Burning Cereal Crop Residues in England

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Up to World War II, there was little scope for burning cereal crop residues in UK. The acreage of cereals was low, mainly on mixed farms where the straw was needed for livestock, and the then method of harvesting by binder removed the straw from the field. Burning anything was a somewhat rare event, apart from occasional accidents often near a railway in dry weather.

The war-time and post-war changes in farming resulted in the introduction on a large scale of the combine harvester, stimulating a concentration of cereal growing on arable farms in climatically suitable areas as more permissive attitudes to rotation developed. There was a tendency for many farms to concentrate on arable crops and eliminate livestock, partly because of better financial returns in relation to capital employed and partly because of an increasing shortage of people prepared to work for 7 days a week. Even on mixed farms, methods of housing animals (the 'cubicle' system) and storing crops which did not need straw became attractive, and straw began to be regarded as a nuisance to be got rid of rather than an integral constituent of a farming pattern.

During the war, the rapid expansion of food production in UK, particularly of arable crops, resulted in the cropping of land which

had been more or less derelict for over a decade with inadequate supplies of fertiliser. This threw up many problems of soil fertility. Consequently, the developing practice of straw burning caused some concern to our agronomists and soil scientists, who were rather conscious that so many other so-called rules of good husbandry were being eroded. Their concern resulted in some investigational work to study the effect of straw burning on subsequent crop yields and the results of this constitutes the major justification for this paper. However, I would like in addition, to comment on the present situation regarding straw burning in UK and the policy we in the agricultural industry are following despite some criticism from other sections of the community.

STRAW DISPOSAL TRIALS 1951–1968

These experiments were intended to extend pre-war studies on the return of straw to arable land (Rayns and Culpin 1948; Rothamsted Report 1951). The earlier trials did not include straw burning, they were confined to two soil types and at the low levels of inorganic manuring then current. The results of the straw treatments tended to reflect the nutrients supplied by the straw application. In the present series of EHF trials an attempt was made to maintain high enough levels of basal fertilisers so that the straw results were not affected by the inorganic nutrients in the straw.

The trials were carried out on four of the Ministry of Agricultures Experimental Husbandry Farms in arable areas of Eastern England. The full results are being published (Short 1973). Details of the sites and of the crop rotations followed are in Table 1.

Each rotation included four cereal crops. After each cereal, straw (at an average rate appropriate for each farm) was either ploughed-in (P) or burnt (B); these treatments were compared with straw removed (R) by baling and carting off, either with or without the application of farm yard manure (F) every 6 years to the potato crop. Fertiliser rates were adjusted to allow for the extra phosphate and potash supplied in the dung and extra nitrogen was given in the spring to those plots which had received ploughed-in straw. Ploughing was always done with a mouldboard plough.

TABLE 1. LOCATIONS OF EXPERIMENTS AND CROP ROTATIONS

FARM	Boxworth	Gleadthorpe	High Mowthorpe	Terrington
COUNTY	Cambridgeshire	Nottinghamshire	Yorkshire	Norfolk
Soil	Calcareous Clay	Loamy Sand	Chalky Silt Loam	Silty Loam
Annual rainfall in mm	560	610	790	560
Altitude (m)	58	46	160	2
Rotation 1.	Potatoes	Potatoes	Potatoes	Potatoes
2.	Winter Wheat	Winter Wheat	Winter Wheat	Winter Wheat
3	Spring Barley	Spring Barley	Spring Oats	Spring Oats
4.	Sugar Beet	Sugar Beet	Sugar Beet	Sugar Beet
5.	Spring Wheat	Winter Wheat	Winter Wheat	Winter Wheat
6.	Spring Oats	Spring Barley	Spring Barley	Spring Barley

Each straw treatment was tested at two levels of nitrogen and the trial continued until after the 1968 crop. There were, at each centre, eight treatments (four straw treatments at two rates of nitrogen) duplicated on each crop, i.e. 12 randomised blocks or 96 plots per year.

During the 18 years of the trial, a few modifications had to be introduced affecting the varieties used, the amount of straw returned or burnt, the amount of compensatory nitrogen given and the level of application of dung. Further the number of levels of nitrogen were increased from two to four and at two centres potash treatments were introduced. Full details are in Short's paper.

The effect of treatments were assessed from the yields of crops, including straw weights and sugar content of beet. Notes were made of disease and pest damage where appropriate and soil samples were taken for analysis.

RESULTS

CROP YIELD

Table 2 summarises the yields of these trials from 1957–1968. This covers two complete rotations after a 'running in' period where the treatments were first being applied.

TABLE 2. SUMMARY OF CROP YIELDS 1957–1968

A Mean total yield of potatoes tonnes/ha (average of 4 farms)

Straw Treatment	1957–63		1964–68	
	N_1	N_2	N_1	N_2
F	26.76	27.42	31.31	33.09
P	26.44	27.17	29.78	32.21
B	25.91	26.79	30.61	32.39
R	24.96	26.59	28.95	32.14
MEAN	26.01	26.99	30.15	32.46

B Mean total yield of winter wheat (85% DM) tonnes/ha (average of 4 farms)

Straw	1957–63		1964–68			
	N_1	N_2	N_1	N_2	N_3	N_4
F	3.40	4.12	3.84	4.49	4.83	4.86
P	3.19	4.05	3.51	4.26	4.66	4.88
B	3.05	4.04	3.60	4.29	4.82	4.88
R	3.05	4.04	3.48	4.33	4.63	4.91
MEAN	3.18	4.07	3.60	4.34	4.73	4.88

C Mean total yield of spring cereals (85% DM) tonnes/ha (average of 4 farms)

Straw	1957–63		1964–68			
	N_1	N_2	N_1	N_2	N_3	N_4
F	3.06	3.99	3.85	4.66	4.98	5.06
P	3.38	4.03	3.40	4.21	4.68	5.03
B	2.96	4.05	3.69	4.41	4.88	5.02
R	2.82	2.98	3.59	4.32	4.83	4.96
MEAN	3.05	4.00	3.63	4.39	4.85	5.01

TABLE 2. (*Continued*)

D Mean yield of sugar tonnes/ha (average of 4 farms)

	1957–63		1964–68	
	N_1	N_2	N_1	N_2
F	5.74	6.13	5.95	6.34
P	5.71	5.98	5.69	6.03
B	5.56	6.14	5.55	6.21
R	5.42	5.91	5.52	6.03
MEAN	5.60	6.04	5.67	6.15

E Mean yields of wheat (85% DM) tonnes/ha (average of 4 farms)

	1957–63		1964–68			
Straw	N_1	N_2	N_1	N_2	N_3	N_4
F	3.34	4.00	3.50	4.05	4.43	4.49
P	3.38	4.07	3.50	4.05	4.27	4.53
B	3.23	3.93	3.46	4.03	4.34	4.44
R	3.15	3.98	3.39	3.98	4.28	4.41
MEAN	3.28	3.99	3.46	4.03	4.33	4.47

F Mean yields of spring barley (85% DM) tonnes/ha (average of 4 farms)

	1957–63		1964–68			
Straw	N_1	N_2	N_1	N_2	N_3	N_4
F	2.96	3.78	3.53	4.37	4.83	5.00
P	3.25	3.87	3.18	4.22	4.59	4.88
B	2.90	3.73	3.57	4.29	4.68	4.93
R	2.80	3.75	3.35	4.26	4.68	4.92
MEAN	2.98	3.78	3.40	4.28	4.71	4.93

Fig. 1. A field after burning straw.

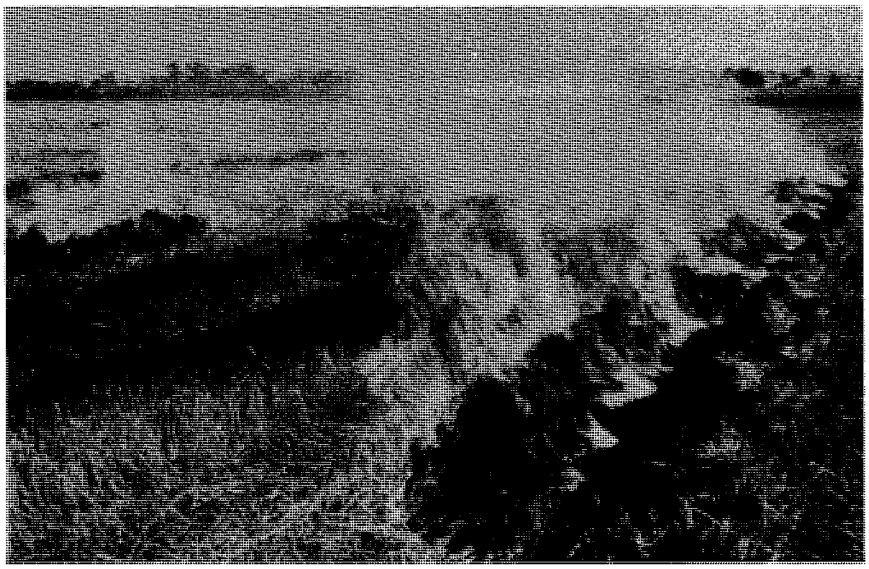

FIG. 2. Burning straw on continuous barley trial (Boxworth, Cambridge) where wild oat build-up was studied (Whybrew 1964).

Potatoes—The highest potato yields were achieved from plots which had just received farm yard manure. Apart from this there was little consistent difference between the effect of straw treatments which proved very small.

Wheat—The wheat following potatoes responded to the farmyard manure given to the preceding crop where the wheat received a low level of nitrogen, but as nitrogenous manuring of the wheat increased this effect became masked. The effects of straw disposal were clearly insignificant compared to the response all centres gave to nitrogen which on average increased wheat yields by over 30 percent.

Spring Cereals—(Barley at two centres, Oats at two)—There were still some signs of the residual effect of dung but as with the wheat the only economically important yield effects were those due to nitrogen.

Sugar beet—There are some signs of differences in sugar field associated with straw treatments, removal or burning the straw tending at the lower level of nitrogen to give poorer yields than ploughed-in straw or the residual effect of dung. But at the higher level of nitrogen, yields after burning tended to be better than after either ploughed-in or straw removed.

Wheat—(Spring sown at one farm)—Nitrogenous manuring was of much more significance than straw treatment, the effects of which were very small.

Spring Barley—(Oats at one farm)—Once more the cereal crops yields were more consistent for nitrogen response, than for straw treatments.

The results from the four individual farms were very similar; such variation as there was, tended to be more noticeable in the farmyard manure response. This was consistently below average on potatoes at High Mowthorpe and farmyard manure residues gave a lower response on beet at Terrington than at the other farms.

Summarising the crop yield data, there are no grounds from these figures justifying one to recommend—or to condemn—any one of the methods of straw disposal which were tested under the condi-

tions of these trials. But it should be remembered that none of the four sites was really low in its organic matter status.

SOIL ANALYSIS

The full summary of soil analytical data is incomplete but will be published by one of my colleagues in due course. The results available (Table 3) suggest that in the 18 year period of these trials there was a small decline in soil organic matter at three of the four farms. Differences between straw treatments were very small but there was some indication that the rate of decline was slightly reduced where farmyard manure had been applied or straw ploughed-in. At the fourth farm (Gleadthorpe) there was less change in organic content and no clear trend was discoverable.

TABLE 3. PERCENTAGE ORGANIC MATTER IN SOIL (0–16 INCHES)

Treatment Farm	year	Manure	Plough	Burn	Removed
Boxworth	1951	2.93	2.96	2.84	2.85
	1968	2.90	2.79	2.62	2.63
Gleadthorpe	1955*	2.10	2.20	2.03	1.97
	1969	2.14	2.10	2.03	2.01
High Mowthorpe	1951	3.97	3.93	3.88	3.91
	1968	3.87	3.78	3.60	3.63
Terrington	1951	2.55	2.58	2.43	2.60
	1968	2.38	2.33	2.34	2.36

* Mean of two blocks only: all other figures means of 12 blocks

SOIL WORKABILITY

One objective attempt was made to assess the behaviour of the land, in terms of dynamometer measurements during ploughing, at the farm (Boxworth) with the heaviest soil. No consistent effect of straw treatment could be discovered. The soils at all four farms were reasonably stable and the slight reductions in organic matter did not create problems in soil management. Such transient effects as

were noticed (in speed of drying out) were always ephemeral, rarely lasting more than an hour or so.

CROP DISEASE

The rotations followed in these experiments were originally designed to minimise the risk of soil borne disease affecting the results. Observations on disease were made but no significant effects were observed.

WEEDS

Routine herbicide treatments were given to all crops where the weed incidence justified this and there was no suggestion from the observations made that the weed population had been affected by the treatments given. However, other work suggests that weed numbers can be affected by straw burning. For example, work at Boxworth on continuous barley concurrently with this trial demonstrated that the build-up of wild oats (*Avena fatua*) from 1.3 per square yard in 1957 was less rapid where the straw was burnt; populations per square yard in 1964 being 61 (straw burned) and 83 (straw removed) respectively (Whybrew 1964).

Thurston (1965) reports that straw burning probably destroys some wild oat seeds and breaks the dormancy of others making them germinate. Unlike the seeds, the seedlings can be destroyed by cultivation. She reports that counts after stubble burning on an infested field showed that there were 10 times as many spring wild oat seedlings per unit area where the stubble was burnt than on adjacent unburnt patches.

DISCUSSION

The United Kingdom grows about 9 million acres of cereals producing perhaps 7½ million tons of straw. Much of this is still used on farms for livestock feed and bedding. A comparatively small tonnage is sold for manufacturing, for example straw board, and some has

been made into paper at times—mainly as a wartime expedient.

Recent estimates by my colleagues suggest that about 2½ million tons are burned mostly in the arable districts of southern and eastern England. The farmer sees straw burning as an easy means of removing an unwanted encumberance to arable farming. Burning, done properly, takes about ⅓ man/hr per hectare while baling and carting may need 5 man hours plus 4 tractor hours per hectare at a time of year when the arable farm is fully stretched. Ploughing-in the straw involves chopping—at best a slow process costing perhaps £5 per hectare and, with large combines and heavy crops or wet weather, an almost impossible job with current equipment. Further in some circumstances ploughed-in straw can depress subsequent crop yields. In addition, burning helps to achieve a speedy start to autumn cultivations, and helps to check weeds. Although it is claimed to reduce sources of disease infection there is seldom a sufficiently clean burn to remove all trash and pathogens may well be present on roots below the soil surface.

However, this practice causes concern from several points of view. Fires get out of control on occasion, resulting in damage to property. This problem has increased and statistics from one important arable county (Essex) showed that fire brigade calls to out-of-control straw burning increased from 101 in 1970 to 207 in 1971 and 300 in 1972. Not all these fires were necessarily the result of deliberate burning. Added hazards arise where there are electric power lines or underground pipelines; the latter have proliferated recently as North Sea gas supplies are exploited.

Damage often occurs to hedgerows, spinneys and there is great public concern in UK for the amenities, including natural history, of the countryside. Smoke, even from well managed fires, has drifted across roads causing accidents and into residential areas causing inconvenience. Public opinion in UK has become deeply concerned about the problem and although some of the arguments become emotive rather than rational few would quarrel with The Times of 12 October 1972 "Straw burning probably did more to alienate general sympathy from modern farming than any other issue for years, including intensive methods of animal production. Indignant

letters poured into local and national newspapers."

There is no doubt that many onlookers imagine extensive mortality of wildlife to be a consequence of burning straw. There are no critical figures to my knowledge from UK. For the larger species (birds, rodents) my own observations of burning in the field do not suggest any significant losses and the opinions of some of my colleagues supports this. For surface living insects (e.g. spiders) considerable mortality would seem likely but the significance of this is unknown. For soil living organisms the effect of burning is so superficial that one would not anticipate much effect on numbers. However, the speculative nature of this paragraph reflects a gap in our knowledge.

The British National Farmers Union, in consultation with the Ministry of Agriculture and other organisations has publicised a Straw Burning Code each harvest, stressing the dangers of burning straw in high winds, in exceptionally dry weather, or near buildings, residential areas, aerodromes and pipelines. Before burning, firebreaks of at least 20 ft. wide should be cleared of straw and cultivated around the field perimeter. The straw should then be burned into the wind so that it burns slowly. However, despite the obvious common sense of the Code, which clearly has the support of most organisations and the majority of farmers, accidents do happen sometimes through bad luck (for example unexpected changes of wind) and sometimes through carelessness or negligence. One must anticipate in a country nine times more densly populated than USA (only Japan, Holland and Belgium have a greater population density than UK) farming will be subject to increasing pressure not to follow practices which though technically satisfactory are liable to inconvenience the population as a whole. But in a situation where, until recently, all fires were bad fires the psychology of fire has necessarily an important influence on mankind's thinking. I very much welcome not merely the opportunity to attend this conference but the body of data which the Proceedings of Fire Ecology Conferences provide which will contribute to a rational approach to such problems.

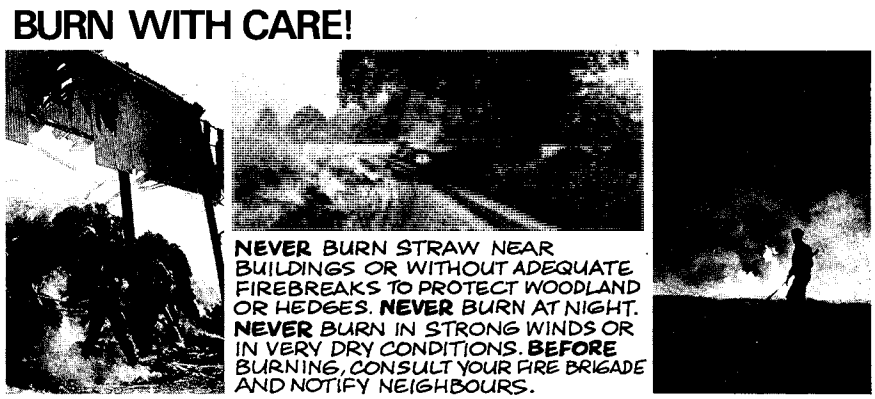

FIG. 3. Safety precautions for burning straw for agricultural purposes published in the British Farmer and Stockbreeder.

SUMMARY

1. Details are given of four trials in Eastern England covering an 18 year period during which straw from 12 cereal crops was disposed of by burning, by baling and removing, by ploughing-in or by returning as farmyard manure.
2. Crop yields were not very much affected by method of straw disposal but there was some response, particularly by potatoes and the succeeding winter wheat, to farmyard manure.
3. Responses to nitrogenous fertiliser were of much more economic importance than to method of straw disposal.
4. The effects on soil analysis were recorded but differences between straw treatments were small.
5. Data from other trials suggest that straw burning can assist with certain weed problems.
6. The current practice in England is discussed and controversial aspects of straw burning reviewed.

ACKNOWLEDGEMENTS

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