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REDUCING WOOD FUEL CONSUMPTION IN FCV TOBACCO CURING IN KARNATAKA

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Flue Cued Virginia (FCV) tobacco is an important commercial crop grown under rainfed conditions in Southern Transitional Zone (STZ) of Karnataka in an area of 0.75 to 0.80 lakh ha. Unlike other produce, the harvested tobacco (matured green leaf) is basically cured in the specialized structures called 'barns' of specific sizes (13 x 13 x 13' or 16 x16 x 16') with the help of thermal energy inside the barn at farm level before marketing. Majority of farmers use fire wood in the state of Karnataka for generating heat in the curing process and at presenta (70 percent) followed by the coffee husk, which is used by some 16 percent of farmers. The fuel wood required to obtain one kg of cured tobacco leaf varies from 5-6 kgs depending upon the stage of leaf harvest, atmospheric weather conditions during curing, leaf moisture content and barn conditions. Significant heat loss in barns occurs through chimneys, roof and ventilation and also due to poor combustion of wood material in the existing furnace structures used by the farmers. Hence, adoption of energy saving methods/techniques in curing minimizes the use of valuable fuel woodmaterials, conservesthe natural resources and the forest ecosystem's apart from reducing the production expenditure for the farmers. The curing studies were conducted during 2016-17 season at ICAR-CTRI RS Hunsur in association with ITC ILTD ltd., Mysore. The barn size adopted for the study were of 16'x16'x16' and 16' x 24' x 13' dimension. In 16'x 16'x16' size barns, Roof insulation with paddy strawresulted in a net saving of 13.3% wood fuel while the installation of turbo fan on the roof top resulted in saving of around 15%wood fuelcompared to control barn of similar dimension. Similarly,inegration of paddy straw insulation in combination with turbo fan technology in a low profile barn (16' x24' x 13') saved around 34.0 % of fuel wood compared to controland also reduced the total curing time by 22%. These energy-saving measures should be further encouraged in tobacco curing within the KLS region, as curing alone accounts for over 30% of the total production cost in FCV tobacco cultivation.

Flue Cued Virginia (FCV) tobacco is an important commercial crop grown under rainfed conditions in Southern Transitional Zone (STZ) of Karnataka in an area of 0.75 to 0.80 lakh ha. Tobacco grown in the Karnataka Light Soils (KLS) zone under rain-fed conditionsis considered as superior neutral filler with high export demand in the international market due to mild and smooth aroma, balancedleaf chemistry, Tobacco-specific nitrosamines (TSNA) levels below detectable level and lowlevels of heavy metals. Around 80-90 million kg of cured leaf is produced annually, with over 70% exported to several countries, generating approximately Rs 6,000 crores in foreign exchange. Unlike other produce, the harvested tobacco (matured green leaf) is basically cured in the specialized structures called 'barns' of specific sizes (13 x 13 x 13' or 16 x16 x 16') withthe help of thermal energy inside the barn at farm level before marketing. In Karnataka, firewood is typically used for generating heat in the curing process, by majority of farmers (70%) as the primary source of energy for curing, followed by coffee husk, which is used by around 16% of farmers (Nayanatara and Nayak 2013).The fuel wood required to obtain one kg of cured tobacco leaf varies from 5-6 kgs depending upon the stage of leaf harvest, atmospheric weather conditions during curing,leaf moisture content and barn conditions.

In FCV tobacco growing areas of Karnataka, currently the annual firewood requirement for curing tobacco is estimated to be 4-5 lakh tons(considering theproductionlevel of around 80-90 m kg during the last three years). In fact the harvesting and curing process alone accounts for more than 30% of the total cost of Production. The huge fuel wood requirement has greater stress on the natural vegetation and forest ecosystem in the tobacco growing regions. The current curing process followed in the existing barn structures in the area is inefficient in terms of energy, leading

to thermal energy loss and increased cost of curing.Much of the heat generated in barns is lost through chimneys, roofs and ventilationdue to poor combustion of wood in the existing furnace structures used by farmers.It has been observed that significant heat loss in farmers' barns occurs through the chimney pipes (40-45%), roofs (20-25%), over ventilation (15-20%) and walls, doors and other miscellaneous areas (5-10%).

Fire wood being commonly used fuel in curing of FCV tobacco in Karnataka, adoption of energy saving methods/techniques in curing minimizes the use of valuable fuel wood materials and alsogo a long wayin conserving the natural resources and the forest ecosystem's apart from reducing the production expenditure for the farmers.

Material and methods

The curing studies were conducted during 2016-17 season at ICAR-CTRI RS Husur in association with ITC ILTD Ltd., Mysore. The barn size adopted for the study were of 16'x 16'x16'and 16' x24' x 13' dimension. In 16'x 16'x16' size barns, one of the barn was fitted with paddy straw insulation while in the other barn turbo fantechnology was adopted and they were compared with the same size barn having no energy saving modifications (control). Curing was carriedout usingfire wood from eucalyptuswood.
In another set of experiments, a low profile barn (with bran dimension of 16' x24' x 13') was adopted for the study wherein the barn was fitted with paddy straw insulation + turbo fan integration and compared with the same size of barn without any energy conservation measures(control). Minimum of 4 and maximum of 5 curings were run and the total time (hours) takenfor each curing and the total quantity of fuel wood consumed were recorded. Based on thetotal cured leaf productivity obtained from each charge, the average wood consumed for producing one kg of curedleaf was worked out in each of the treatments. Thepercent energy saving due to various energy saving modificationsadopted in comparison to control were assessed. The various energy conservation measures adopted are described as follows:

Paddy straw insulation: The insulation involvesfastening atwo-inch-thick paddy straw sandwiched between the chicken wire mesh and galvanized iron (G.I) sheet to the ceiling of the barn from inside the roof. Unlike roof insulation the ceiling of the paddy straw insulation is long lasting, necessitating replacement of only paddy straw with the GI sheet support remaining intact.

Low profile barn: Theconventional barns in Karnataka are normal measure either 13x13x13' or 16x16x16' and consume over 5 kg of fire wood per kg cured leaf production. CTRI designed a low profile barn with increased plinth of 16' x14' and reduced the height of 13'. Low profile barn provides for better & improved heat circulation and also can accommodate more green leaf (40% more than the 16x16x16').

Turbo fan:Turbo fan fitted to the ventilator or on roof top facilitates achieving desired air changes which enables effective heat transfer between the flue gases and fresh air by forced convective heat transfer. It is operated during yellowing stage to provide enough oxygen supply to ensure complete biochemical changes and during leaf and mid rib drying stage to let out hot humid aiearly. The adoption of turbo fan known to reduce the fuel requirement by 10-15% and also resulting in good quality cured leaf production.

Results and discussion

The data on the green leaf weight loaded, number of hours taken, cured leaf weight obtainedand the amount of fuel wood consumed in the experiment pertaining to modifications in 16'x16'x16' size barn are provided in Table 1.Adopting paddy strawinsulation inside the barn roofresulted in consumption of 4.56 kg wood fuel forone kg cured leaf while the installation of turbo fan on the roof top of the barnin 16'x16'x16' reduced fuel consumption to4.58.kg of fuel woodper kg of cured leaf, compared to 5.26 kg wood requirement in control barn without any energysaving methods. The total time taken for the curing is reduced by 10% in case of paddy straw insulation treatment and by 4% in case of turbo fan fitted barn. Loss of heat through the roof is mainly because of the considerable amount of air leakage taking place in tiled roofs, while it is because of high heat conduction to the outside temperature in case of zinc sheet roof. Use of paddy

Table 1: Total hours taken and the fire wood consumed under different treatments in 16'x 16'x16'

Treatments	Charges	No. of sticks	Green leaf weight (kg)	Cured Leaf weight (kg)	Total Hours	Fuel wood	kg wood / kg leaf
Paddy straw insulation	**1**	523	2629	293	131	1350	4.60
	2	404	2307	252	110	1100	4.36
	3	379	1554	206	116	950	4.61
	4	447	1938	214	100	1000	4.67
	Mean	**436**	**2107**	**239**	**115**	**1100**	**4.56**
Turbo fan installation	**1**	542	2980	312	126	1500	4.80
	2	628	3465	426	125	1400	4.28
	4	434	2030	242	121	1100	4.54
	5	377	1512	215	115	950	4.65
	Mean	**495**	**2497**	**299**	**122**	**1237**	**4.58**
Control barn	**1**	430	1285	191	104	1100	5.75
	2	602	2191	298	138	1600	5.37
	3	450	2025	212	134	1200	5.66
	4	502	2215	267	123	1200	4.50
	Mean	**496**	**1929**	**242**	**127**	**1272**	**5.26**

Table 2.Total hours taken and the fire wood consumed under different treatments in 16'x 24'x13'

Treatments	Charges	No. of sticks	Green leaf weight (kg)	Cured Leaf weight (kg)	Total Hours	Fuel wood	kg wood / kg leaf
Paddy straw insulation + Installing Turbo Fan (16' x 24'x13' size)	1	872	4604	484	130	1610	3.33
	2	570	2888	305	100	1200	3.93
	3	800	3755	444	125	1500	3.37
	4	739	2636	364	113	1250	3.02
	Mean	**745**	**3470**	**399**	**117**	**1390**	**3.41**
Control barn (16' x 24' x 13'ize)	1	590	3245	328	137	1640	5.01
	2	893	4552	473	165	1920	4.07
	3	752	4102	376	153	1720	4.57
	4	763	3852	342	141	1585	4.63
	Mean	**742**	**3899**	**400**	**151**	**1750**	**4.57**

straw insulation is one of the ways to minimize the loss of heat through roof. Thusthe technology involving paddy straw insulation resulted in a net saving of 15.4% wood fuel while the installation of turbo fan on the roof top resulted in wood fuel saving of around 14.8% compared to control barn of similar dimension.Shenoy *et al* (2003**)** reported 30% saving in wood fuel by adopting low cost effective technology like paddy straw insulation in the curing tests done at farmers' barn by the core committee of different agencies in KLS.

In another set of experimentconducted in low profile barn with dimension of 16'x24'x13' size, the integration of Paddy straw insulation combined with installing turbo fan technology consumed only 3.02 kg of wood fuel per kg of cured leaf as compared to 4.57 in control barn of same size and dimension without any energy saving measures. Gopalachari and Nageshwra arao (1976) designed and tested a low profile barn which was found to have many advantages like more number of sticks for the same volume reduction in curing time easy loading and unloading of the barn and reduced fuel consumption. Thus adopting paddy straw insulation in combination with turbo fan in the low profile barn tested saved around 34 % of fuel wood compared to control. Apart from this there was also reduction in the total time taken for curing by 29%.

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