THE SIGNIFICANCE OF A NEW HARVEST TECHNOLOGY IN THE INTENSIVE PRODUCTION OF SUNFLOWER

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Where agriculture is primarily concerned with improved efficiency of intensive enterprises, flexibility and control of ressources is a characteristic of the more successful farms, particularly where large scale production is involved.

Harvest of sunflower and other oil seeds is frequently a difficult period, largely because its onset is unpredictable so that suitable planning of resource distribution and availability is impossible, and control poor.

This has an adverse effect on efficiency, not only of sunflower production but on other enterprises, such as harvest of other crops and land preparation, which are going on at the same time and competing for a share of available resources.

Reliance upon suitable weather to ripen crops which have reached the correct growth stage is the basic problem and with sunflower the seeds frequently reach maturity before the leaves and stems of the crops are sufficiently dry to allow combine harvesting to take place.

Clearly, in this situation there is a need to replace the influence of weather on the later stages of crop maturity with a technology giving the same effects but with an increase in predictability and control.

Chemical desiccation before harvest is extremely useful in a wide range of crops with similar problems. The use of Reglone * for this purpose on potatoes, rice, legumes and rape oil seed crop is well established. The technology has only recently been extended to sunflower following preliminary work with promising results (13, 14).

The more recent work examined the technical efficacy, the economic and mangement advantages, effects on oil quality and the safety of using oil and feeding stuffs produced from treated crops (10).

* Reglone — active ingredient diquat (1 : 1′-ethylene 2 : 2′-bipyridylium) — a registered trade name of ICI Plant Protection Ltd.

AGRONOMIC AND MANAGERIAL BENEFITS

There are a number of direct and indirect management problems which are difficult to avoid with conventional harvesting systems for sunflower.

The uneven dryness of sunflower plants at the time of seed maturity, is often exaggerated by variation in maturity between plants in different parts of large fields due to the effect of soil differences on plant growth. Under some circumstances there may be a break-down in weed control by harvest and this can significantly add to the amount of moist green material in the field when the crop is harvested.

During the period of natural desiccation required before combine harvest is possible losses, primarily due to bird damage, take place. The longer the delay the greater the potential loss. Estimated losses of 8—10% for bird damage may regularly occur and losses much higher than this have been recorded (11). As a result, not only is a planned utilisation of harvest resources difficult but the risk of seed yield reduction is increased.

Delay in harvesting can seriously interfere with the harvest of other crops, in particular maize and preparation for the next crop. Moist green and immature plant material not only causes combine blockages and slows combine output; it can add to the moisture content of ripe seeds which are mixed with this material as it passes through the combine. This in turn may add to the cost of drying and reduce the throughput of drying machinery.

These difficulties can be removed, or at least considerably alleviated, by the aerial application of Reglone to replace the effect of weather on the later ripening processes.

Application is made at the time of seed maturity using 1—3 l/ha Reglone with 0.1% by volume of a non ionic watter and from this point to the end of harvest the planning process becomes predictable.

Reglone desiccation accelerates drying of the plant by quickly killing all the green material in the crop and the decision of when to harvest is made easy.

There is a marked advance in the date of harvest from 9—16 days (6, 10, 13). Because of the reduced exposure to bird damage this factor can give considerably improved yield recovery, although obviously this will vary according to the degree of bird damage on untreated crops (table 1). The more uniform dryness of the desiccated crop will also improve the efficiency of the harvesting operation since the number of holdups due to blockage will be greatly reduced. Combine output has been improved by an extra 2—3 ha/combine/day (2, 10, 13) reducing costs in the sunflower crop and allowing better combine utilisation in competing crops.

Accelerated drying of desiccated plants can considerably reduce the moisture content of seed giving obvious saving in drying costs. This is partly a factor of lower seed moisture content before combining

but probably more a result of reduced transfer of moisture from other plant material as seeds pass through the combine (table 1).

Table 1

Sunflower: mean effects of desiccation on seed yield, moisture content and harevesting dates (3, 5, 6, 11)

Trial	No. of trials	Rates of Reglone l/ha	Yields q/ha[1])	Difference		Moisture[2]) content of seeds %	No. of days harvest advanced
				q/ha	%		
Hungary 1970	4	2	19.05	+3.65	124	—	—
		Control[4])	15.40		100	—	—
Hungary 1972	2	1.2 and 3	10.54	+2.18	126	10.5	+16
		Control	8.32		100	25.2	
Canada 1971/72	3	1.4 and 2.8	16.02	+0.65	104	7.7	+ 9
		Control	15.37		100	13.1	
Poland 1967/69	4	3	20.39	+0.94	105	13.6	Same date[3])
		Control	19.45		100	17.4	

[1]) Corrected to 10% moisture
[2]) Measured after combining except for Polish trial
[3]) Probably for experimental design reasons
[4]) Conventional harvest

Finally, the clearing of fields earlier than is possible with conventional harvest greatly assists preparation for the next crop and makes ressources more quickly available for other purposes including maize harvest and land preparation.

The clear managerial and economic advantages resulting from the new harvest technology must be supported by evidence that oil quality is unimpaired and that there is no hazard associated with the utilisation of the oil by-product.

ANALYTICAL RESULTS: HUMAN AND ANIMAL SAFETY

Samples of seed, oil and cake have been analysed for residues of diquat, the active ingredient of Reglone (table 2). Diquat residues in

Table 2

Sunflower: mean levels of diquat in seed, cake and oil from desiccated crops

	No. of trials	Interval (days) spray to harvest	Diquat residues (ppm)			
			Seed with husk	Husk	Cake	Oil
Hungary	2	11	<0.05	—	—	—
Poland	6	13	0.18	0.30	0.12	<0.05
Canada	2	23	<0.05	0.06	<0.05	<0.05

Samples from treatments at 1 — 3 l Reglone/ha
Limit of detection < 0.05 ppm

sunflower seed after treatment are normally low and frequently absent, due to the pendulous nature of the sunflower head which protects the seed from direct contact with the spray. Where they occur they tend to concentrate in the seed coat.

Diquat is not soluble in oil so that residues have never been detected in the oil from sunflower or any other desiccated crop.

After extraction of oil, residues, if present in the seed, will become concentrated in the extracted cake but the seed coat is not usually included in the extracted cake used for stock feed. This, in association with the normally low seed residue levels, accounts for the low concentration of diquat in extracted cake.

The significance of these analytical results is related to the utilisation of oil and cake by-products for human and stock feeding.

With no possibility of residue in extracted oil the product is obviously completely safe for human consumption. However, in view of the importance of cake from sunflower seed as a constituent of animal rations, it must be established that there is no indirect hazard to humans from residues of diquat in the cake fed to farm animals occuring in the milk or meat products of these animals ; and that the small residues present in cake have no detrimental effect on farm animals themselves.

This aspect was examined in detail in 1973 (12). Experimental milking cows were fed a ration containing cake artificially fortified with up to 50 ppm diquat. This was 50—100 times the residue level which would normally be expected to occur in cake produced from crops treated at the recommended rate of Reglone and the ration was fed for a period of 30 days. Milk samples were analysed at 6 day intervals for possible residues of diquat (table 3) and at the end of the trial some cattle from each group were slaughtered and various tissues dissected out and analysed for diquat residues (fig. 1).

No residues of diquat were detected in any of the milk samples (table 3).

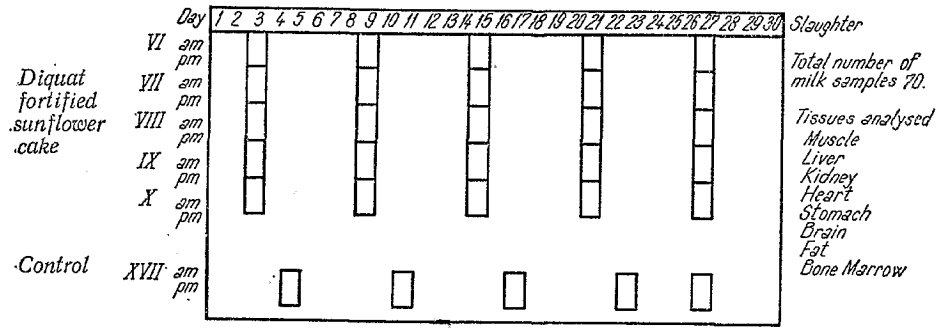

Fig. 1 — Sunflower cake feeding trial (1973). Scheme for feeding, milk-sampling and slaughtering.

Table 3

Sunflower cake feeding trial (1973) (10). Analysis of milk

Diet	Cow No.	Time of milking	Length of feeding (days) diquat residue (ppm)					
			3	9	15	21	27	30
Dairy ration containing fortified sunflower seed (50 ppm diquat)	VI	am	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
		pm	"	"	"	"	"	"
	VII	am	"	"	"	"	"	"
		pm	"	"	"	"	"	"
	VIII	am	"	"	"	"	"	"
		pm	"	"	"	"	"	"
	IX	am	"	"	"	"	"	"
		pm	"	"	"	"	"	"
	X	am	"	"	"	"	"	"
		pm	"	"	"	"	"	"
Dairy ration (only)	XVII	am	"	"	"	"	"	"
		pm	"	"	"	"	"	"

Milk from cows fed the control diet (cow number XVIII) was sampled on the days indicated in Figure 1.
N.D. = not detected, < 0.005 ppm
Recovery at 0.01 ppm fortification 83.6 (30 determinations).

Table 4

Sunflower cake feeding trial (10). Analysis of tissues after slaughter

Diet	Cow No.	Tissue analysed and diquat residue (ppm)							
		Muscle	Liver	Kidney	Heart	Stomach	Brain	Bone Marrow	Kidney Fat
Fortified sunflower (55 ppm diquat)	VII	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	VIII	N.D.	N.D.	0.04	N.D.	N.D.	N.D.	N.D.	N.D.
	IX	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Control	XVII	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Limit of detection	—	0.01	0.01	0.02	0.01	0.01—0.02	0.03—0.05	0.03—0.04	0.01
Recovery of diquat in analytical method (%)	—	55	48	61	63	65	73	81	65

N.D. = not detected at limit of detection.

The results of tissue residue analysis indicated that residues of diquat were not detectable in muscle, heart, stomach, brain, bone-marrow, kidney fat and liver. Very low residues of diquat were in the kidney from one animal (0.04 ppm) but this value was not toxicologically significant (table 4). The treated animals remained healthy during the period of the trial and readily consumed their dairy ration (12).

Similar results have been obtained when both sunflower seed and forage crops desiccated with Reglone have been fed to cattle and sheep. Diquat-desiccated grass silage containing up to 13 ppm diquat, was fed to sheep and cattle over long preiods (1). No diquat was detected in the meat or milk produced. Diquat desiccated lucerne hay containing 23 ppm diquat was fed to a cow and 2 sheep for 29 days (2). Again, no diquat was found in the milk or meat.

Finally, daily diets including 5 kg ground sunflower seeds containing 0.2 ppm diquat were fed for long periods to cattle and sheep (4). No diquat residues were found in milk, liver and kidneys of treated cows, or in the liver and kidney of treated sheep and a milk fed calf born to a treated cow.

Clearly, the feeding of Reglone desiccated oilseed to cattle will not lead to any hazard to consumers of meat and milk subsequently produced from the animals, even when the oilseeds are fortified with diquat to a residue level of 50—100 times that which occurs following desiccated of the seeds in the field. This in conjunction with the evidence for oil, indicates the complete safety of the utilisation of the treated crop both for humans and for animals.

MANUFACTURING QUALITY

Where analysis of standard parameters has been carried out the difference between treated and untreated samples has been small (table 5).

The most important parameters for industrial analysis are probably contents of oil (free fatty acids) and refining loss.

Reglone treatment can increase oil content and reduce FFA content, both important advantages. There is no marked difference in the refining properties of the oils, with the ratio of refining loss to FFA at 2.6—3.0 similar to the untreated oil.

Reglone treatment can lead to a chlorophyll content near the higher limits of standard values, but the higher value recorded (0.48 ppm) is only near the lower limit found in soya bean oils.

The established trend for rape oil, for which many more samples have been analysed, is very similar (7, 9) and no deleterious effects have been recorded or are anticipated sufficient to offset the important advantages of increase in oil content and reduction of FFA content in treated samples either of sunflower or rape.

Table 5

Effect of Reglone treatment on sunflower seed quality parameters (8)

P.P.L. Code		Control	1 l/ha Reglone	2 l/ha Reglone*)	3 l/ha Reglone
Food RA Code		5419/72	5420/72	5421/72	5422/72
Extraneous matter	%	2.73	1.60	1.76	4.13
Moisture content	%	5.87	5.31	5.11	4.70
Oil content (pure seed)	%	46.02	48.18	49.07	48.70
Oil content (pure dry seed)	%	48.89	50.88	51.71	51.10
Oil content Tale quale	%	44.76	47.40	48.21	46.69
Analysis of Extracted oil					
F.F.A. (as oleic)	%	3.41	2.78	2.25	1.94
Unsaponifiable matter	%	0.33	0.28	0.25	0.44
Sterol content of unsaponifiable	%	54	35	37	58
Hydrocarbon content of unsaponifiable	%	39	30	15	21
Terpene content of unsaponifiable	%	7	35	48	21
Lecithin (as P)	%	0.013	0.013	0.013	0.013
Lecithin (as P × 25.5)	%	0.33	0.33	0.33	0.33
Chlorophyll	p.p.m.	0.17	0.48	0.35	0.36
Colour (Lovibond 1" cell)					
Yellow		33	40	32	23
Red		1.2	1.4	1.4	1.2
Refining loss	%	9.16	8.30	6.73	5.03
Refining loss					
F.F.A.		2.69	2.99	2.99	2.59
Analysis of Fat Free Dry Cake					
Total protein (N × 6.25)	%	36.88	35.16	36.20	35.09
Soluble protein	%	0.04	7.11	8.21	7.06
Soluble Protein					
Total Protein		21.80	20.22	22.68	20.12

* Recommended rate of application.

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