Soil Fertility and Fertilizers
Professor Somsubhra Chakraborty
Agriculture and Food Engineering Department
Indian Institute of Technology, Kharagpur
Lecture: 58
Agriculture Productivity and Environmental Quality (Contd.)

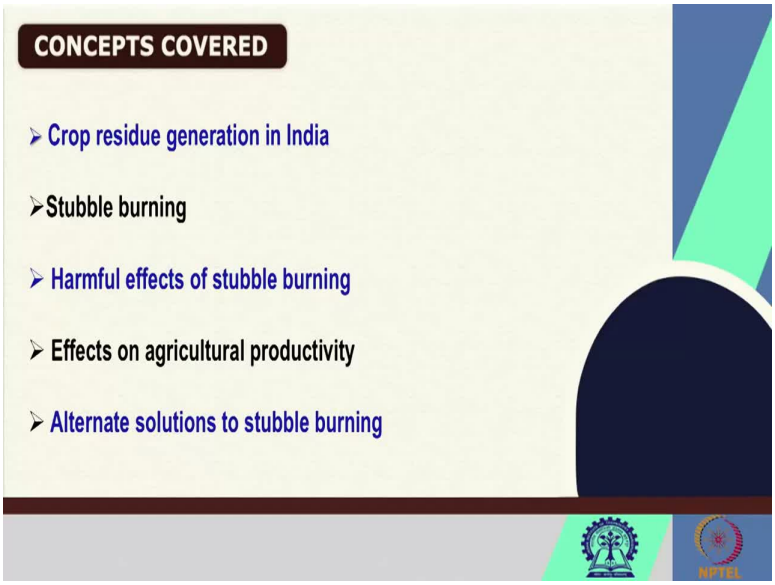
(Refer Slide Time: 0:17)

Welcome friends to this 58th lecture of NPTEL online certification course of Soil Fertility and Fertilizers. We are at currently week 12 lecture. So in this week our topic is agricultural productivity and environmental quality. In different lectures of this week, we are discussing some of the broader environmental impacts of agricultural practices and how we can mitigate some of the deleterious or hazardous impacts of agricultural practices.

So in a previous two lectures, we have discussed about carbon sequestration and how agricultural practices are linked with carbon sequestration. And another lecture we have devoted for discussing the fertilizer based environmental problems, eutrophication and how we can control those problems using alternate sources of plant nutrients like bio fertilizers, manures and so on.

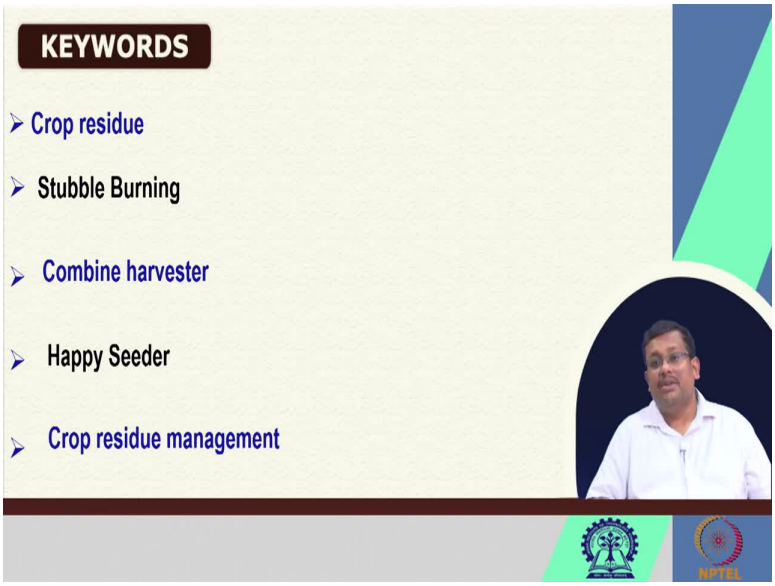
So in those previous two lectures, you have seen the discussion on carbon sequestration and fertilizer based environmental problem. Now in this lecture number 58, we are going to focus on another very important environmental problem, which is related to agricultural practices specifically in Indian condition. So we are going to discuss stubble burning and its impacts on soil and other environmental properties.

(Refer Slide Time: 02:16)



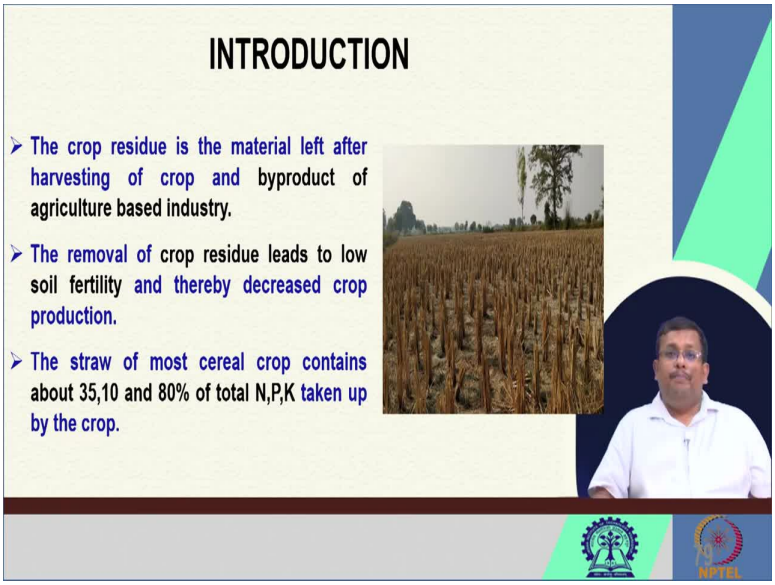
So these are the concepts which we are going to cover in this lecture. First of all, we are going to discuss about crop residue generation in India. Then we are going to discuss stubble burning and how the stubble burning is impacting the environment we are also going to discuss. Then effects of stubble burning on agriculture productivity we are going to also discuss, and then we are going, we will try to find some alternative solution to stubble burning so that the health hazards which are linked with stubble burning can be reduced.

(Refer Slide Time: 03:00)



Now, these are some of the keywords for this lecture crop residue, stubble burning, combine harvester, happy cedar and crop residue management, which we are going to discuss in this lecture.

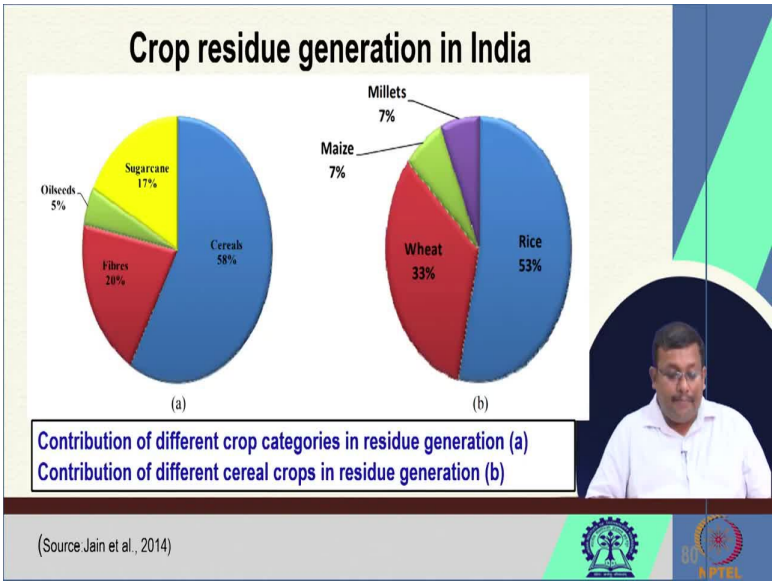
(Refer Slide Time: 03:10)



So let us discuss what is stubble burning and why it is very important at environmental problem in India. The crop residue is the material which is left after harvesting of crop and byproduct of agriculture based industry. So whenever we harvest the crop the stubbles for example, in case of rice and wheat, the stubbles which is left in the field are known as crops, these are several these are crop residues.

Now the removal of crop residue leads to low soil fertility and thereby decrease crop production. And the straw of most cereal crop contains about 35 to 10 and 80 percent of the total N, P, K taken up by the crop. So these are very important consideration to understand the impact of stubble burning. Remember that the straw of the most cereal crop contains about 35, 10 and 80 percent of the total N, P, K taken up by the crop.

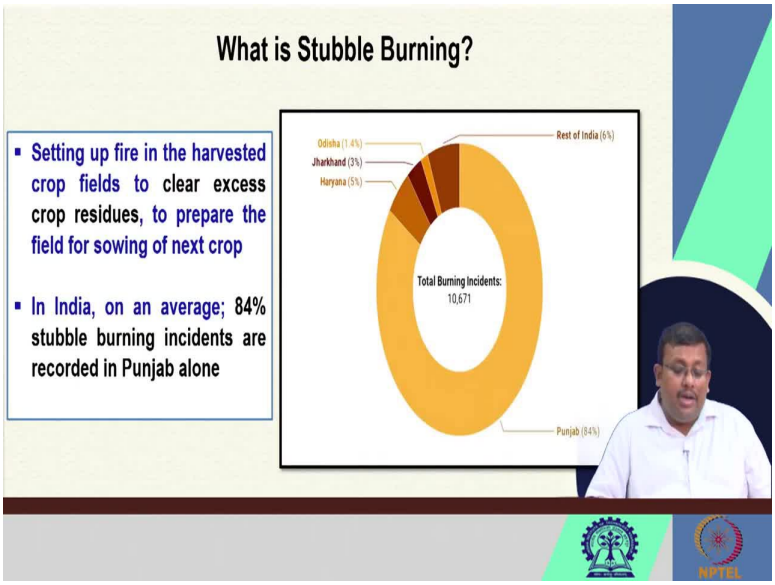
(Refer Slide Time: 04:25)



Now if we see the crop residue generation in India, the scenario of crop residue generation in India, here we can see that cereals accounts for 58 percent of the total crop residue generated in India, fibers accounts for 20 percent, then oil seed accounts for 5 percent, and sugarcane accounts for 17 percent. So these are, this is the distribution of crop or crop wise crop residue generation in India.

And then if we see that contribution of different cereal crops because cereal crop as you can see here, it accounts for majority of the crop residue. Now if we see within the cereal also, rice accounts for 53 percent of the residue, whereas wheat accounts for 33 percent of the generated residue, maize account for 7 percent, whereas millets accounted for 7 percent. So these are the contribution of different cereal crop in residue generation.

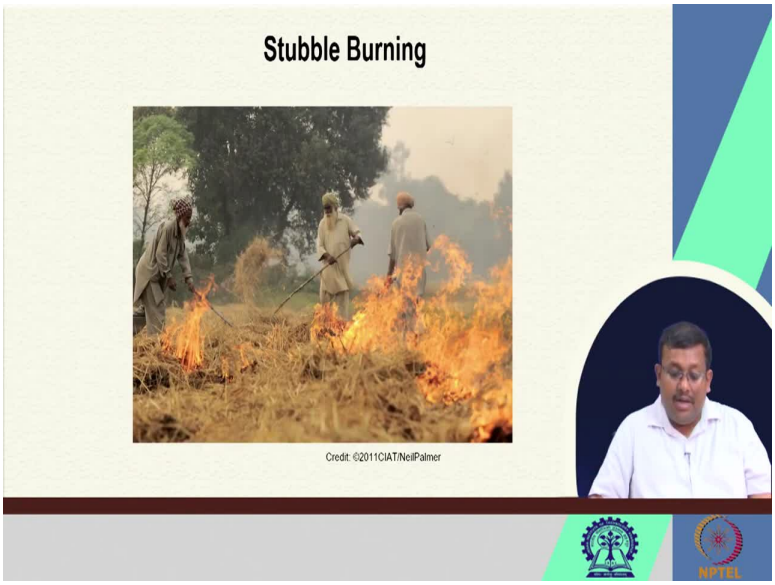
(Refer Slide Time: 05:32)



Now what is stubble burning? Now stubble burning is setting up fire in the harvested crop fields to clear the excess crop residues to prepare the field for sowing of next crop. So this is called stubble burning. What people do say basically the farmers? They setup the fire in the harvested crop fields after harvesting the crop to clear the excess of the crop residues to prepare the field for sowing of the next crop, so that is called stubble burning.

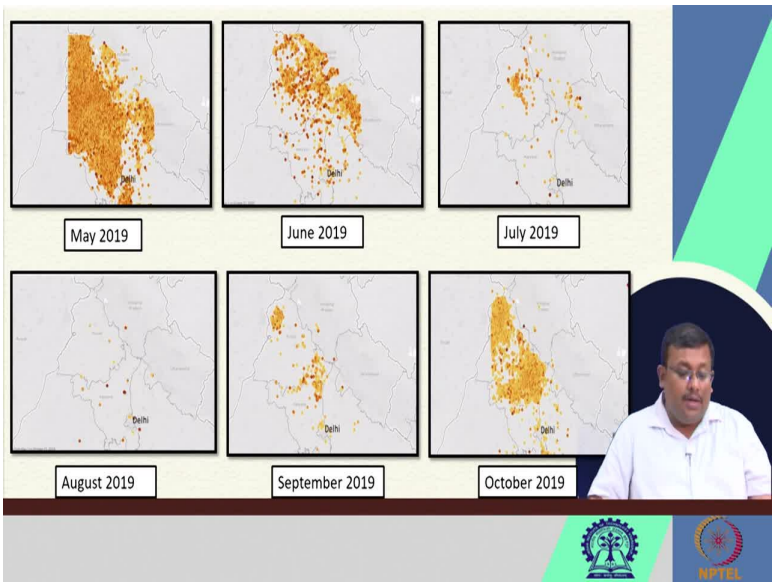
Now in India on an average 84 percent stubble burning incidents are recorded in Punjab. So Punjab accounts for the majority of the stubble burning incidents in India. So if you see the distribution of contribution from different states, we can see Punjab accounts for 84 percent whereas, Haryana accounts only 5 percent, Jharkhand accounts for 3 percent whereas, Odisha accounts for only 1.4 percent and rest of the India accounts for 6 percent. So if you consider the total burning incidence of 10,671 the data we have seen the 84 percent of this stubble burning occurs in Punjab.

(Refer Slide Time: 06:54)



Now this is the picture of stubble burning where you can see farmers are burning the straw which are left in the field after the harvest and this is a very common practice after the rice harvest.

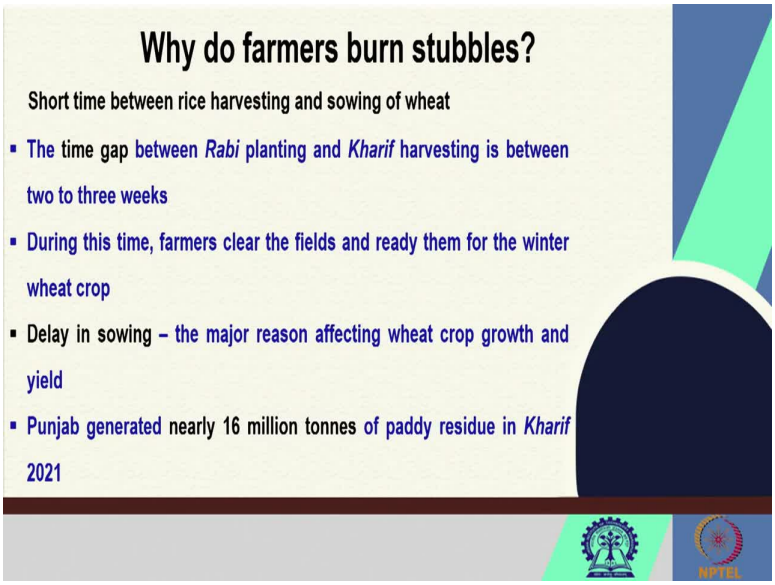
(Refer Slide Time: 07:16)



Now, you can see the occurrence of temporal variation of occurrence of stubble burning in Punjab. So you can see in during the May the most occurrence of stubble burning appears here in Punjab region, and then this is June and July the incidence of stubble burning considerably goes down and then in August almost negligible and then from September onwards up to October again stubble burning is increasing. So that shows the temporal

variation and of course, this temporal variation of stubble burning matches with the crop the timing of the growing different successive crops.

(Refer Slide Time: 08:04)



Now, the question comes to our mind why do farmers burns stubble? This is the most important question where we will discuss stubble burning, and if we want to, if we want to address the problem of stubble burning, we have to understand why do farmers burn stubbles?

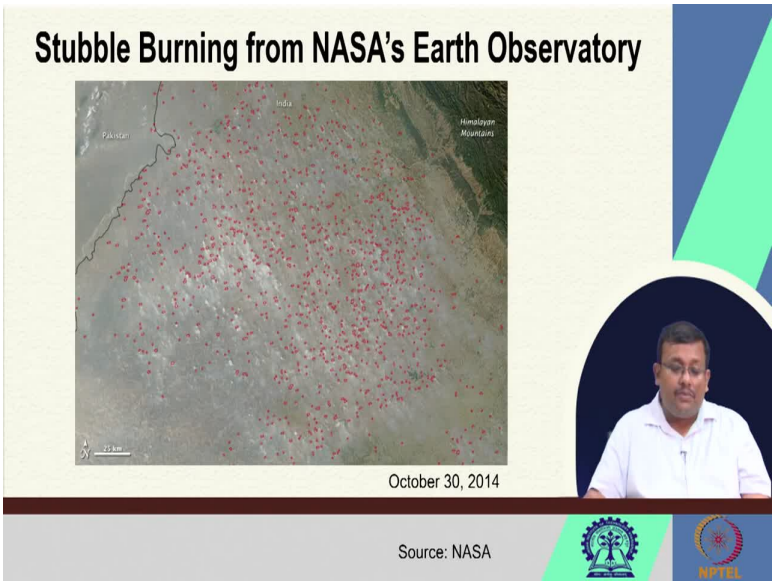
Because in case of Punjab they have very short time between rice harvesting and sowing of wheat. So the time gap between Rabi planting and Kharif harvesting is between 2 to 3 weeks. So during the Kharif harvesting of rice crop and successive planting of Rabi crops that is wheat, the time gap is very limited, which is only 2 to 3 weeks.

Now, during this time farmer clear the fields and ready them for winter wheat crops. So whatever they have to do, they have to complete all the operation within this 2 to 3 weeks. However, if there is a delay in sowing that is the major reason effective wheat crop growth and yield. They cannot delay the sowing of wheat crop, because if they delay the sowing of the wheat crop that will affect the wheat crop growth and yield.

So and also remember that Punjab generated nearly 16 million tons of paddy residue in Kharif 2021. So that shows clearly that since the time gap between the Kharif harvesting and the planting of the successive wheat crop is very short, and farmers has to clear the field before the planting of the wheat crop they get very short amount of time to complete all these

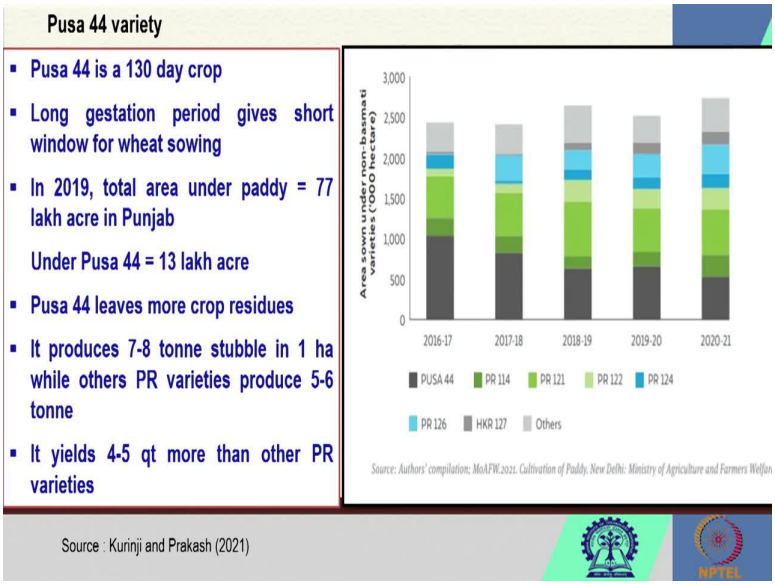
operations. And as a result the burning of the stubble becomes one of the feasible options to the stem.

(Refer Slide Time: 10:12)



So as a result, what happens instead of carrying and disposing the stubble from the field and spending money on management of this residue, they just set it on fire and thereby destroying whatever standing residue are there after the harvest. So that becomes an economic solution for the farmers to clear their field within a very short period of time. So that they do not delay the sowing of the successive crop. Now if you see the stubble burning from NASA's Earth Observatory, you can see that it is a data of October 30 2014. Now you can see the occurrence of stubble burning in Punjab region of India.

(Refer Slide Time: 11:08)

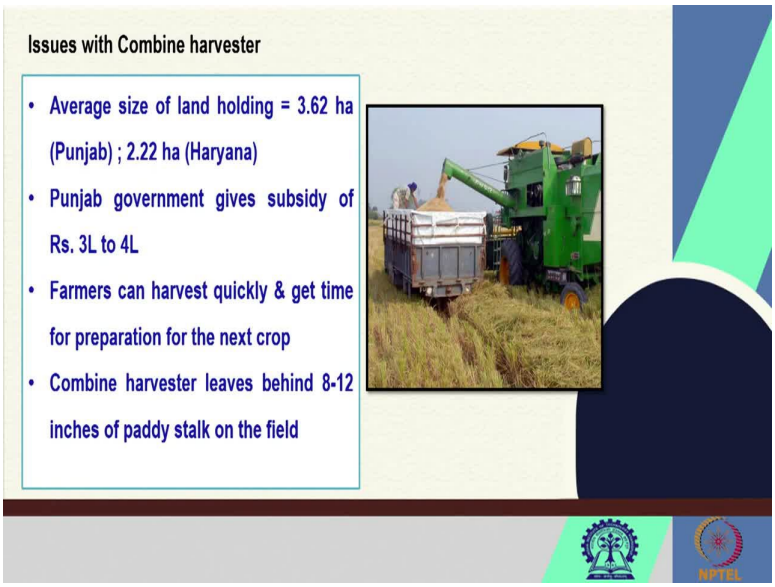


Now, we can see that the major crop, one of the major variety which is grown in Punjab is Pusa 44. Now this Pusa 44 variety is a 130 day crop. So the duration of this crop is 130 days. Now long gestation period gives short window for wheat growing. So since this Pusa 44 has a long gestation period, it allows for very short window for wheat sowing. Now in 2019 total area under paddy was 77 lakh acre in Punjab and under Pusa 44 out of the 77, 13 lakh acre were under this Pusa 44 variety.

And remember that this Pusa 44 leaves more crop residues than other varieties. Now it produces 7 to 8 tons stubble in one hectare, while other varieties produce 5 to 6 times. So it yields 4 to 5 quintal more than other rice varieties. So you can see here this is, this is the year wise data from 2016 to 2020-21 you can see area sown under non-basmati varieties you can see that Pusa 44 accounts for the majority.

Although the share of the area covered under Pusa 44 has gradually declined in recent time however, you see that as compared to the other varieties it is still dominating, and that is why they produce huge amount of stubble and thereby encouraging the farmers to destroy the stubble by burning them in the field.

(Refer Slide Time: 13:12)

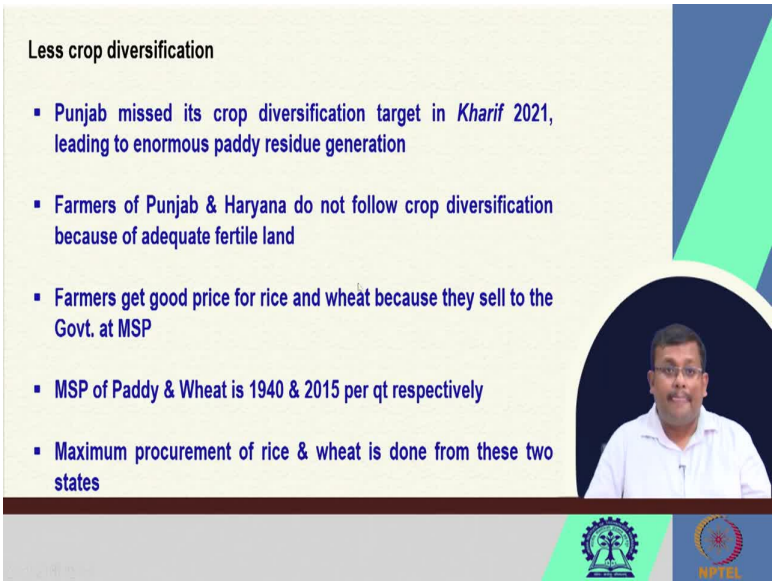


Now, there is a instrument called combine harvester. So combine harvester is being used in the field for harvesting of the crop. And if we see the average size of landholding in Punjab and Haryana that is in Punjab it is 3.62 hectare, whereas in case of Haryana is 2.22 hectare. Now, Punjab government gives subsidy to rupees 3 lakh to 4 lakhs, so of course, for to

harvest the in this huge field you need to have kind of instruments or machines to be operated in the field.

So Punjab government gives subsidy of rupees 3 lakh to 4 lakh, so farmers can harvest quickly and get time for preparation for the next also. So they all use this combined harvester to harvest the crop so that they can harvest the crop very quick and get the enough time for preparation for the next crop. Now, the combine harvester leaves behind 8 to 12 inches of paddy stock on the field. So that creates the issues of stubble burning.

(Refer Slide Time: 14:30)



Now, another reason is less crop diversification. Now Punjab missed its crop diversification target in Kharif 2021 leading to enormous paddy residue generation. And as we have seen, the majority of the area comes under Pusa 44 varieties, so the diversification is less as a result the generation of residue is huge.

Now farmers of Punjab and Haryana do not follow crop diversification because of adequate fertile land. So they do not need to follow this crop diversification because they have adequate amount of fertile land and farmers get good price for rice and wheat because they sell to the government at minimum supported price.

So, minimum support price of paddy and wheat is 1940 and 2015 per square per quintal respectively for Paddy and wheat. And the maximum procurement of rice and wheat is done from these two states, from Punjab and Haryana. So these are the reasons for less crop diversification and when there is a less crop diversification, majority of the area will come

under Pusa 44 which is a residue generating variety and as a result there will be incidents of stubble burning.

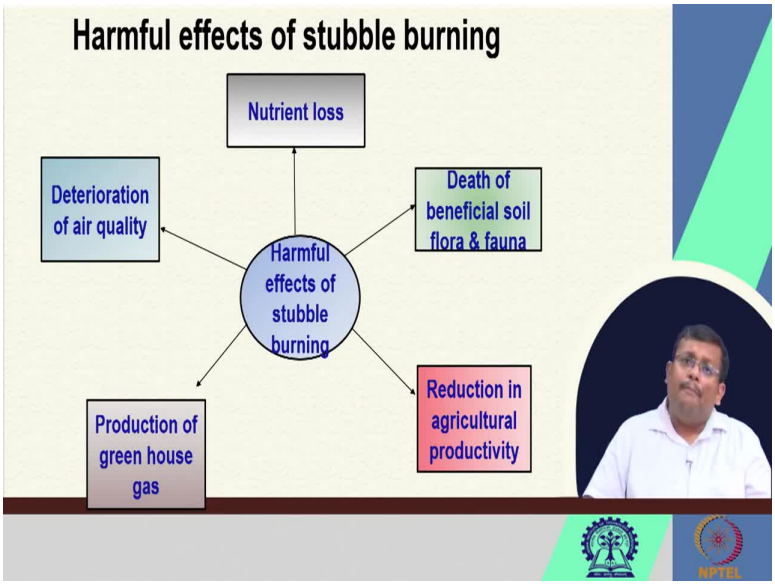
(Refer Slide Time: 15:56)

And also these rice straw which are left in the field and not very popular animal feed also because rice straw has high silica and lignin content and low crude protein content. So if the stubble is used as fodder, it impacts the quality of the milk also, because the calcium content can be decreased by up to 2 percent.

So you can see that these rise straw cannot be alternatively used as a popular animal feed because of these two reasons. And of course, high fuel cost is another big reason for stubble burning. So the happy seeder and the super seeder are tractor towed implements. So the fuel consumption of happy seeder is 16 liters of diesel per hectare and super seeder consumed 22 liter of diesel per hectare, that is 9 liter per acre and price of diesel is quite high right now.

So these are some of the reason for which encourage the farmers to burn their stubble as a lucrative option for residue management or economic option I would say, it is an economic option to them for residue management.

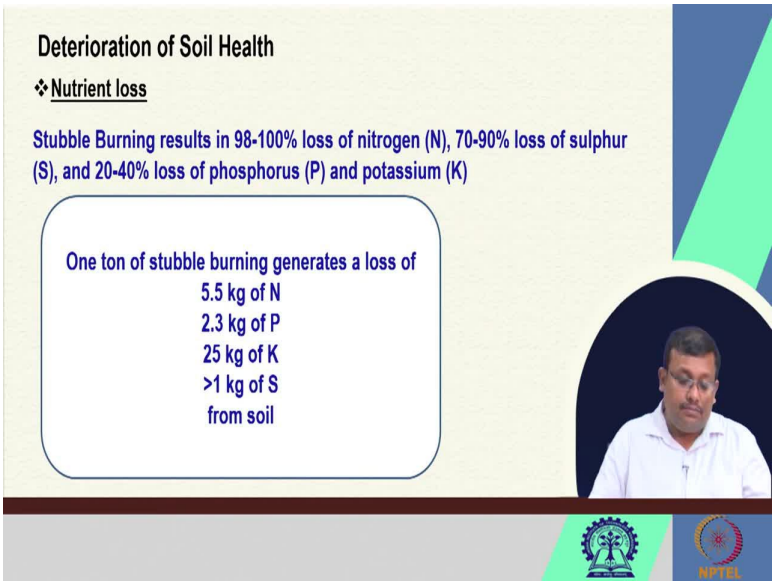
(Refer Slide Time: 17:19)



Now, what are the harmful effects of stubble burning? We can see first of all, there will be nutrient loss of course, we are burning the stubble, so that means we are losing the nutrients which are there in the residue. Secondly, when we are burning this residue, there is depth of beneficial soil flora and fauna, so this is another important impact of stubble burning. Then reduction in agricultural productivity of course, the stubble burning will harmfully affect and reduce the agricultural productivity. So this reduction in agricultural productivity is another major impact of stubble burning.

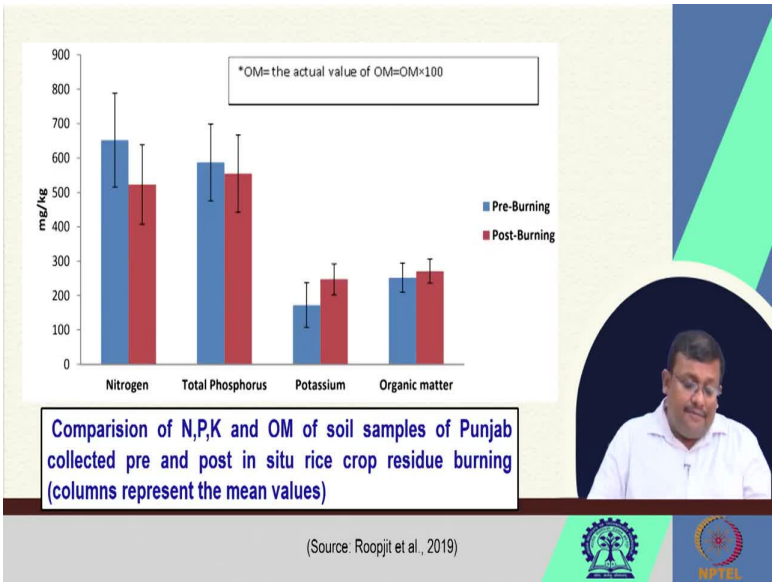
Then production of greenhouse gases, huge amount of greenhouse gases are produced as a result of this harmful stubble burning. And deterioration of air quality is another this is a major environmental impact deterioration of the air quality the recently for last couple of decades, the air quality of New Delhi and nearby places have been polluted, I mean the air quality scenario in this region has been declining since last couple of decades and the situation becomes worse during the winter months, because of stubble burning, because before the winter planting of it the farmers of Punjab they burn the stubble and as a result, during the winter months, there is a huge deterioration of the air quality in New Delhi and nearby places. Also, you can see reduction in visibility due to the air pollution and that causes human health hazards also. So these are all harmful effects of stubble burning.

(Refer Slide Time: 19:24)



If you see the deterioration of soil health, of course, stubble burning results in 98 to 100 percent loss of nitrogen and 70 to 90 percent loss of sulphur and then 20 to 40 percent loss of phosphorus and potassium. Now one ton of stubble burning generates a loss of 5.5 kg of nitrogen, 2.3 kg of phosphate, 25 kg of potassium and then more than 1 Kg of Sulphur from the soil. So these are the detrimental effects of stubble burning, one of the detrimental effects of stubble burning.

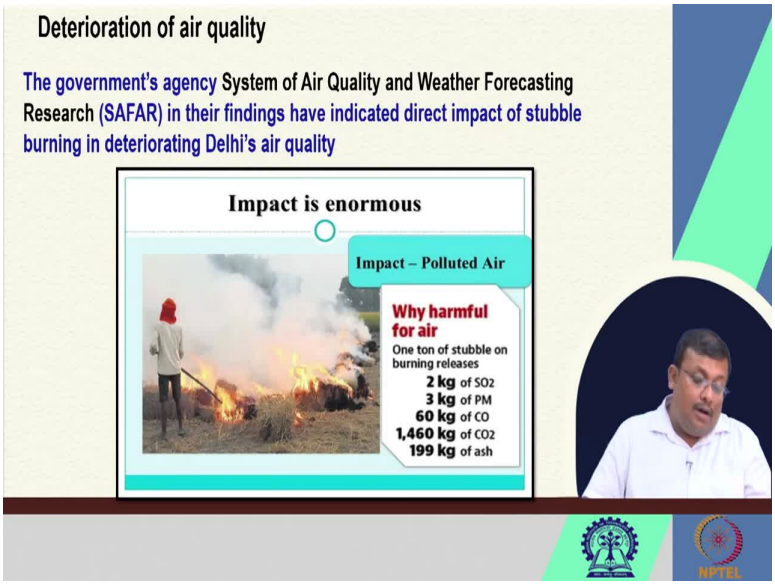
(Refer Slide Time: 20:07)



If you see the comparison of N, P, K and organic matter of soil samples of Punjab, collected pre and post in situ rice crop residue burning, you can clearly see that after the burning of the residues, the nitrogen as well as phosphate and these two important nutrients are reduced as

compared to the pre burning scenario however, potassium has increased. So that shows the impact on nutrient loss by stubble burning.

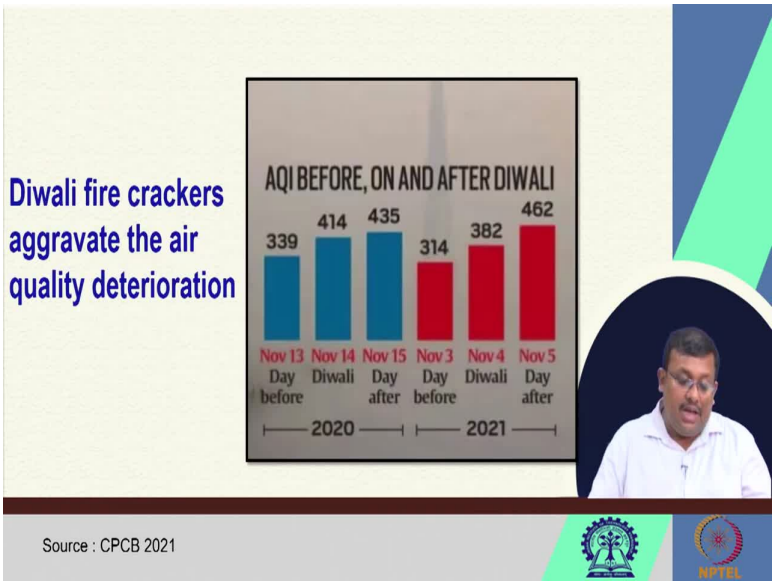
(Refer Slide Time: 20:46)



Of course, the government agency system of air quality and weather forecasting research that is SAFAR in their findings have indicated the direct impact of stubble burning in deteriorating Delhi's air quality, we know that because this stubble burning one ton of stubble on burning releases 2 Kg of Sulphur dioxide, 3 kg of particulate matter, 60 kg of Carbon Monoxide, 1460 kg of carbon dioxide, and 199 kg of ash.

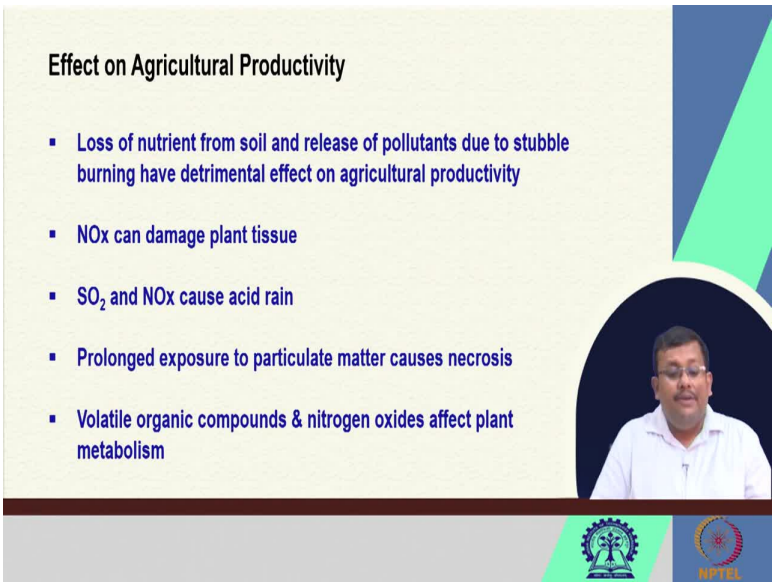
So all these are very much harmful for environmental quality as well as human health and that is why the air quality has been drastically reduce. I mean, we have seen that the air quality of Delhi and nearby places have been deteriorating for last couple of decades due to this stubble burning.

(Refer Slide Time: 21:55)



Of course, you can also see during this winter months the Diwali one of the major festival in India burning of firecrackers also aggravate the air quality deterioration apart from the stubble burning. So according to the data from CPCB central pollution control board.

(Refer Slide Time: 22:17)

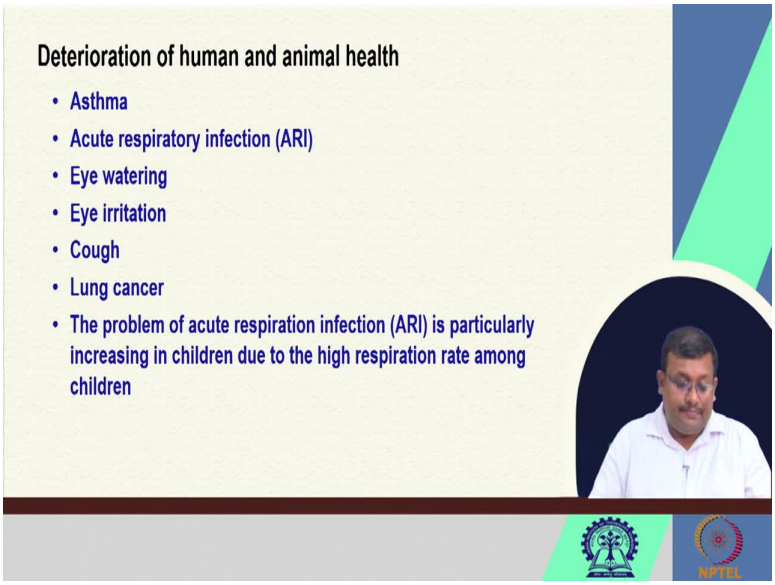


Now if you see what are the other effects on agricultural productivity we know that loss of nutrients from soil and release of and release of pollutants due to stubble burning have detrimental effects on agricultural productivity, and these NOx gases or nitrogen oxide gases can damage plant tissue and then sulphur dioxide and nitrogen oxide gases can cause acid rain, because once they produce they go to the atmosphere and mix there with the air water

vapour and then they produce the sulfuric acid and nitric acid and come back in the form of rain.

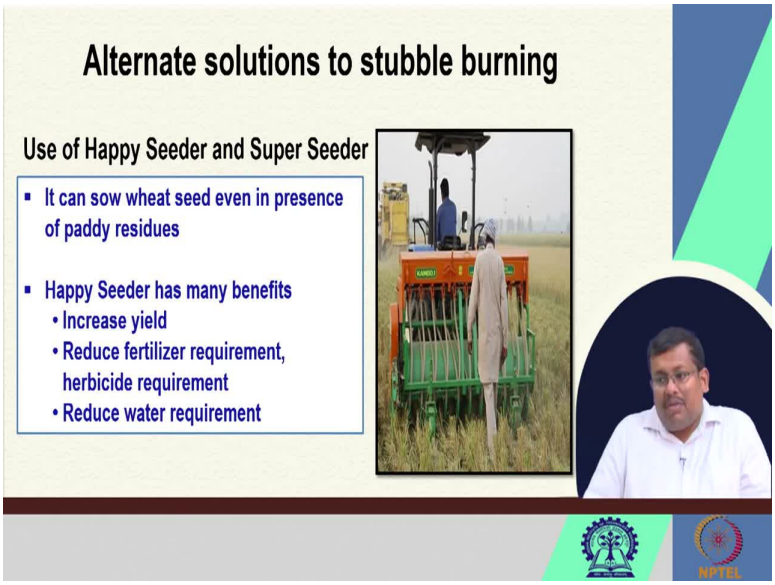
So that is an although this acid rain is it is a localized event but that also impact the environment. So this is one of the harmful impact on agricultural productivity. Then prolonged exposure to particulate matter causes necrosis of the crops also. And then volatile organic compounds and nitrogen oxides affect plant metabolism. So these are the harmful effects on agricultural productivity.

(Refer Slide Time: 23:28)



Then of course deterioration of human and animal health due to poor air quality like and then create asthma, acute respiratory infection, then eye watering, eye irritation, cough, lung cancer, and the problem of acute respiration infection or respiratory infection is particularly increasing in children due to the high respiration rate among children. So these are some of the detrimental effects on human and animal health by the stubble burning.

(Refer Slide Time: 24:06)

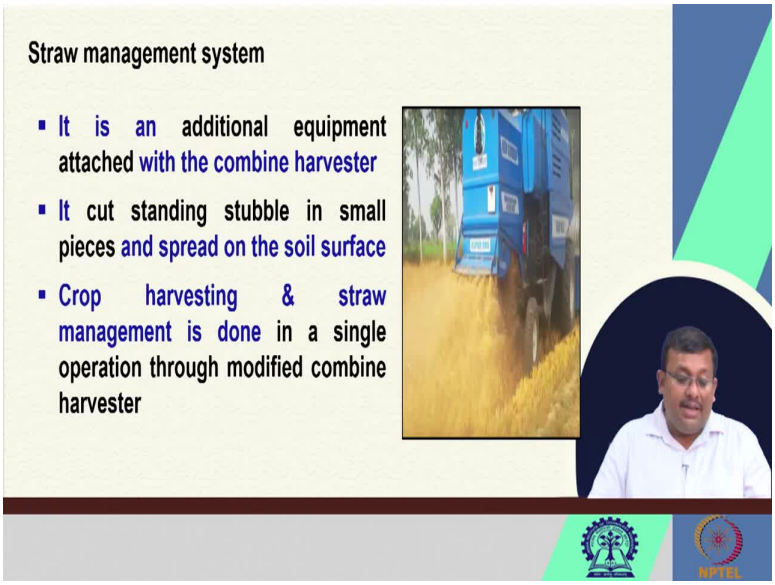


Now at the end, let us discuss what are the alternate solutions to stubble burning? First of all, you can use happy seeder and super seeder, we have already discussed about happy seeder and super seeder, but this could, these are the possible solution. Of course, you have to keep in mind the energy, the price of the energy to run these equipments. So this happy seeder and super seeder they can so which seed even in the presence of paddy residue.

So and happy seeder has many benefits like increase yield, reduce fertilizer requirements, herbicide requirement and reduced water requirement also. However, at the same time you should also make a cost benefit analysis by considering the energy requirement or fuel requirement to run this, to run this equipment.

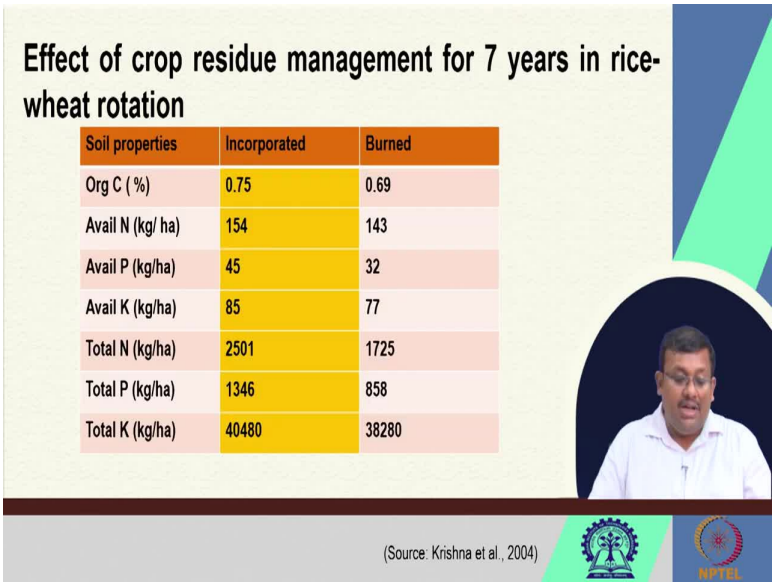
However, these happy seeder and super seeder are having, they are having some beneficial properties I would say they have some advantages while fighting against this stubble burning, because they can sow the seed in the presence of paddy residue. So you do not need to remove those residues for growing the wheat crop.

(Refer Slide Time: 25:32)



Then another is called the straw management system. So it is an additional equipment attached with the combine harvester and it cut standing stubble in small pieces and spread on the soil surface. And crop harvesting and straw management is done in a single operation. So modified combined harvester.

(Refer Slide Time: 25:53)

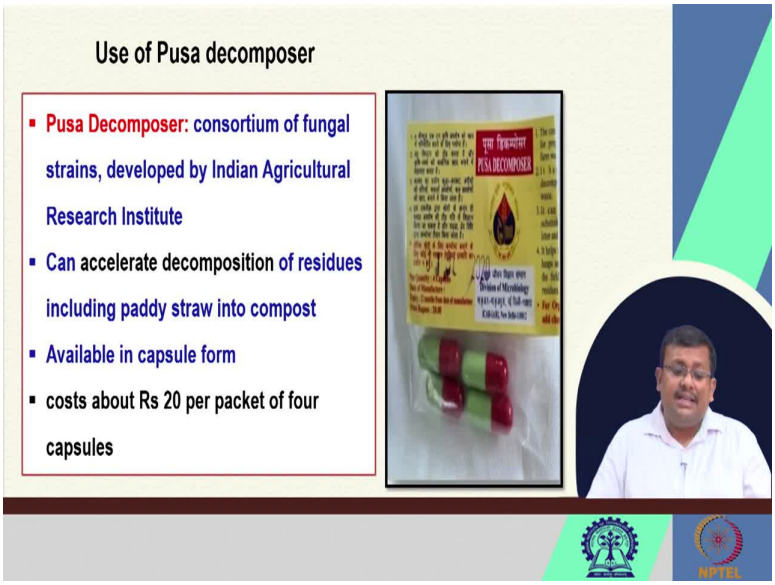


Soil properties	Incorporated	Burned
Org C (%)	0.75	0.69
Avail N (kg/ ha)	154	143
Avail P (kg/ha)	45	32
Avail K (kg/ha)	85	77
Total N (kg/ha)	2501	1725
Total P (kg/ha)	1346	858
Total K (kg/ha)	40480	38280

Now if you see the effect of crop residue management for 7 years in a rice wheat rotation, which was published in 2004, we can see that organic carbon has been declined in due to stubble burning, available nitrogen has been also declined, available phosphate declined, available potassium declined, total nitrogen also declined, total phosphate also declined and then total potassium also declined. So you can see that incorporation or proper residue

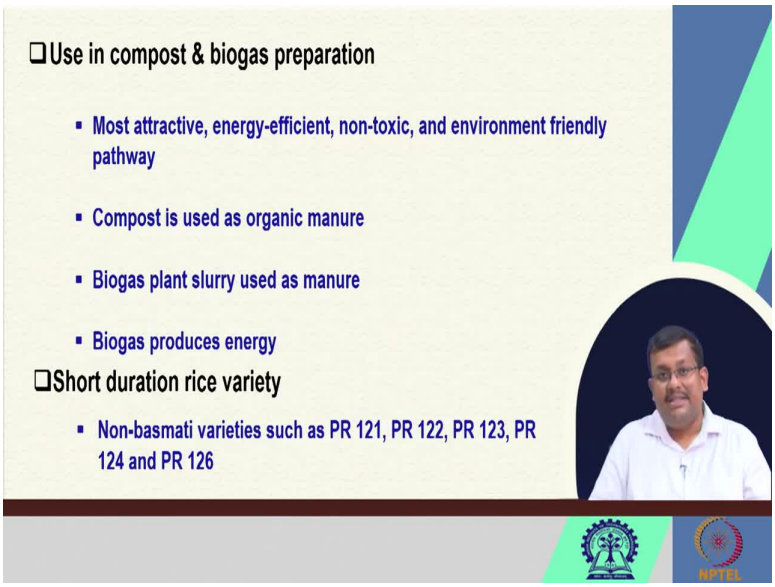
management, crop residue management can enhance the fertility status of the soil as compared to the soil where the stubble burning is practiced.

(Refer Slide Time: 26:45)



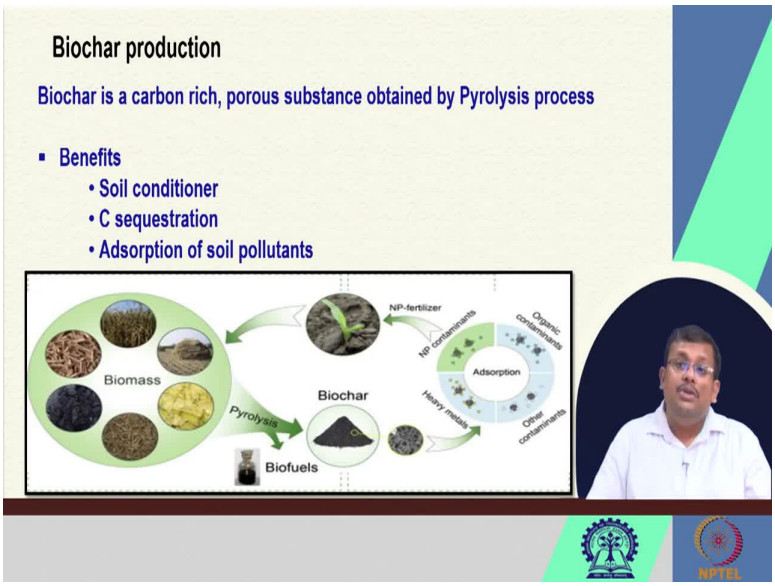
There is another latest development in stubble management that is the Pusa decomposer, Pusa decomposer is the consortium of fungal strains developed by Indian Agricultural Research Institute which can accelerate decomposition of residue including paddy straw into compost and these are available in capsule form. So they are very cheap, cost about 20 per packet of 4 capsules. So you can use this for decomposing the, decomposing the residue.

(Refer Slide Time: 27:17)



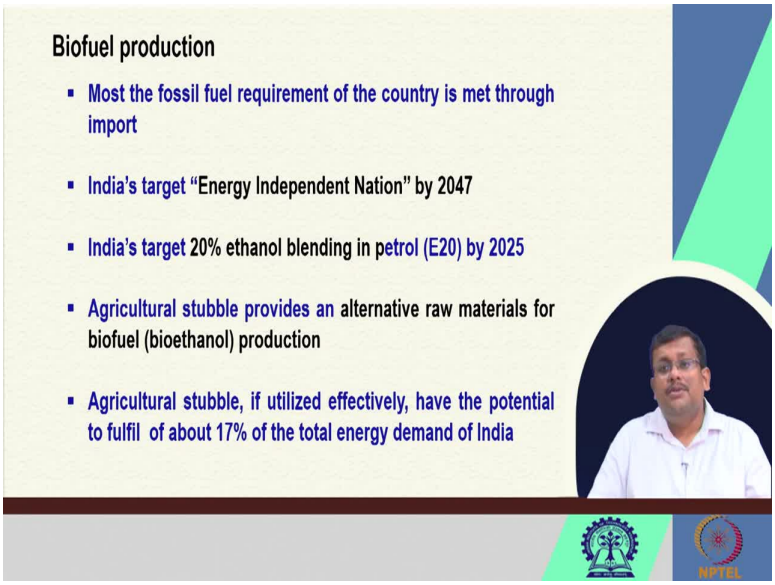
And you can also use your crop residue for compost and biogas preparation. This is most attractive and energy efficient, nontoxic and environmental friendly pathway. Compost is used as organic manure to improve the soil fertility, we have already discussed. Then biogas plant slurry can be also used as manure, and biogas also can be used to produce the energy. And you can also grow short duration rice variety, non-basmati varieties such as PR 121, PR 122, 123, 124 and 126.

(Refer Slide Time: 27:57)



You can also use this stubble for biochar production. So biochar we have already discussed which is a carbon rich porous substance obtained by pyrolysis process. And we know that incorporation of biochar can help in carbon sequestration, it can also acts as a soil conditioner and also they can, it can also absorb soil pollutants.

(Refer Slide Time: 28:20)



You can also use for biofuel production. So most of the fossil fuel requirement of the country is made through import. And India's target "Energy Independent Nation" by 2047. So India's target is 20 percent ethanol blending in petrol by 2025. So agriculture stubble provides an alternative raw materials for this biofuel, or bioethanol production. And agriculture stubble if utilised collectively have the potential to fulfil about 17 percent of the total energy demands in India.

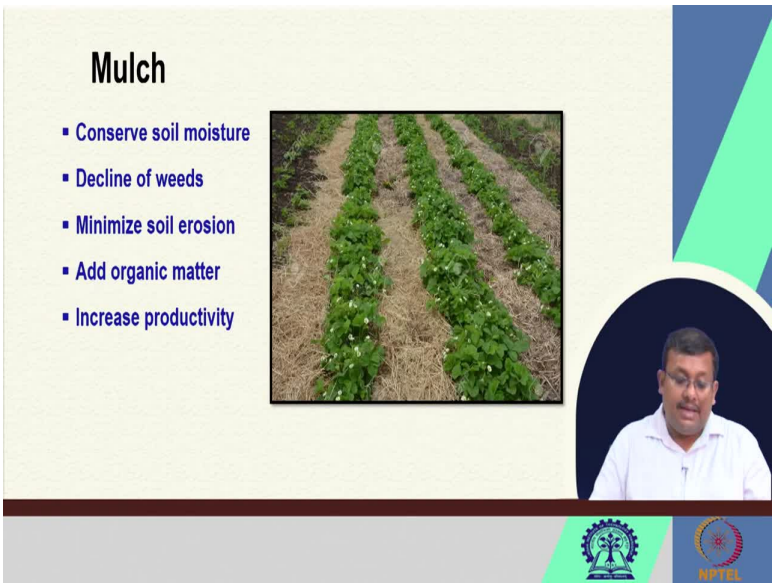
(Refer Slide Time: 28:56)

You can also use this stubble for mushroom cultivation, paddy straw can be used for conveniently for making mushroom growing house and it reduces the cost of cultivation also. So these are alternative solutions.

(Refer Slide Time: 29:09)

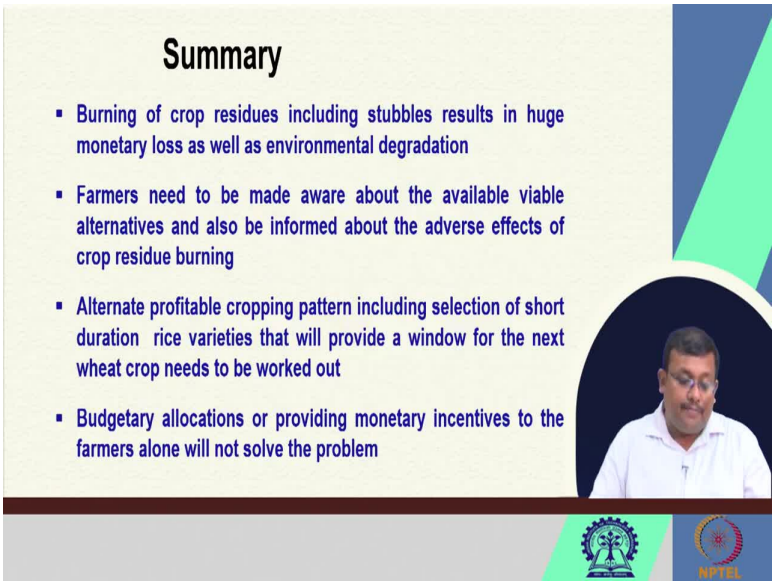
You can also use as a fodder, use straw as fodder, and paddy straw uses a bedding material for cattle poultry etc.

(Refer Slide Time: 29:18)



And then you can of course use this crop residues for mulching which can conserve soil moisture. Also they can control the weeds, minimize soil erosion, add organic matter into the soil and increase the soil crop productivity.

(Refer Slide Time: 29:35)

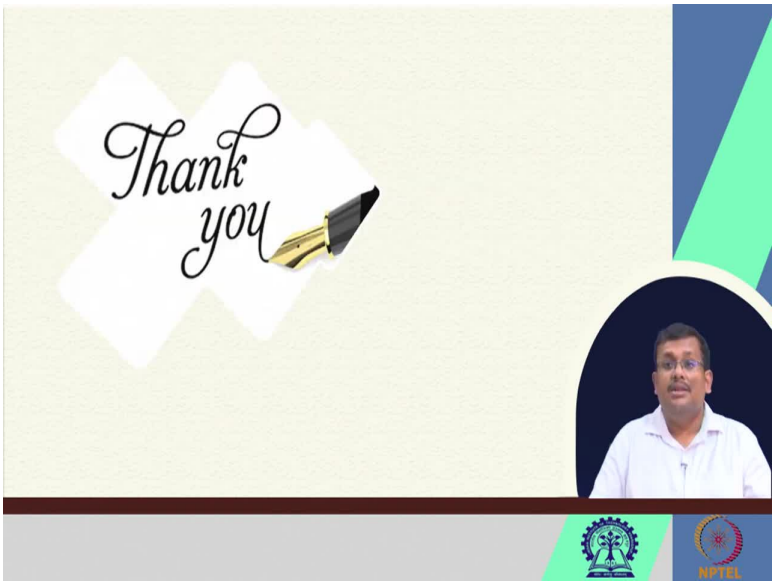


So, summarily we know that burning of crop residues including stubble results in huge monetary loss as well as environmental degradation. So farmers need to be made aware about the available viable alternatives and also be informed about the adverse effects of crop residue burning.

Alternate profitable cropping pattern including selection of short duration rice varieties, that will provide a window for the next wheat crop needs to be worked out. And budgetary allocation for providing monetary incentives to the farmers alone will not solve the problem.

So, these are some of the important message from this lecture, I hope that you have understood the major problem of stubble burning, why farmers burn the stubble and what are their impacts and then how you can manage the stubble burning in alternative ways, so we have discussed them all.

(Refer Slide Time: 30:39)



These are some of the references which we have used for this for this lecture, please go through this for more knowledge on stubble burning and residue management. Let us meet in our next lecture to discuss some other issues. Thank you.