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STRATEGIES TO AVOID CROP RESIDUE BURNING IN THE PHILIPPINE CONTEXT */

TEODORO C. MENDOZA[1/] and ROGER SAMSON [2/]

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1/ Associate Professor, Department of Agronomy, UP Los Baños, College, Laguna, Philippines and concurrently National Technical Adviser on Farm Productivity Improvement. Dept. of Agrarian Reform.

2/ Executive Director, Resource Efficient Agricultural Production (REAP), Canada.

INTRODUCTION

Since its discovery, fire has been used by human kind in both positive and negative ways. In farming, fire is used to facilitate land clearing (the slash-and-burn shifting cultivation method of upland farming) (Gomez, Swete Kelly and Baril, eds. 1998; Blaikie, 1985). If not for fire or burning, early farmers could not have transformed, log-over or bush land into productive crop land (Lasco, 1998). About 11.4 million ha grassland/bush land are utilized through slash and burn method supporting 17-18 million people in the Philippines.

Fire is also used as a quick and labor saving tool in crop residue disposal as in rice and sugarcane production. The Philippines, having a tropical humid climate could easily support 2 rice cropping per year. Hence, about 3.0 M ha is grown to this staple food crop. Nine (9) out of ten (10) farmers are rice farmers. Sugarcane, a sun-loving crop is also widely grown. There was a time when sugarcane is the single leading export commodity providing 20% of total Philippine exports. The sugar industry provides about 0.5M direct employment.

About 0.5M ha were planted to the crop during its glorious exporting years. Presently, about 370,000 ha is still devoted to cane monocropping.

It has been estimated that about 90% of all rice farmers (2 million of them) simply burn their rice straw and about 64% of the sugarcane fields are burned before or after harvesting.

This paper aims to present estimates of the annual burning levels of these crops and the greenhouse gases (GHG) loading potential to the atmosphere. The latter part (3.0) is devoted in scrutinizing the reasons why rice and sugarcane farmers burn their crop residues and strategies being done to reduce if not altogether stop this practice of burning as a crop residue disposal technique.

Carbon Dioxide Loading Estimates for Rice and Sugarcane due to Crop Residue Burning

The average rice and sugarcane production area for the last 5 years were obtained (Table 1 and 2). The rice straw burnt during dry and wet season was estimated at 8,164,728 tons. The carbon contribution to the atmosphere in the form of CO_2 lost during burning is estimated using the following formula:

Total C lost = Total Rice Straw x 0.40

The 0.40 is the conversion factor for rice straw to C-content (Tanaka, 1978).

Total C lost = GHG estimate

For rice : the total C lost yearly is estimated at

Total C lost = (8.16M tons) (0.40)

= 3.26M tons/year or 11.93 tons of CO_2 in the atmosphere.

For sugarcane, the total biomass burnt is estimated at 3.0M tons.

Total C lost = (3.0M) (0.40)

= 1.20M tons/year or 4.4 tons of CO_2 in the atmosphere

The annual C lost for the two crops is about 4.46 tons or about 16.32 tons or CO_2 in the atmosphere.

It was observed that massive rice straw burning began when rice farmers adopted high-yielding varieties (HYV). This trend started in 70's or at least for the past 25 years. Hence, rice straw burning has contributed about:

= 3.26M tons x 25 years

= 81.50M tons of C or 298.8 tonnes of CO_2 in the atmosphere

Burning of sugarcane trashes has started in the 20’s or for the last 80 years. Hence, the total C-lost is estimated at 1.20M tons/year x 80 years

= 96M tons of C or 351.4 tons of CO_2 in the atmosphere

Rice and sugarcane production in the Philippines had contributed a total of 177.5 million tons of carbon as through crop residue burning or about 649.65 tons of CO_2 assuming all the C were released as CO_2 in the atmosphere.

This is still small compared with the 2.7 billion tons (Lasco, 1998) of C-lost due to deforestation (15.7M/ha) of our tropical forest. GHG contribution of rice and sugarcane production for the last century is about 6.6% of the total GHG contributed by deforestation starting 1900. Nonetheless, it is a major loss of energy from the ecosystem on an annual basis at 4.46 tons C-lost. Assuming an energy of 17 GJ/tonne of these residues, a total of 75.8 million of GJ of energy are being lost. The annual energy equivalent of burning crop residues (rice + sugarcane only) is about 13 million barrels of oil.

Table 1. Estimates of rice straw produced and burnt during wet and dry season

- Area (5 year average 1993-97) : 3.72M ha
- Production (5 years average 1993-97) : 10.62M tons (1)

Assumptions:

- Grain to straw ratio : 1 ton grain : 1.5 ton straw
- 0.5 tons straw are left on the field at harvesting
- 10% of farmers do not burn their straw
- 30% of the 3.72M ha are irrigated (2)
- 90% of straw is burnt during dry season crop
- 60% of straw is burnt during wet season crop

- Dry Season (DS) Rice straw production

  = 0.3 (3,718,000 ha) x 0.9 x 3.7 tons/ha straw

  = 3,714,282 tons

- Wet Season (WS) Rice straw Production :

  = 0.7 (3,718,000 ha) x 0.6 x 2.85 tons/ha straw

  = 4,450,446

  TOTAL for DS + WS

  = 3,714,282 tons + 4,450,446

  = 8,164,728 tons

SOURCE: PhilRice Statistics (1); Bureau of Soils and Water Resources (2)

Table 2. Estimated sugarcane trash + tops burned at pre-post harvest time*.

Harvest Schedule	Biomass Burned (tons)
Early harvest* (Oct-Dec)	149,184
Regular harvest (Jan-Mar)	1,660,560
Late harvest (Apr-May)*	732,600
	2,542,344
For Ratoon establishment	457,209
Total biomass burned	2,999,553

*Estimated from Appendix Tables 1, 2 and 3

The net CO_2 loading into the atmosphere of crop residue burning is not that high as CO_2 released annually is mostly absorbed during plant growth. However, during the natural decomposition process (if the materials were nor burned), some of the carbon would be transformed into soil organic matter and microbial biomass. The greenhouse gas reduction potential or not burning rice straw results primarily from the nitrogen fertilizer savings from residue carbon stored in the landscape, and increases in soil organic matter. Conserving straw will also help to reduce greenhouse gas emissions from nitrous oxides to the atmosphere, which are released from wet soils, and through the burning of nitrogen containing straws.

Thus, conserving crop residues in the farming landscape would still substantially reduce CO_2 loading in the atmosphere and the energy CO_2 yielding consequences of crop farming. Instead of burning, there are potentials to use some of the sugarcane trash and rice straw as an energy source for producing biofuels to reduce rural energy fossil fuel requirements, or wood or charcoal demands (Lawland et al., 1999).

The interactive effects of crop residue burning, its direct effect on C-lost and its indirect but additive effects on GHG emission in the atmosphere is shown in Fig. 1. Rice and sugarcane are the two crops utilizing more than 80% of all fertilizer used in crop farming in the Philippines (Balisacan, 1990). Non-crop residue recycling has been attributed to soil fertility (soil productivity) decline (Aggarwal, 1994; Velayutham and Bhardwaj 1994; FAO, 1982). Chemical application rates had increased over the years (.2-.4 bag/ha/year for rice and 0.3-0.5 bag/ha/year for sugarcane, Mendoza 1989). Hence, the heavy usage of chemical fertilizers in these 2 crops indirectly contributes massive GHG. Fertilizer manufacture burns fossil fuel energy.

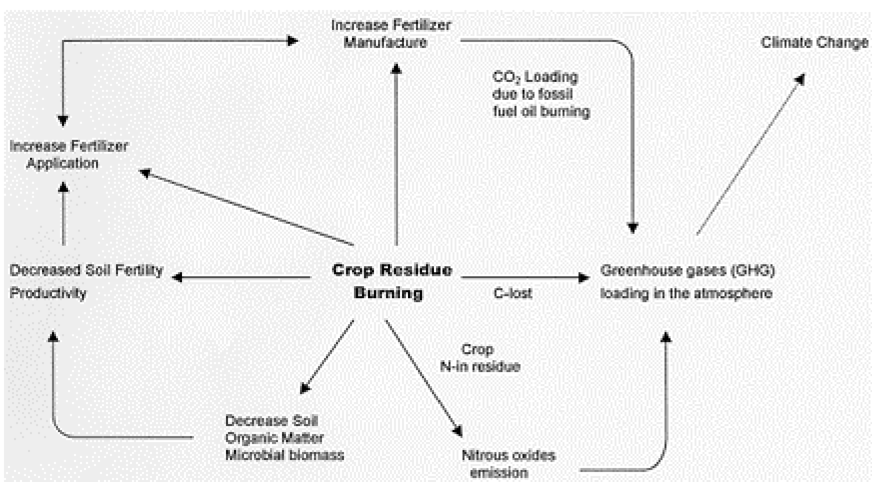

Fig. 1. Interactive (additive) effects of Crop Residue burning in relation to Greenhouse gases (GHG) loading in the atmosphere.

Burning : The Most Common Crop Residues Disposal

Why do farmers burn rice straw?

Coinciding with the massive promotion of high yielding and non-photoperiod sensitive rice cultivars in the 70's is the start of farmers' practice of burning rice straw. The reason provided by the farmers interviewed was – "We were advised to burn rice straw to prevent the further spread of rice tungro virus (RTV)." It was the belief then that the infected stem could further spread RTV. Installation of irrigation facilities and the availability of short maturing HYV allowed farmers to continuously plant rice. The short turn around time required quick land preparation after harvesting the previous crop that often requires machine draft power. Included in the promotion of HYV-seeds was the use of small hand-tractors although some farmers tried big tractors. Problems on traction and stoppage in the field (due to deep mud, the heavy tractors were literally buried in the mud) prevented farmers from using big tractors. If only for farmers to acquire hand tractors that prove effective in quick land preparation, most of these farmers sold their carabaos.

With their carabaos gone, preserving rice straw became unnecessary. Rice straw was observed to obstruct land preparation using small hand tractors. Hence, to facilitate disposal they simply burn rice straw.

The decades long practice of burning rice straw led to a parallel increase in fertilizer application rates. Also, cost of production was increasing (Fig. 1). Still farmers do not fully realize the need to re-cycle back rice straw (Mendoza, 1989; FAO, 1982). In most parts of the country, except in the Ilocos region where rice straw is used as mulch for garlic and onion, the rampant practice of burning rice straw persisted. In various seminars and field interviews conducted, the reasons why they burn rice straw are summarized below:

- Farmers believed that rice straw serves as a hiding and/or breeding place for rats. Field rat is one of the most damaging vertebrate pests in rice fields. In Iloilo and Nueva Ecija (two major rice growing provinces in the Philippines), rat tails are being gathered as contest to promote rodent eradication. Prizes are given to those who could submit the most rat tails.
- Also, partially decomposed straw leads to yellowing of newly transplanted seedlings. Farmers do not realize that this is merely temporary (Narwal, 1994).
- Spreading rice straw is perceived to be laborious. As harvesting is done almost simultaneously, available man power (landless rural workers)) is focused on harvesting operations (cutting/piling of rice straw, threshing/hauling). Spreading rice straw immediately after threshing requires only two (2) mandays per hectare. If heavy rains occur before spreading it add undue burden because straw becomes heavy. More mandays (10-12) are required to spread the straw (Masajo, 1988. A rice farmer, personal communication).
- Duck caretakers intentionally burn rice straw. Grains that go with the rice straw during threshing could be eaten by the ducks after burning.

- Rice straws piled near community roads are burnt when passers by throw their cigarette butts on the pile.

Agricultural technicians who were asked "Why do farmers burn rice straw" mentioned the following:

Farmers do not fully understand the merits or value of rice straw. They are "lazy" thus, they simply burn them. We are advising them to collect and prepare the straw into compost but only few participated. The Department of Science and Technology (DOST) and the Department of Agriculture (DA) had earlier launched a national program on composting with the use of *Trichoderma* *harsianum* – a compost activator. Primarily, the program was designed so that farmers could save on fertilizers and STOP burning rice straw.

When other researchers where asked why farmers simply burn rice straw, they attributed this to the following:

- Chemical fertilizers application is easy and fertilizers provide immediate effect.
- In the past, the government rice production program provided subsidy for fertilizers making it unduly cheap. This had accustomed the farmers to simply burn rice straw. Any nutrient lost can be easily or cheaply replenished back through chemical fertilizers.
- Technicians/sales representatives are given incentives proportional to the number of bags of fertilizer sold to the farmers.

Some Strategies being done to STOP Burning Rice Straw

Researcher/Academic led on-farm trials

Academic based researchers conducted on-farm trials to demonstrate to the farmers the fertilizer cost saving effect of rice straw recycling. It was documented that rice straw could substitute for 2-4 bags of fertilizer per ha per cropping (Mendoza, 1989), or about 2-5 kg N per ton straw (Watanabe, 1978)> An annual estimates of about 80 kg N per ha per year can be realized through rice straw farming (Patraik, 1978).

While the researcher-managed and farmer-participated trials proved its merit technically, it did not gain widespread acceptance or popularity among farmers. The evidence is simple, still, burning rice straw is the rampant practice. The reasons could be any of those discussed earlier.

NGO/PO – led campaign on "No Burning of Rice Straw (NBS)

While NGO/PO movement is ideologically influenced, hence, their activities as well, but soon the organic farming/sustainable agriculture advocacy gained prominence. Most active promoters are NGO's and the PO's.

During trainings and seminars the adverse effects of burning rice straw were discussed. The advantages of NBS were emphasized. Table 3 listed the summary of benefits of NBS.

The farmers were requested to prepare action plans to disseminate the information or knowledge acquired during the seminar.

During the presentation of action plans, the farmers suggested the following:

> Since HYV was rapidly introduced through the government sponsored program, NBS can also be promoted if incorporated as one policy requirement before farmers could avail credit. To convince the government, NGO/PO supervised credit were modified accordingly. NBS became one of the requirements before PO members could avail credit.

The impacts of this NGO/PO initiative was also limited:

First, PO members account for few percentage (5-10%) relative to the total number of farmers in the community they are working with.Second, their credit program is also limited.

Table 3. Summarized Benefits of Not Burning of Straw (NBS)

- Rice straw can be used for mulching. Mulching prevents weed growth, conserves moisture and soil.
- Rice straw contains 0.6%N, 0.15% P, 1.83% K, 40% C (Tanaka, 1978)
- Rice straw can be used as in-situ or ex-situ composting. Compost provides nutrients and org-c to the soil. In situ composting as in spreading the straw evenly after threshing, provide benefits in many ways:

    - Supplies organic matter for N-fixation by heterotrophic N-fixing microorganisms contributing substantial amount of N(2-5 kg/1 ton straw) (Watanabe, 1978) which could then be absorbed by succeeding rice crop.

    - Straw incorporation contributes up to 80 kg/ha of N yearly (straw – N + N-fixed by microorganisms). (Patnaik, 1978)

  - In-situ composting provides mulching benefits.

- Adds to Soil Organic Matter (SOM). In effect, it is C-sequestration or using the soil as C-sink.

- NBS minimizes the direct greenhouse gases (GHG) contribution of rice production. More GHG are contributed through increased fertilizer application.

Third, successive calamities (drought, typhoons, flood) had rendered farmers unable to repay back their loans. Soon NGO/PO credit became unsustainable. Farmers reverted back to previous lenders (formal/informal). Some farmers continue NBS. Others simply burn rice straw again.

Local Government Participation

Part of the developments in the NGO/PO community is mainstreaming or participation in the political arena. Some NGO/PO or farmer advocates joined the electoral process and some of them were successfully elected. At Barotac Viejo, Iloilo, the town mayor successfully introduced a Municipal Ordinance on NBS. The ordinance stipulates: P 200.00 fine + 1 week imprisonment.

This proved to be very effective as all farmers suddenly stopped burning rice straw. There are some farmers who are complaining but NGO staff helped the local government in explaining to the farmers the merits of the ordinance.

Increasing number of villages (smallest government unit in the Philippines is called barangay or village) are enacting village ordinance on NBS. But their impact is limited. Village ordinance should be sanctioned by the Municipal Council before the village could impose the fines or penalties. In some case where the village officials are affiliated with party opposing the town mayor, some problems automatically crop up. Incidentally, in a democratic type of government even NBS is also influenced by politics.

On Burning Sugarcane Fields

Cultural practices in sugarcane production start from burning the cane fields in predominantly sugarcane growing areas. Burning of canes signal the start of milling, and cane establishment either as a new crop or ratoon. (Ratoon is the crop grown from the tillers that emerge from the stubbles of the previous crop). Barring environmental considerations, burning is associated with cane production and milling.

Over the years, it was attempted to find out specifically why sugarcane is being burned (Table 4). There are two general reasons namely: the pre- and post-harvest burning.

A pre-harvest burn is being done to facilitate cutting and piling of sugarcane stalks. Sugarcane produces 25-40 leaves per plant. A mature cane has only 20% (5-8) actively photosynthesizing leaves. Thus, canes are trashy. If harvested unburned, much labor is incurred in removing the trash. This slows down harvesting by about 40%. The mill imposes penalty as much as 5% for delivered trashy canes. Trashy canes affects juice clarification and boiler efficiency. Also, some fields are weed infested. Besides, if the field is too weedy, it is associated with the presence of snakes. The fear of snake bite plus the weeds obstructing the easy cutting of the stalks give the harvesters no choice except to burn the canes.

Table 4. Reasons for pre-and post-harvest burning of sugarcane fields

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- Pre-harvest burn is being done to facilitate cutting and piling of sugarcane stalks.

    ‣ Unburnt canes are too trashy. It is laborious to remove the trash and it acellerates harvesting by about 40%. The mill imposes stiff trash penalty.

- Post-harvest burning of remaining trash and tops (or even those unburned canes before harvest) is done due to the following reasons:

  ‣ Unburnt field is perceived as "Dirty" field. Farm workers are accused of being lazy by the landowner ("haciendero") if the fields are "dirty".

    ‣ Remaining trash + tops obstruct the operations involved in ratoon crop establishment or in preparing the land for new cane establishment.

    ‣ There are cases or experiences where properly piled trashes between cane rows are burned together with the established cane crop.

    ‣ It is laborious to pile the trashes between cane rows to provide space for cultivation and fertilizer application. Harvesting time is also the time to establish new cane crop or ratoon. Competition for "labor" is severe.

    ‣ Piled trashes are perceived as hiding and/or breeding places for rats.

Many reasons are mentioned for "post-harvest" burning of the remaining trash and tops. These are as follows:

The remaining trash and tops obstruct the operations involved in new or ratoon crop establishment. New crop establishment involves plowing. Sugarcane produce thick mulch of trash and tops. Tillage implement could hardly penetrate the field especially the small to medium sized tractors. Super large tractors used in pineapple farms can feasibly plow under the sugarcane trash. They are expensive and are unaffordable to small scale farmers (ave. farm size is 13.0 ha). Even large plantations do not use them due to low net income derived from sugarcane compared with pineapple. Meanwhile, ratoon crop establishment requires stubble shaving. Since hand held bolos or machete is used in cutting stalks, about 2-3 inches of the basal stalk remains in the field. These protruding basal stalks should be cut to "subdue" floating tillers, or to allow basal tillers to emerge, hence, obtaining good ratoon crop stand. Stubble shaving requires burning the trash. This also facilitate inter-row cultivation and fertilizer application.

There are cases/experiences where properly piled trashes between cane rows are burned together with the established cane crop. Reasons cited why this happen are as follows:

- Cigarette butts thrown by passers by
- Laid-off workers burn the trash in reprisal to their bosses
- Burning of nearby cane fields can be accidentally started especially during windy days.
- Piled trashes are perceived as hiding and/or breeding places for rats.
- It is laborious to pile the trashes and tops between cane rows to provide space for cultivation and fertilizers application. Harvesting time is also the time to establish a new cane crop or ratoon. Thus, competition is so severe. **Decision:** burn the trash**.**
- It is also the perception that unburned/trashy field is a "dirty" field. Dirty field is associated with laziness of farm workers. Hence, for them, burning the trash is part of their routine activity to please the visit of their boss (haciendero)

Strategies tried to STOP Pre- and Post harvest burning of Canes

Recognizing the reasons why burning of canes is the standard practice, series of trials were conducted.

Cane Detrashing

As the cane is too trashy and the removal of the trashes slows down harvesting, it was tried to detrash the canes between 6-7 months old. For regularly planted cane, this occurs in July-August. During this time, it is rainy season and considered lean months. It is providing work to the un-employed farm workers.

However, hacienderos/farmers who are into cost cutting measures find the practice as an added cost. The recycled nutrients could not convince them to continue this practice.

Trash Farming Scheme (Fig. 2)

The site for trash + tops deposition at harvest time should be incorporated in the planting pattern. Thus, a re-arrangement of the conventional even furrow spacing of 1.0-1.5 m was tried. Several spatial arrangement were tried (Mendoza, 1979, 1985). Soon, the optimal spacing was validated. This consisted of **2 rows at 0.75 m and a larger interval space of 2.0 m**.

The larger interval space of 2.0 m is optimum for intercropping short maturing crops particularly legumes – mungbean, soybean, bush sitao, or vegetables such as eggplant, tomatoes, pechay, mustard, etc.

It was shown that sugarcane yields with modified spacing remains comparable with the conventional spacing (Mendoza, 1979, 1985)

The advantage is evident in the ratoon (Table 5). The trash applied plots gave higher ratoon yields (156.74 PS/Ha). The advantages were:

- reduction of N-fertilizers by 50%
- reduction of weeding on the trash-mulch plot
- the trash-mulch effect had better moisture retention during summer months
- lesser interrow cultivation in the trash-mulch covered interrows

One farmer (an American retired teacher who worked in Saudi Arabia and married his Filipina co-teacher) adopted the practice in his 1.8 ha sugarcane farm at Florida Blanca, Pampanga, Philippines. He had phenomenal results as his yield was almost double the yield level in the community. His neighboring farmers simply ignored this and nobody adopted the practice.

Future Prospects of No Burn Canes.

The implementation of agrarian reform in the sugarland offers bright prospect in introducing trash farming cum intercropping. Former farm workers who simply obey their boss can now make decisions in their farm. A diversified and low external input sugarcane farming practices are being discussed with farm workers-turned-farm owners during farmers' training specifically designed for them.

Training materials + brochures should be written in the local language. About 80,000 ha of sugarcane lands have been transferred to qualified beneficiaries through land reform.

The change in ownership provided a signal to the change in farming systems. This is what is being emphasized during seminars.

Table 5. Sugarcane yield of two varieties as affected by trash application.

Variety	Trash Treatment	Yield Components					
		TC/Ha		PS/TC		PS/Ha	
		Plant Crop (1)	Ratoon (2)	(1)	(2)	(1)	(2)
Phil 56-226	w/o trash	81.60a	55.41a	1.56	1.52	127.30	84.22b
	w/trash	82.52a	57.37b	1.56	1.75	128.73	100.40b
	MEAN	82.06a	56.39b	1.56	1.63	128.01	92.31b
Phil 67-23	w/o trash	68.16b	67.58b	1.35	1.61	92.02	108.80b
	W/trash	70.16	90.08a	1.35	1.74	97.16	156.74a
	MEAN	69.16b	78.83a	1.35	1.68	94.59	132.77a
F Test							
Variety (V)		ns	**	*	ns	ns	*
Trash Treatment (T)		ns	**	ns	*	ns	*
V x T		ns	ns	ns	ns	ns	ns

ns - not significant

* - significant at 0.05 p-level

** - significant at 0.01 p-level

Means with the same letter are not significantly different at 0.05 p-level (DMRT)

SOURCE : Bergonia, et al., (1987)

SUMMARY AND CONCLUSION

Greenhouse gases (GHG) contribution of burning crop residues for rice and sugarcane, two major crops in the Philippines, is relatively small (6.6% of the 2.7 billion C-lost due to deforestation since 1900). While this maybe true, burning as a quick, easy and labor saving crop disposal tool should be discontinued. Instead of simply burning the voluminous rice straw and sugarcane trash, pursuing farming practices to recycle the organic matter is the more logical practices. Soil fertility decline (hence, soil productivity) is generally attributed to the nonadoption of crop residue recycling of farmers. Reliance on quick results and impact yielding practices (heavy use of fertilizers) are too simplistic and effects are short lived. This has resulted in gradual but perceptible impairment of agricultural production. It is still practical and ecologically sustainable to pursue long-term soil fertility improvement options such as residue recycling, composting, green manuring

Incidentally, rice and sugarcane are the two crops utilizing more than 70% of all fertilizers used in crop farming in the Philippines. Philippines is a net importer of chemical fertilizers. Chemical fertilizer manufacture burns fossil fuel contributing in the process considerable amount of GHG. This is suggestive that auditing the GHG contribution of crop farming should not only be focused on CO2 loading in the atmosphere due to crop residue burning.

Meanwhile, there are time-tested farming approaches (organic, biodynamic, natural farming) and practical methods of crop residue recycling that can be readily implemented by farmers. In the Philippine context, these practices, however, are not expected to be done in a massive scale in the near future. Several logical and practical reasons are being raised by farmers why they adopt burning as crop residue disposal tool.

On the other hand, there are promising experiences or approaches that had been implemented. These should be explored further.

- nvolving/working with the farmers to implement different crop residue disposal options has been found to be effective in some ways (MASIPAG Rice Farming).
- Incentives, policies, training, info-dissemination/campaign were also found necessary and to a certain extent were also found effective in convincing farmers (Mendoza, 1998).
- Participation of Local Government Units (LGU's) in non-crop residue burning was found to be very effective. It should be explored further (barotac Viejo, Iloilo).

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Appendix Table 1. Estimating sugarcane biomass burned.

Total Biomass

1. STALK
2. TOPS
3. Dried leaves/leaf sheath (trash)

Extent of burning by season

Early harvest : 80% trash + 20% tops

Regular harvest : 90% trash + 40% tops

Late harvest : 100% trash + 60% tops

Estimates of biomass burned for early harvest

- 0.8 [22,000 ha x 5.6 tons/tons trash] = 99,956 tons
- 0.2 [22,200 ha x 11.2 tons/ha tops] = 49,728 tons

TOTAL = 149,184 tons

Estimates for Regular Harvest

- 0.9 [148,000 x 6.6 tons/ha trash] = 879,120 tons
- 0.4 [148,000 x 13.2 tons/ha tops] = 781,440 tons

TOTAL = 1,660,560 tons

Estimates for late harvest

- 1 [66,600 ha x 5.0 tons/ha trash] = 333,000
- 0.1 [66,600 ha x 10 tons/ha tops] = 399,600

TOTAL = 732,600

Appendix Table 2. Estimating the Extent of Sugarcane Pre-harvest Burning

Early harvesting (30%) 111,000 ha	October November December	111,000 x 0.20 = 22,200 ha
Regular harvest (50%) 185,000 ha	January February March	185,000 x 0.8 = 148,000 ha
Late harvest (20%) 74,000 ha	April May	74,000 x 0.9 = 66,600 ha
TOTAL: 370,000 ha		TOTAL Area Burned (ha) = 236,800 ha

% Burned Area = (236,000 divided by 370,000) x 100 = 64%

Appendix Table 3. Estimating the left-over trash + tops unburned but needs to be burned to establish the ratoons

Ratoon area	0.3 x (370,000 ha)	11,000 ha
Early ratoon	33,300 ha x 4.48 tons/ha	149,184
Regular ratoon	55,500 ha x 4.75 tons/ha	263,625
Site ratoon	22,000 x 2.0 tons/ha	44,400
	TOTAL ha	457,209