farming and the use of stubble. Some of the problems of burning stubble go further than the risk to cause a wildfire. Stubble burning damage the quality of the air such as [Mittal et al. \(2009\)](#) found in Patiala due to the burning of wheat and rice crops. [Dhammapala et al. \(2006\)](#) measured high particulate emissions from wheat and Kentucky bluegrass stubble in eastern Washington and northern Idaho. Another impact of stubble burning is the changes in soil hydraulic and physical properties ([Valzano et al., 1997](#)) and the changes in soil organic matter, aggregation and earthworm population ([Virto et al., 2007](#)). There are other impacts such as the ones to the human health that [Saggu et al. \(2018\)](#) shown in the Malwa region of India, where the respiratory health of the school children was affected by stubble burning. All those problems request that stubble burning must be legislated and Turkey is an example of how the laws and their application will contribute to improving the management of stubble.

As can be assumed from the data given in this review article, it is forbidden to burn the country's stubble as in the European Union countries, and legal measures have been taken to prevent the stubble's burning ([Mourao and Martinho, 2019](#)). Turkish legislators, like their European counterparts, are aware of the harmful aspects of burning stubble. Despite this, it is impossible to prevent massive fires caused by burning stubble neither in Europe nor in Turkey, a candidate country for the European Union ([Karmilowicz et al., 2018](#)). This is a similar situation in the USA ([Stephens and Ruth, 2005](#); [Stephens et al., 2016](#)), which is a

worldwide trend along with the world (Herawati and Santoso, 2011; Stupak et al., 2007; Turyahabwe et al., 2008).

The proportion of stubble burning due to forest fires in Turkey in 2019 is 6.81%, while the ratio of the area of burning forests was determined as 3.58 % (406.45 ha). It is believed that the principal reason why stubble burning could not be prevented despite the laws is that the farmers and villagers, in particular, have not received sufficient training for not burning the stubble. Although there is an emphasis on education in the circulars issued by the governorships based on the laws, this training are either insufficient or cursory. The way to fight stubble should be not only with in-depth and ordinary training in the post-harvest seasons but also with methods embedded in formal education and training in village, town, and mukhtar meetings. The related units of institutions and organizations such as the Ministry of Agriculture and Forestry, Universities, Ministry of National Education, municipalities, fire brigade, gendarmerie, police, and non-governmental organizations should be involved in these training plans. Thus, lawmakers, advisors to lawmakers, law enforcement, and those who have to obey the law gather on the same platform. It is the only way for a society to become conscious of all age groups. The departments of universities such as forestry, environmental engineering, law, and medicine, primarily the faculties of agriculture, should prevent stubble fires with the outcomes of their studies. For instance, the availability of worms in stubble management can be studied by agricultural faculties.

On the other hand, settling a policy with target groups helps create more enforceable laws, and leads to less opposition and veto. While preparing laws for preventing stubble burning, getting opinions from all addressees, including those who burn stubble, will provide it possible to make more applicable, realistic, and rational laws. Effective laws are always more challenging to break. Perhaps the most crucial point in preventing stubble fires is that lawmakers and stubble burners understand each other. Sociologists who are quite familiarized with village sociology should build a bridge between lawmakers/enforcers and rural farmers. Thus, sociologists must be involved in both educational activities and legislative commissions.

The effectiveness of the legal regulations concerning the burning of stubble also depends on the deterrence of penalties. Although the penalties determined by the Forest Law in Turkey are very deterrent, the penalties determined by other laws are low. Of course, it is not the precise approach to impose strict punishments on a community that is not adequately aware of burning stubble. Nevertheless, when an adequate level of education is reached about the burning of stubble in rural areas, the fine for burning the stubble must be increased to a higher value than the current one. When the subject is viewed from another perspective, it occurs that reward may be more effective than punishment in obtaining success. Providing a state subsidy to the farmer who will manage accurately instead of burning the stubble can effectively fight stubble burning. The Turkish State provides farmers' support on many issues, and many successes have been achieved with these supports. For instance, a certain amount of money support for each declared stubble that is not burned; in other words, properly managed, can be an effective application. In addition to this financial support, farmers can be motivated by the projects to be developed. For example, in one of these projects, state support can be provided for the exemplary farmers who manage stubble most properly for a certain period, for instance, two or three years to pay a short-term visit with their families to a model agricultural enterprise in one of the European Union countries, as far as the allowances permit. On the one hand, it will contribute to the intellectual development and mental and spiritual relaxation of the rural people who visit abroad. Again, it will motivate other farmers in the region. This practice can be started by choosing one of the villages as a pilot area in Central Anatolia, where stubble burning is common. Consequently, the way to fight stubble burning can be possible by an educated and conscious society.

Stubble burning uses the roots and stems of the crops harvested during agricultural production. In Turkey, it is very common that farmers use to burn stubbles for various purposes; however, it also hurts soil properties deteriorating soil quality and soil human health. In addition to the serious environmental pollution it creates, stubble fires can damage energy and communication lines within agricultural lands or even generate wildfires. Therefore, the main aim of this review was to integrate information about the harmful effects of stubble burning, laws applicable in Turkey against stubble burning and some methods that can be applied instead of burning stubble. We summarize 6.8% of the forest fires in Turkey occurred in 2019 due to stubble burning. The most two relevant wildfires were located in Mersin-Gülnar (07 July 2008 and 5037 hectares of forest burned) and in İzmir-Gaziemir/Gümüldür (20 July 2008; 1228 hectares). In Turkey, stubble burning TV programs prepared for the farmers and broadcasting national channels in the 1980s had encouraged farmers who were still unconscious towards crop rests' destruction by burning after harvesting (Coskan et al., 2006). However, with the entrance of Turkey as in the EU integration process, it has begun to

be a series of measures to prevent these malpractices. The use of a straw to control soil degradation is very positive as previous researchers demonstrated in agriculture and forest land. Novara et al. (2018) demonstrated the positive use of a straw to increase the soil organic matter which confirms the positive effect of the cover management (Novara et al., 2019). The use of a straw to control the soil losses were demonstrated by Rodrigo-Comino et al. (2020) in olive orchards; Keesstra et al. (2019) in citrus plantations, Cerdà et al. (2016) in persimmon plantations and Cerdà et al. (2017) in the El Teularet soil erosion and degradation experimental station. The use of stubble will contribute then to more stable soils and accomplish the Sustainable Development Goals of the United Nations and the Land Degradation Neutrality objective (Keesstra et al., 2018; 2019; Visser et al., 2019). This is found in other recent publications such as Rodrigo-Comino et al. (2020); Novara et al. (2021), Barrena-González et al. (2020), López-Vicente et al. (2020) and Cerdà et al. (2021).

Limon-Ortega et al. (2002) investigated the change in soil structure, compaction and microbial biomass with the change in the next crop yield when wheat and corn stubble are burned or mixed into the soil without burning. The results obtained showed that if the wheat and corn stubble were burned or left to the soil as they were, there was no significant difference between the applications in terms of yield values in the first 2-3 years of the trial, and at the end of the 5-6 years, there was a higher grain yield in the stubble applications. Adding organic soil conditioners to stubble burned agricultural areas is a rational way to follow (Coskan et al., 2006).

Conclusion

We conclude that the current legislation in Turkey promote sustainable management of the soil resources as the maintenance of the stubble in the field will promote soil recovery and the soil functions and ecosystem services induced by the straw cover. This is similar to other legislation in other countries which has the target to achieve the Sustainable Development Goals of the United Nations and the Land Degradation Neutrality Challenge. The lack of information and subsidies to the farmers is the reason why the stubble is burnt now, and this should be changed with new policies based on the education of farmers and other users to promote the use of stubble as mulches and avoid their burning.

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References

- Agudo-Gonzalez, J., 2010. An integrative approach at European level for wildfires: towards a Framework Directive. *European Energy and Environmental Law Review* 19: 87-101.
- Akıs, R., 2016. Effects of crop residue burning on soil physical and hydrological properties in semi-arid agricultural production systems. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi* 33(3): 223-235.
- Akman, B., 2019. Distribution and some ecological features of *Acanthodactylus schreiberi* Boulenger, 1878 in Anatolia. *Biological Diversity and Conservation* 12(2): 1-8.
- Anonymous, 1949. Türkiye Cumhuriyeti İl İdaresi Kanunu. Kanun No: 5442. 18 Haziran 1949 tarih ve 7236 sayılı Resmi Gazete.
- Anonymous, 1956. Türkiye Cumhuriyeti Orman Kanunu. Kanun No: 6831. 08 Eylül 1956, tarih ve 9402 sayılı Resmi Gazete. [in Turkish].
- Anonymous, 1983. Türkiye Cumhuriyeti Çevre Kanunu. Kanun No: 2872. 11 Ağustos 1983 tarih ve 18132 sayılı Resmi Gazete. [in Turkish].
- Anonymous, 2004. Tük Ceza Kanunu. Kanun No: 5237. 12 Ekim 2004 tarih ve 25611 sayılı Resmi Gazete. [in Turkish].
- Anonymous, 2005. Türkiye Cumhuriyeti Kabahatler Kanunu. Kanun No: 5326. 31 Mart 2005 tarih ve 25772 sayılı Resmi Gazete. [in Turkish].
- Anonymous, 2020a. 2019 Yılı Orman Genel Müdürlüğü Resmi İstatistikleri. [in Turkish]. Available at [access date: 04.08.2020]: <https://www.ogm.gov.tr/ekutuphane/Istatistikler/Forms/AllItems.aspx>
- Anonymous, 2020b. 6831 Sayılı Orman Kanunu. TC Yasal Mevzuatı. Resmi Gazete Kabul tarihi 31/8/1956. [in Turkish].
- Anonymous, 2020c. Bilecik İl Tarım ve Orman Müdürlüğü, 2020 yılında anız yangınlarının önlenmesine ilişkin usul ve esaslara ilişkin karar. [in Turkish]. Available at [access date: 23.07.2020]: https://www.bilecik.bel.tr/sources/upload/duyurular/duyuru_19_doc02213220200605070421.pdf

- Anonymous, 2020d. Tekirdağ İl Tarım ve Orman Müdürlüğü, 2019 yılında anız yangınlarının önlenmesine ilişkin usul ve esaslar. [in Turkish]. Available at [access date: 17.02.2020]: <https://tekirdag.tarimorman.gov.tr/Duyuru/185/2019-Yili-Aniz-Yanginlarinin-Onlenmesi-Ile-Ilgili-Esas-Ve-Usuller>
- Anonymous, 2020e. Çorum İl Tarım ve Orman Müdürlüğü, 2020 yılında anız yangınlarının önlenmesine ilişkin usul ve esaslara ilişkin karar. [in Turkish]. Available at [access date: 23.07.2020]: <https://corum.tarimorman.gov.tr/Sayfalar/Detay.aspx?Ogeld=291&Liste=Duyuru>
- Baltacı, U., Yildirim, F., 2021. Multi-criteria analysis and mapping of forest fire risk in Mugla Regional Directorate of Forestry. *Ormanlık Araştırma Dergisi* 8(1): 1-11 [in Turkish].
- Barrena-González, J., Lozano-Parra, J., Alfonso-Torreño, A., Lozano-Fondón, C., Abdenour, M. A., Cerdà, A., Pulido-Fernández, M., 2020. Soil erosion in Mediterranean chestnut tree plantations at risk due to climate change and land abandonment. *Central European Forestry Journal* 66(2): 85-96.
- Batra, C., 2017. Stubble burning in North-West India and its impact on health. *Journal of Chemistry, Environmental Sciences and Its Applications* 4(1): 13-18.
- Beig, G., Sahu, S.K., Singh, V., Tikle, S., Sobhana, S.B., Gargeva, P., Ramakrishna, K., Rathod, A., Murthy, B.S., 2020. Objective evaluation of stubble emission of North India and quantifying its impact on air quality of Delhi. *Science of The Total Environment* 709: 136126.
- Budak, M., Gunal, H., 2018. Carbon storage potentials of soils under different land uses in Upper Tigris Basin. *Anadolu Orman Araştırmaları Dergisi* 4(1): 61-74 [in Turkish].
- Cerdà, A., Borja, M.E.L., Úbeda, X., Martínez-Murillo, J.F., Keesstra, S., 2017. Pinus halepensis M. versus Quercus ilex subsp. Rotundifolia L. runoff and soil erosion at pedon scale under natural rainfall in Eastern Spain three decades after a forest fire. *Forest Ecology and Management* 400: 447-456.
- Cerdà, A., Novara, A., Dlapa, P., López-Vicente, M., Úbeda, X., Popović, Z., Mekonnen, M., Terol, E., Janizadeh, S., Mbarki, S., Saldanha Vogelmann, E., Hazrati, S., Sannigrahi, S., Parhizkar, M., Giménez-Morera, A., 2021a. Rainfall and water yield in Macizo del Caroig, Eastern Iberian Peninsula. Event runoff at plot scale during a rare flash flood at the Barranco de Benacancel. *Cuadernos de Investigación Geográfica* 47: 95-119.
- Cerdà, A., Rodrigo-Comino, J., Giménez-Morera, A., Keesstra, S.D., 2017. An economic, perception and biophysical approach to the use of oat straw as mulch in Mediterranean rainfed agriculture land. *Ecological Engineering* 108: 162-171.
- Cerdà, A., Terol, E., Aliakopoulos, I. N. 2021b. Weed cover controls soil and water losses in rainfed olive groves in Sierra de Enguera, eastern Iberian Peninsula. *Journal of Environmental Management* 290, 112516.
- Christian, D.G., Bacon, E.T.G., Brockie, D., Glen, D., Gutteridge, R.J., Jenkyn, J.F., 1999. Interactions of straw disposal methods and direct drilling or cultivations on winter wheat (*Triticum aestivum*) grown on a clay soil. *Journal of Agricultural Engineering Research* 73: 297-309.
- Coskan, A., Gok, M., Dogan, K., 2006. Effects of tobacco waste applications on burned and non-burned wheat stubble on biological N₂-fixation and yield. *Tarım Bilimleri Dergisi* 12(3): 239-245 [in Turkish].
- DeBano, L.F., Neary, D.G., Ffolliott, P.F., 1998. Fire's effects on ecosystems. John Wiley and Sons. Inc. Toronto, Canada.
- Dhammapala, R., Claiborn, C., Corkill, J., Gullett, B., 2006. Particulate emissions from wheat and Kentucky bluegrass stubble burning in eastern Washington and northern Idaho. *Atmospheric Environment* 40(6): 1007-1015.
- Dilber, E., Guler, M., 2015. Stubble burning-agriculture-environment relationships. 11. Tarla Bitkileri Kongresi. 7-10 Eylül 2015. Çanakkale, Turkey. [in Turkish].
- Dimopoulou, M., Giannikos, I., 2004. Towards an integrated framework for forest fire control. *European Journal of Operational Research* 152(2): 476-486.
- Erdal, G., Erdal, H., Yavuz, H., 2016. Stubble burning and consciousness level of farmers. *Turkish Journal of Agriculture - Food Science and Technology* 4(8): 662-667.
- Fernandes, P.M., Guiomar, N., Mateus, P., Oliveira, T., 2017. On the reactive nature of forest fire-related legislation in Portugal: A comment on Mourão and Martinho (2016). *Land Use Policy* 60: 12-15.
- Fernandez-Anez, N., Krasovskiy, A., Müller, M., ..., T., Yakupoğlu, T., Smith, T., Doerr, S., Cerda, A., 2021. Current wildland fire patterns and challenges in Europe: a synthesis of national perspectives. *Air, Soil and Water Research* 14: 1-19.
- Fynn, R.W.S., Haynes, R.J., O'Connor, T.G., 2003. Burning causes long-term changes in soil organic matter content of a South African grassland. *Soil Biology and Biochemistry* 35(5): 677-687.
- Galiana-Martin, L., Herrero, G., Solana, J., 2011. A wildland-urban interface typology for forest fire risk management in Mediterranean areas. *Landscape Research* 36(2): 151-171.
- Gursoy, S., 2012. The evaluation of the wheat stubble and stalk management systems applied in Diyarbakir province. *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi* 22(3): 173-179 [in Turkish].
- Gursoy, S., Sessiz, A., Akın, S., 2013. Tillage systems used in Diyarbakir province and problems encountered during the machine planting. *Tarım Makinaları Bilimi Dergisi* 9(3): 181-186 [in Turkish].
- Heard, J., Cavers, C., Adrian, G., 2006. Up in smoke-nutrient loss with straw burning. *Better Crops* 90(3): 10-11.
- Hemwong, S., Cadisch, G., Toomsan, B., Limpinuntana, V., Vityakon, P., Patanothai, A., 2008. Dynamics of residue decomposition and N₂ fixation of rain legumes upon sugarcane residue retention as an alternative to burning. *Soil and Tillage Research* 99: 84-97.
- Huang, K.H., Fu, J.S., Hsu, N.C., Gao, Y., Dong, X., Tsay, S.C., Lam, Y.F., 2012. Impact assessment of biomass burning on air quality in Southeast and East Asia during BASE-ASIA. *Atmospheric Environment* 78: 291-302.

- Inanc, S., Aydin, I.Z., 2019. Assessment of forest fires in Turkey in the context of national forestry program. 4th International Symposium on Innovative Approaches in Engineering and Natural Sciences. November 22-24, 2019, Samsun, Turkey. pp. 548-554.
- Kaptanoglu, A.S., Namli, A., 2019. The effects of forest fire and post-fire salvage logging on soil properties. *Ormançılık Araştırma Dergisi* 6(1): 29-46 [in Turkish].
- Karmiłowicz, E., Skrzecz, I., Matyjaszczyk, E., 2018. Plant protection and forest protection—the development of legislation and forest protection services in Poland. *Folia Forestalia Polonica* 60(1): 52-60.
- Keesstra, S., Mol, G., de Leeuw, J., Okx, J., de Cleen, M., Visser, S., 2018. Soil-related sustainable development goals: Four concepts to make land degradation neutrality and restoration work. *Land* 7(4): 133.
- Keesstra, S., Nunes, J. P., Saco, P., Parsons, T., Poeppel, R., Masselink, R., & Cerdà, A., 2018. The way forward: Can connectivity be useful to design better measuring and modelling schemes for water and sediment dynamics?. *Science of The Total Environment* 644: 1557-1572.
- Keesstra, S., Wittenberg, L., Maroulis, J., Sambalino, F., Malkinson, D., Cerdà, A., Pereira, P., 2017. The influence of fire history, plant species and post-fire management on soil water repellency in a Mediterranean catchment: The Mount Carmel range, Israel. *Catena* 149: 857-866.
- Keesstra, S.D., Rodrigo-Comino, J., Novara, A., Giménez-Morera, A., Pulido, M., Di Prima, S., Cerdà, A., 2019. Straw mulch as a sustainable solution to decrease runoff and erosion in glyphosate-treated clementine plantations in Eastern Spain. An assessment using rainfall simulation experiments. *Catena* 174: 95-103.
- Korucu, T., Arslan, S., Dikici, H., Tanriverdi, C., 2007. The effect of post harvest period and stubble burning on the variation of soil penetration resistance and moisture content. *Tarım Makinaları Bilimi Dergisi* 3(1): 41-49 [in Turkish].
- Korucu, T., Say, S.M., Cerit, İ., Ülger, A.C., Kirişçi, V., Turkay, M.A., Sarıhan, H., Şen, H.M., 2005. Effects of tillage methods on soil compaction and maize grain yield. *Tarım Makinaları Bilimi Dergisi* 1(1): 77-83 [in Turkish].
- Koulelis, P., Mitsopoulos, I., 2007. A study of the socioeconomic factors influencing wildfire occurrence in Mediterranean basin countries. In: Proceedings of the third international symposium on fire economics, planning, and policy: common problems and approaches. González-Cabán, A. (Ed.). USDA Forest Service, Pacific Southwest Research Station: Albany, CA (PSW-GTR-227), pp. 314–320.
- Limon-Ortega, A., Sayre, K.D., Drijber, R.A., Francis, C.A., 2002. Soil attributes in furrow-irrigated bed planting system in Northwest Mexico. *Soil and Tillage Research* 63(3-4): 123-132.
- López-Vicente, M.; Calvo-Seas, E.; Álvarez, S.; Cerdà, A. 2020. Effectiveness of Cover Crops to Reduce Loss of Soil Organic Matter in a Rainfed Vineyard. *Land* 9(7): 230.
- Mavsar, R., Cabán, A.G., Varela, E., 2013. The state of development of fire management decision support systems in America and Europe. *Forest Policy and Economics* 29: 45-55.
- McCarty, J.L., Korontzi, S., Justice, C.O., Loboda, T., 2009. The spatial and temporal distribution of crop residue burning in the contiguous United States. *Science of the Total Environment* 40: 5701-5712.
- Mierauskas, P., 2012. Policy and legislative framework overview of fire management in Lithuanian protected areas. *Flamma* 3(3): 1-5.
- Mittal, S.K., Singh, N., Agarwal, R., Awasthi, A., Gupta, P.K., 2009. Ambient air quality during wheat and rice crop stubble burning episodes in Patiala. *Atmospheric Environment* 43(2): 238-244.
- Montiel-Molina, C., 2013. Comparative assessment of wildland fire legislation and policies in the European Union: Towards a Fire Framework Directive. *Forest Policy and Economics* 29: 1-6.
- Mourao, P.R., Martinho, V.D., 2019. Forest fire legislation: Reactive or proactive? *Ecological Indicators* 104: 137-144.
- Novara, A., Cerda, A., Barone, E., Gristina, L. 2021. Cover crop management and water conservation in vineyard and olive orchards. *Soil and Tillage Research* 208: 104896.
- Novara, A., Pulido, M., Rodrigo-Comino, J., Di Prima, S., Smith, P., Gristina, L., ... Keesstra, S., 2019. Long-term organic farming on a citrus plantation results in soil organic matter recovery. *Cuadernos de Investigación Geográfica* 45: 271-286.
- Novara, A., Sarno, M., Pereira, P., Cerdà, A., Brevik, E. C., Gristina, L., 2018. Straw uses trade-off only after soil organic carbon steady-state. *Italian Journal of Agronomy* 13: 216-220.
- Pausas, J.G., 2004. Changes in fire and climate in the eastern Iberian Peninsula (Mediterranean basin). *Climatic Change* 63: 337-350.
- Pausas, J.G., Keeley, J.E., 2014. Abrupt climate-independent fire regime changes. *Ecosystems* 17: 1109-1120.
- Ravindra, K., Singh, T., Sahil, M., Singh, V., Kumar, T., Singh, M., Kumar, S., Dhankhar, R., Suman, M., Beig, G., 2019. Real-time monitoring of air pollutants in seven cities of North India during crop residue burning and their relationship with meteorology and transboundary movement of air. *Science of The Total Environment* 690: 717-729.
- Rodrigo-Comino, J., Giménez-Morera, A., Panagos, P., Pourghasemi, H. R., Pulido, M., Cerdà, A., 2020. The potential of straw mulch as a nature-based solution for soil erosion in olive plantation treated with glyphosate: A biophysical and socioeconomic assessment. *Land Degradation & Development* 31:1877-1889.
- Rodrigo-Comino, J., Terol, E., Mora, G., Giménez-Morera, A., Cerdà, A., 2020. Vicia sativa roth. Can reduce soil and water losses in recently planted vineyards (*Vitis vinifera* L.). *Earth Systems and Environment* 4: 827–842.

- Saggu, G.S., Mittal, S.K., Agarwal, R., Beig, G., 2018. Epidemiological study on respiratory health of school children of rural sites of Malwa region (India) during post-harvest stubble burning events. *MAPAN* 33(3): 281-295.
- San-Miguel-Ayanz, J., Camia, A., 2010. Mapping the impacts of natural hazards and technological accidents in Europe. An Overview of the Last Decade. EEA, Copenhagen, 146p.
- San-Miguel-Ayanz, J., Schuck, E., Schmuck, G., Camia, A., 2013. The European Forest Fire Information System in the context of environmental policies of the European Union. *Forest Policy and Economics* 29: 19-25.
- Sannigrahi, S., Pilla, F., Basu, B., Basu, A.S., Sarkar, K., Chakraborti, S., Joshi, P.K., Zhang, Q., Wang, Y., Bhatt, S., Bhatt, A., Jha, S., Keesstra, S., Roy, P.S., 2020. Examining the effects of forest fire on terrestrial carbon emission and ecosystem production in India using remote sensing approaches. *Science of The Total Environment* 725: 138331.
- Searle, S., Bitnere, K., 2017. Review of the impact of crop residue management on soil organic carbon in Europe. The International Council on Clean Transportation, ICCT working paper no: 2017-15. Available at [access date: 19.02.2021]: <https://theicct.org/publications/impact-of-crop-residue-mgmt-EU>
- Smith, R., Adams, M., Maier, S., Craig, R., Kristina, A., Maling, I. 2007. Estimating the area of stubble burning from the number of active fires detected by satellite. *Remote Sensing of Environment* 109: 95-106.
- Tedim, F., Leone, V., Xanthopoulos, G., 2016. A wildfire risk management concept based on a social-ecological approach in the European Union: Fire smart territory. *International Journal of Disaster Risk Reduction* 18: 138-153.
- Temel, M., 2012. Biçerdöver ve Anız Yangınları, Turkish Agricultural Chamber Publications, No: 42. Ankara, Turkey.
- Temiz, H., Olgar, K., 2017. Investigation of insulation properties of panels produced from natural and artificial fibers. *Karaelmas Fen ve Mühendislik Dergisi* 7(2): 608-618 [in Turkish].
- TUIK, 2020. Turkish Statistical Institute. Main agricultural statistics data-2019 [in Turkish]. Available at [access date: 27.06.2020]: <http://www.tuik.gov.tr/UstMenu.do?metod=temelist>
- Turyahabwe, N., Banana, A.Y., 2008. An overview of history and development of forest policy and legislation in Uganda. *International Forestry Review* 10(4): 641-656.
- Valzano, F.P., Greene, R.S.B., Murphy, B.W., 1997. Direct effects of stubble burning on soil hydraulic and physical properties in a direct drill tillage system. *Soil and Tillage Research* 42(3): 209-219.
- Velez, R., 2010. Prescribed burning for improved grazing and social fire prevention: the Spanish EPRIF Programme. In: Best Practices of Fire Use-Prescribed Burning and Suppression Fire Programmes in Selected Case-Study Regions in Europe. Montiel, C., Kraus, D. (Eds.). European Forest Institute Research Report 24, Porvoo, Finland. Available at [access date: 19.02.2021]: https://www.ucm.es/data/cont/docs/530-2013-10-15-efi_rr2449.pdf
- Venkataraman, C., Habib, G., Kadamba, D., Shrivastava, M., Leon, J.F., Crouzille, B., Streets, D.G., 2006. Emissions from open biomass burning in India: integrating the inventory approach with high-resolution Moderate Resolution Imaging Spectroradiometer (MODIS) active-fire and land cover data. *Global Biogeochemical Cycles* 20(2): 1-12.
- Vermeire, L.T., Mitchell, R.B., Fuhlendorf, S.D., Gillen, R., 2004. Patch burning effects on grazing distribution. *Journal of Range Management* 57: 248-252.
- Virto, I., Imaz, M.J., Enrique, A., Hoogmoed, W., Bescansa, P., 2007. Burning crop residues under no-till in semi-arid land, Northern Spain—effects on soil organic matter, aggregation, and earthworm populations. *Australian Journal of Soil Research* 45(6): 414-421.
- Visser, S., Keesstra, S., Maas, G., De Cleen, M., 2019. Soil as a basis to create enabling conditions for transitions towards sustainable land management as a key to achieve the SDGs by 2030. *Sustainability* 11(23): 6792.
- Williams, R., Poole, N., Fraser, T., Grant, D., Hanson, N., Orson, J., Rolston, P., Sim, J., 2020. Review of the role and practices of stubble burning in New Zealand, including alternative options and possible improvements. FAR Report by Canterbury Regional Council, NZ. Available at [access date: 19.02.2021]: https://www.far.org.nz/assets/files/uploads/130809_FAR_Stubble_Burning_Review_Final.pdf
- Xanthopoulos, G., Caballero, D., Galante, M., Alexandrian, D., Rigolot, E., Marzano, R., 2006. Forest fuels management in Europe. Andrews, L.; Butler Bret, W. (compilers): Proceedings of the Conference on Fuels Management - How to Measure Success; 2006 March 28–30; Portland, Oregon, USA. Proceedings RMRS-P-41. Fort Collins, CO: Rocky Mountain Research Station, Forest Service. U.S. Department of Agriculture, pp. 29-46.
- Yilmaz, G., Bilgili, A.V., Toprak, D., Almaca, A., Mermut, A.R., 2014. Effects of stubble burning on the carbon dioxide emission. *Harran Tarım ve Gıda Bilimleri Dergisi* 18(1): 26-32 [in Turkish].