THE LAND AND DEFENCE

UK Agriculture: What Possibilities?[1]

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It may seem strange following accounts of the 'Nuclear Winter' and the possible catastrophic atmospheric consequences of nuclear war to present a paper which asks: what possibilities? If previous speakers are correct then the paper would indeed be a short one. I am personally convinced that they probably are correct, but not everybody is. The public at large tend to be sceptical of scientists who predict the end of the world putting them in the same category as Jehovahs Witnesses and Flat-Earthers. The feeling of scepticism grows when they hear equally eminent scientists disagreeing. For example Edward Teller 'Father of the H-bomb' recently wrote:

> 'Nonetheless, the myth of the nuclear apocalypse has grown steadily. Conclusive scientific studies have demonstrated that neither radiation nor atmospheric effects from any possible nuclear war could destroy life on the planet.'[2]

Now admitedly he is not actually saying that the 'Nuclear Winter' is not possible. But that is not how most people will understand him. They will pick upon his statement to mean that the 'Nuclear Winter' will not occur. It is therefore to the sceptic that this paper is addressed. The purpose of this paper is to show the agricultural consequences of a nuclear war upon this country, assuming that there are no severe atmospheric consequences.

Firstly we shall look at the effects of a single 1 MT ground burst explosion upon the countryside. We shall then look at the agricultural consequences of a nuclear war involving the explosion of approximately 230 MT of nuclear explosives.

A single bomb

Numerous studies have been done of the effect of a one megaton bomb on a city - it is almost the stock-in-trade of the anti-nuclear campaigner. Generally a most effective tool. The effect of a 1 MT bomb upon a comparatively unpopulated area is not so common, and not surprisingly. Let us suppose that there is a 1 MT ground burst explosion, what would be the effect upon agriculture and the countryside of that explosion?

There are four items with which we need to deal: immediate radiation; heat; blast and fallout. We can forget about the immediate radiation; anything within the lethal area of that will die from at least two other major causes. 50% of the bomb's energy yield is accounted for by blast which has the obvious effect of flattening crops, trees, buildings etc. At the point of explosion there would be a crater up to ¼ mile wide and 300 feet deep. Within 6.7 miles of the explosion 90%

of the trees will be blown down, reduced to 30% at just over 9 miles, an area of approximately 65 square miles. Less sturdy plants might be flattened further out still. Animals and humans are fairly resistant to blast. Half the animals within 1.3 miles might be killed by blast and those within 2.5 miles might suffer lung damage. Fatalities will be caused further away by animals being struck by flying objects.

Heat accounts for 33% of the energy output of a nuclear explosion. The distance at which the thermal radiation is effective depends not only on the size of bomb, but also the atmospheric conditions prevailing at the time. If it is assumed that it is a moderately clear day, with visibility at ten miles then fairly dry grain crops will be ignited up to fourteen miles from the explosion, 50% of animals and humans exposed to the heat up to 11.3 miles from the explosion would die from burns. Fires and burns injuries would, of course, occur still further away.

When a nuclear bomb explodes at or near ground level it sucks up large amounts of soil and rock, perhaps millions of tons. This forms the familiar mushroom cloud. The debris soon begins to fall back to earth, the larger particles first and the lighter particles later, causing a plume of fallout downwind of the explosion. Assuming a constant 15 mph wind, and no rain, within one day the area which is lethal to 50% - 100% of unsheltered farm animals would extend 52 miles downwind and 9 miles wide at its widest point. Exposed animals may take days to die, mainly from damage to the intestine, preventing absorption of food, or damage to the blood causing the breakdown of the immune system.

Should the explosion have occured on a nuclear power station - normally located in rural areas - the area seriously effected may be three or four times as large. Such areas would be particularly hazardous as the radioisotope mix from nuclear power stations is such that the radiation would be dangerous much longer than that from nuclear weapons.

<u>A nuclear war</u>

So much for the effect of one bomb. In a nuclear war involving NATO and WTO it is most unlikely that once a war had begun, the use of nuclear weapons could be prevented or controled. I must first explain the assumptions behind, and the non-agricultural outcomes of the scenario. What we are looking at is the result of a Soviet nuclear attack on Britain as part of a general nuclear war. It is essential that the likely targets are identified and the consequences of the attack on the general political and industrial infrastructure is made clear before the implications for agriculture are considered.

Firstly: what would the Soviet targets be? Obviously we can never be certain, but there are clues in the literature suggesting what the range of targets might be. There is a central strand in Soviet strategic writings from the early 1960's to the present day which make it clear that nuclear war must entail not just the defeat of the enemy, but also his destruction. Marshal Sokolovski in <u>Soviet Military Strategy</u> writes that targets to be struck are 'strategic nuclear weapons, economy, system of government and military control'[3] with the purpose of bringing about 'the annihilation of the opponent's armed forces, the destruction of targets deep in his territory and the disorganisation of the country'.[4] The primacy of this point of view is made explicit in the Soviet <u>Military Historical Journal</u>: 'war must not simply be the defeat of the enemy, it must be his destruction. This condition has become the basis of Soviet military strategy.'[5]

The range of targets is clearly a mixture of military, political and economic targets. The military and political targets are easy to spot: airfields, Royal Navy bases, command and communication centres, munitions stores, regional and national centres of government. But what of industry? The choice of possible industrial targets has kept many American academics and technicians busy since the last war. Jean Leavitt[6] surveyed twelve different studies of this problem. In the twelve studies there is not one single industry which is considered essential by all. One author, Goen, was responsible for four of the studies surveyed; his conclusions also varied from work to work. Leavitt concluded that it was impossible to provide a sigle list of essential industries acceptable to everyone, and proved it by producing her own list. She also concludes:

> '... any set of criteria chosen subjectively by the researcher is correct. There is no absolute set of criteria; the "decision" is abritrary, in the best sense of the word.'[7]

The targets that might be chosen in Britain could include: power, the single most important industry, comprising: 14 nuclear power stations, 20 conventional power stations of over 900 MW output; accounting for 55% of generating capacity. Oil refineries and terminals would make 16 targets, North Sea gas 6. 26 steel industry targets; 19 chemical industries producing feeder chemicals for plastics manufacturing; 26 Royal Ordnance Factories; 29 non-ferrous metal producers; railway brakes and draw gear 7 targets; pharmaceuticals and agrochemicals another 16 and 11 respectively. Agriculture per se would not be targeted.

The total scenario would involve 430 aim points; military, political and economic. Each target receives on average just under 0.5 MT, though in practice the size of the explosions would vary from 0.15 MT for an SS 20 warhead to 1 MT for an SS 5. Altogether approximately 230 MT - not far from Home Office estimates of 200 MT, although they suggest only 179 targets. Despite being a vast amount of explosive power it represents only $^1/_{10}$th of the Soviet long range theatre nuclear forces. Britain, because of this important military position and its strong economy could easily justify $^1/_5$th of the Soviet long range theatre nuclear force. Some of the reserve would be required to replace missiles which fail to work according to plan. It is clear though that it is not straining the Soviet Union's resources to anticipate a 200+ MT attack.

Briefly: what would be the economic and political outcome of this attack? Clearly there would be widespread destruction on a scale never before experienced. The country would be brought to an industrial halt and would be likely to remain that way for the forseeable future. The power industries would be destroyed, preventing economic recovery from even beginning to take place. Political collapse and the collapse of the monetary system would also have occured putting the prospect of industrial revival yet further away.[8] It is possible that within two months, if SANA and the BMA are correct, there would only be 15 million survivors out of a population of 56 million. This is the position from which we start and the political picture which forms the background for the future of post-holocaust agriculture.

If we now look at the immediate effects on agriculture we can divide it into two groups: the effect of heat and the effect of fallout. The emphasis will be on two crops: barley and wheat, ie those which have the greatest potential for providing food.

It was outlined earlier the effect of heat on crops. We now have to multiply that by at least 200. Most of England would be in areas which could be affected by heat. The losses from thermal radiation would depend upon the time of year and the dryness of the crops. Should the attack occur when the crops are at their driest losses would be phonomenal. A total of over 51,000 square miles would fall within the area in which standing grain could catch fire. Losses might amount to 78% of barley, and 75% of wheat. Losses in livestock would be high, but of a totally different magnitude: at a conservative estimate 5% of sheep, 12% of non-dairy cows and 28% of dairy cows might be lost. At other times of the year losses from radiation would dominate, and it is to this that we now turn.

There can be no precise prediction of where the fallout would land, but idealised patterns can be produced which give an indication of the likely magnitude of the problems that would be faced. From the scenario outlined above approximately 60,000 square miles of Britain might receive a dose of over 100 rads; 4,214 sq miles, 3000 - 5000 rads and 3,031 sq miles over 5000 rads. The LD50 for man is 450 rads.

Radioactive fallout comes in three types: alpha, beta and gamma. Alpha we can largely ignore as its ability to penetrate any matter is very small. Beta radiation can penetrate a few inches of air and a few milimetres of tissue and is therefore only of concern when in contact with plant or animal tissue. Gamma radiation is very penetrating, able to pass through feet of steel and concrete, though losing much energy in the process. Fallout is normally given in terms of the gamma dose only, which is normally sensible for animals which can take shelter. For field crops however beta radiation will also have some effect. Although it is open to debate it is likely that beta radiation would at least double the dose received by crops in the field. That is gamma + beta = 2 gamma. Therefore we can effectively reduce the radio-resistance of exposed plants in half: so an LD 50 of 1000 to gamma alone becomes 500 to gamma and beta. Throughout this paper I refer to plants' radiosensitivity in terms of beta plus gamma, which is why they may appear more sensitive than usual to those who know of their tolerance to gamma radiation alone.

As with destruction from thermal radiation damage from fallout varies according to the time of year. For example should winter sown barley receive 500 rads or greater before spring the loss is likely to be 100%, the same dose after ear emergence might reduce the yield by only 14 - 23% of normal.

Taking into account the distribution of crops and the time of year in which the attack occured it was found that in the worst case 34% of grain yield was lost due to radiation alone; on average the lost yield was 16.4%. There would be additional losses owing to thermal effects, but owing to difficulties in modeling the effect this has not been included, except for the months July and August when the thermal effects would dominate. Should the attack occur in these months then yield might be reduced by 76%.

Deaths from radiation amongst livestock, again taking into account the amount of shelter that might be available at different times of the year were also calculated. Approximately 20% of sheep may be lost; 26% of non-dairy cattle and 37% of dairy cattle. Many more would sicken, resulting in weight loss, infertility and sickly offspring.

Survivors

So much for the immediate losses. But what about the survivors? Would there be sufficient food to see them through to the first harvest, and would that harvest, leaving aside the problem of whether it could be gathered in, be sufficient to feed the survivors? If we assume that the average survivor requires 2000 calories and 8g of protein per day it means that one million survivors will require 180,000 tons of wheat or barley per annum. Therefore 40 million survivors would require 7.2 million tons of grain 15 million survivors, 2.7 million tons. The two figures representing the most optimistic Home Office assessment[7] and the most likely SANA figure[10]. I shall in future only be dealing with the SANA figure as this is by far the most reasonable assessment of the immediate casualties resulting from this scale of attack.

If there are forty million survivors then grain in store would be sufficient to feed survivors until the first post-attack harvest, unless the attack occured from April onwards, in which case there would be a deficit of 0.1 million tons rising to 0.8 tons. Consequently starvation would be inevitable. If there are only 15 million initial survivors then a food surplus is likely whenever the attack occurs. Food in store would almost be certain to see the likely number of survivors through to the first harvest.

That first harvest, if it can be gathered would produce somewhere between 11 and 15 million tons of grain if the attack occurs between September and June; again leaving a surplus over the 15 millions' demand for 2.7 million tons of grain. Should the attack occur in July or August only 3.9 million tons might be harvested, still theoretically sufficient for the survivors.

Table 1 Crop production: first post attack harvest (millions tons)

Month attack occurred	Winter barley	Spring barley	Wheat	Total
Normal	2.81	6.57	7.02	16.4
Jan	1.5	6.6	6.4	14.5
Feb	2.0	6.6	5.6	14.2
Mar	2.5	4.0	5.6	12.1
Apr	2.5	3.3	5.1	10.9
May	2.5	3.9	6.4	12.8
Jun	2.5	5.8	6.4	14.7
Jul*	2.1		1.8	3.9
Aug*	2.1		1.8	3.9
Sept	1.5	6.6	4.5	12.6
Oct	1.4	6.6	6.4	14.4
Nov	1.4	6.6	6.4	14.4
Dec	1.5	6.6	6.4	14.5

* For July and August thermal effects cause greatest damage.

In the pesimistic world of post-attack predictions this seems an optimistic conclusion, but we have not considered all the problems yet. There are other factors which will tend to decrease agricultural yield still further. It is to the investigation of these problems that we now turn. The problems are: land denial to farmers; the disruption of the food supply system and the lack of essential imputs. We shall look at this last mentioned problem first.

Firstly the supply of fuel. It is obvious that farms require petrol, diesel or electricity for nearly every operation. British agriculture uses approximately 1.7% of the national annual fuel consumption. Following a nuclear attack electricity would be unavailable, and other savings could be made: reducing the fuel demand by perhaps 50%. The final demand would therefore be 806 kt of diesel and petrol, per annum. If - and it is a big 'if' - all frozen fuel stocks were made available to farming then for the first post-attack year problems from lack of fuel may not be acute. Thereafter, but probably sooner, the problem of no petroleum would have to be faced. Massed human labour would have to replace the tractor; the spade replace the plough; the reaper replace the harvester. It is inevitable that efficiency would be lost. By how much? It is a difficult question to answer. As a rough estimate - perhaps by 30% - perhaps more, perhaps less.

Table 2. Harvests: Second and subsequent years.
(millions tons of grain)

Pre Attack	16.426
less 75% (land unproductive)	11.990
total	4.436
less 30% (efficiency loss)	1.330
total	3.106
less 75% (lack of agrochemicals)	2.328
total	0.778

Total population that can be supported at 2000 calories per person per day:
4.32 million.

Not only would the quality of cultivation decrease, but so would the quantity. 15 million people armed with shovels could not maintain the amount of agricultural land that is used at present. If we assume that the amount of land that can be cultivated is proportional to the number of survivors it would mean that 15 million people could cultivate 27% of the land at present used. If we allow for this, and the 30% reduction in efficiency we find that 15 million people could produce 3.1 million tons of grain - they require 2.7 million tons - so there is a slight surplus. We can conclude that loss of fuel alone is not necessarily sufficient to jeapordise the long term survival of the survivors.

It should be noted that it is unlikely that the loss of cultivated land is directly proportional to the number of immediate survivors, as I have suggested. There is room for refinement in many of these calculations. I have however, where there is a large area of doubt, attempted to err on the conservative, or the optimistic, side. The most common complaint that I have had of this study is that I underestimate the problems. I do this quite consciously - I have no desire to be accused of being alarmist.

The second major group of agricultural imputs to which we turn our attention is that of fertilisers and other agrochemicals. Chemical fertilisers and British agriculture appear inseperable; the increased use of such fertilisers are largely responsible for the increase in output per acre over recent decades; though of course improved strains and other improvements in agriculture have played their part. Brown and Pulz[11] in 1969 estimated that the cessation for fertiliser supplies to US agriculture would result in a yield decrease of 40%. British use of fertiliser is at present 500% above the US 1969 figure[12] - a conservative assessment might suggest that UK yields might drop by 50% without fertilisers.

The decrease in crop yield would not occur immediately but over two or three years as supplies are used up and that already in the ground is depleted. It is extremely unlikely that industrial recovery could even begin to get under way by this stage, thus no new stocks of fertiliser could be expected.

Stocks of pesticides would also be depleted - this would be a particular problem in the post-attack environment. It is almost certain that the numbers of insect pests will increase: most insects are uneffected by 3000 rads where as animals which prey upon them have an LD 50 of about 500 rads. Bacteria and fungi have an enormous radioresistance; weeds, which would be quick to colonise areas laid to waste by fire and radiation can also be very resistant to radiation. Foxgloves, for instance, have an LD 100 of 50,000 - 75,000 rads compared to 2,000 - 3,000 for wheat[13]. Fletcher[14] suggests that without pesticides crop losses in the field and in storage might amount to 25%. Following a nuclear attack this is probably a conservative estimate, but we shall accept it anyway.

What is the outcome of this? We have seen that without fuel the 15 million survivors can produce 3.1 million tons of grain: sufficient for their needs. Now, however, we must subtract a further 75% to take account of the lack of other inputs. The result is that the survivors might produce only 0.78 million tons of grain per annum, sufficient for only 4.3 million survivors. Clearly, we have identified a critical problem. The lack of chemical inputs would mean that the population could not support itself and widespread starvation is almost certain. Even the estimate of just over 4 million is optimistic as it assumes the optimum organisation of labour and distribution of resources - a most unlikely possibility in the post-attack environment.

We have a few more areas at which we should look, which may further reduce food production. I propose to deal with them very briefly.

Firstly, the radiation effects on the offspring of irradiated crops and livestock. As well as reducing the yield of irradiated crops, radiation can reduce the growth and fertility of later generations. In general this would not be a particular problem in the post-attack environment. Where radiation was at its worst there will be few survivors and consequently little agriculture, thus little planting will take place of seed from the most irradiated crops. Livestock production is a similar case. Although the time of year affects the result, generally crops lost from this source might amount to a loss of 5%, a figure which would decrease over subsequent years. This would put a further strain on the ability of the harvest to support a large number of survivors. The loss in livestock is more difficult to predict, but is unlikely to be of significance to most survivors.

The control and distribution of food is essential to prevent areas of localised starvation and plenty. To this end the MAFF have devised a tight-knit plan for controling production. It is, however, highly unlikely that the system could operate, particularly as all the major control centres are located in cities which are likely to be attacked, and that the wealth of fuel and good communications that the plans require are unlikely to exist. Farmers will be effectively left on their own to intuitively do the best that they can.

As far as distribution is concerned, not only could it not be organised efficiently, but there would not be the fuel to run it. We have already seen that it would be difficult to find 800 kt of fuel for agriculture - the 3.2 MT required[15] for distribution would certainly not be available.

The inevitable consequence of these findings is that the number of immediate survivors of a nuclear attack is likely to be reduced, not only as a consequence of a shortage of food, but also because of the inadequate distribution of what exists.

The unequal distribution of food is itself likely to cause further problems. The hungry survivors from an inadequately fed area will migrate to other wealthier areas looking for food. Upon reaching affluent areas it is likely they would help themselves to food, with possibly disast rous effects upon the agricultural plans for that area. Consequently, although satisfying the short term food needs of the refugees, the long term survival of the refugees and the host population is likely to be compromised. There are modern parallels to this problem in the Third World where large numbers of refugees displaced by war, famine or persecution migrate to another country, bringing the host nation to the brink of starvation or economic collapse. In these situations, though, the refugees are still largely under the control of the host nation and their security forces. In post-attack Britain no marshalling of refugees into controlled camps is likely. Therefore, because of the impossibility of evenly distributing what food remains it seems likely that the number of long term survivors will decrease. It is impossible to estimate what the reduction in numbers might be; 10%? 25%? Who can tell? What is clear is that the estimate of 4 million long term survivors is beginning to look very optimistic.

Finally, in this part of the paper, we consider the problems of land denial. A nuclear attack and the need to shelter from fallout will mean that for a week or two no work can be done on the land. Will this significantly reduce the amount of food produced? The short answer is: no. There is no single agreed time when fertiliser must be applied; the tolerance of cereal crops is such that a delay of a week or two in sowing or harvesting will not significantly effect the national outcome. Fallout from a nuclear power station aparently presents more of a problem. Fetter and Tsipis[16] estimate that an area of 680 square miles down wind of a nuclear reactor might be experiencing doses in excess of 100 rads per annum. However this is only 8.3 rads a month, and whilst increasing the risk to those in the area it may well be considered an insignificant risk compared to others experienced in the post-attack environment. Indeed, unless in possession of radiac equipment people living in the area are unlikely to realise the dose they are receiving. Thus, if people survived in this area, it is unlikely that the land would not be used. In short land denial is likely to reduce yield nationally by less than 1% and is therefore ignored in my calculations.

To conclude thus far. A nuclear attack of approximately 230 MT might leave 15 million survivors in the short term. Grain stores and other supplies of food are likely to provide sufficient food for them to survive until the first post-attack harvest can be gathered in. Fallout might reduce the yield of that harvest to 65 - 80% of normal, depending upon the time of year. Should the attack occur in July or August then perhaps 76% of crops would be lost. There would still be sufficient food for the survivors.

The problems occur in the next and subsequent years. Lack of fuel for planting, harvesting and processing could lead to a reduction in yield of 30%; only 30% of the land previously worked might be maintained and owing to lack of fertilisers and pesticides a further reduction by 75% in yield could be expected on top of this. Within a few years grain production may be down to 0.8 million tons at best. Sufficient for 4 million people. Even so there would be further deaths caused by inadequate distribution of food and the chaos resulting from the depradation of large numbers of refugees moving from areas of food shortage to areas initially having a surplus.

Conclusions

This study might be called the 'good news' after hearing of the 'Nuclear Winter', but even this shows that the consequences of a nuclear war are far worse than is popularly imagined. Certainly it is worse than one would imagine from reading either Protect and Survive or the BMA's report The Medical Effects of Nuclear War.

Is there anything that can be done to limit the effects of a nuclear war on agriculture? The answer must be: no. Prevention is the only way in which disaster can be avioded. Even if stocks of fuel and fertiliser were built up they provide only a finite resource. They might put off the evil hour by a year or two, but eventually the problem of starvation and primitive agriculture would have to be faced.

The conclusions of this paper and the others presented at this conference make it clear why the MAFF have been silent about the effects on agriculture of a nuclear war. It also explains the continued delay in the publication of Home Defence and the Farmer. Once a nuclear war begins there is nothing that can be done to protect food production, and in the aftermath of a nuclear war it is food production that is the single most critical factor.

Notes

1. This paper is an abidged version of The agricultural consequences of nuclear war. To be published by the School of Peace Studies, Bradford University, this Spring.

2. International Civil Defence No 343 January 1984.

3. Sokolovski, V. D., Soviet military strategy. (RAND/Pentice Hall 1963) p. 402.

4. Ibid, p. 305.

5. Clarke, M., The nuclear destruction of Britain. (Croom Helm 1982).

6. Leavitt, J., Analysis and identification of nationally essential industries. (National Technical Information Services 1974).

7. Ibid, p. 26.

8. The full list of targets and the analysis supporting this conclusion is given in Crossley, G. J., British civil defence and nuclear war. Peace Research Reports No. 1 (Bradford University 1983).

9. Neal, J.W.L., 'United Kingdom considerations in agriculture defence planning' in Bensen and Sparrow (eds), Survival of food crops and livestock in the event of a nuclear war. (Brookhaven 1971).

10. Openshaw, S. et al, Doomsday. (Blackwell 1983).

11. Brown, S.L. and Pilz, U.F., US agriculture: potential vulnerabilities. (Stanford 1969 MU-6250-052), p. 28.

12. MAFF, Crop nutrition and soil science 1981. (HMSO 1981), p. 61.

13. Peterson, J. and Hinrichsen, D. (eds), Nuclear war: The aftermath. (Pergamon Press 1982), p. 137.

14. Fletcher, W.W., The pest war. (Blackwell 1974), p. 149.

15. Leach, G., Energy and food production. (IPC Science and Technology Press 1976), pp. 54-5.

16. Fetter, S.A. and Tsipis, K., 'Catastrophic releases of radioactivity'. Scientific American. (April 1981), pp. 33-9.