

NORGES LANDBRUKSHØGSKOLE
Institutt for grønnsakdyrking
Stensiltrykk nr. 79
ISBN 82-576-5536-8

Memorandum fra "UAR/UNDP/FAO
Project No 39 Vegetable
Improvement and Seed Production
Research Centre, Dokki, Cairo,
UAR".

LIQUID MULCH FOR VEGETABLES

Experiences from Northern Climate
of possible interest for UAR

Professor Arnulf R. Persson

SYNOPSIS: GENERAL CHARACTERISTICS OF LIQUID MULCH ARE DISCUSSED. IT IS RECOMMENDED IN NORWAY FOR DIRECTLY SOWN CROPS AS CARROTS, ONIONS, BEANS AND SWEET CORN TO IMPROVE EARLINESS AND PREVENT EROSION. ASPHALT EMULSION MUST ALWAYS BE USED IN CONJUNCTION WITH APPROPRIATE WEED CHEMICALS.

1. BACKGROUND.

As for mulching vegetable crops two possibilities have drawn considerable attention in recent years:

1. Plastic (various qualities and colours).
2. Petroleum emulsion (which can be of various qualities).

Both types of mulch may have their places in the vegetable production. For instance, recent investigations on the use of clear plastic in growing pickling cucumber in the open, clearly demonstrates that one may gain a considerable yield increase under certain conditons. In this report I am only going to deal with fluid mulch. Generally speaking, a production factor to improve climate, must be regarded in the same way as all other production factors, i.e. it is not possible to predict the economical consequences in each particular case. This is true for instance with regard to the use of chemical fertilizers and various pesticides and weed killers as well as to the means to improve the climate. Our input is more like an insurance premium to secure a stable high yield. In modern intense vegetable production with high cost of manpower and investments, it is more and more important to obtain a stable high yield. The great variations in summer temperatures from season to season are the most decisive factor for the yield fluctuations in Norway. The growers are willing to invest in their productions in order to minimize the temperature effect on their crop. For this reason the asphalt mulch is an interesting new item worthy of a thorough investigation. Asphalt emulsion may be classified as liquid mulch. In general one may say that this type of mulch has the following advantages:

- (a) One can easily treat large areas. Liquid mulch fits nicely into an industrialized production. It can easily be applied with tractor equipment.

- (b) There is a great flexibility as to the amount to be applied on a certain area, for example, the distance between rows, the width and the thickness of the mulch strip. There is also the possibility to reduce the amount needed by mixing the mulch with water.
- (c) There are possibilities of combining liquid mulch with other chemicals such as herbicides, insecticides and fungicides. The positive effects of Encap may be associated with the following factors:
 - Increase of the soil temperature
 - Preservation of the soil humidity
 - Preservation of the soil structure
 - Prevention of erosion, and this may be split up into erosion caused by rain, water and wind.

Two of these factors, however, increase of soil temperature and prevention of wind erosion, play the most important roles in Norway. As to the appreciation of the practical growers it is difficult to tell which of these two factors is most decisive. In the South-west part of our country, where wind erosion in the early spring is a great menace to the carrot crop, the growers experienced a great beneficial effect of asphalt emulsion in 1965. As to the temperature effect, it appears that in the years 1962 and 1965, when the summer temperatures were lowest of the trial period, the yield increase for early carrots was at highest.

2. ASPHALT EMULSION FOR CROPS SOWN DIRECTLY

2.1. Carrots

From the information we got from the onset of the experiments, carrot, somewhat to our surprise, was probably the most promising crop. As for our experimentation during these four years, we have collected the most extensive observation in this crop. In 1962 we had three experimental fields located near the Oslofjord on various types of soil. The results from these trials showed clear beneficial effect of the mulch. In 1963 it was possible to extend the experimentations in carrot to cover various growing districts in the country. A special feature which we thought was worth while looking into was if the benefit of the mulch increased with the length of the day. The latitude of the carrot growing area of

Norway ranges from approximately 58° to 70° Northern latitude, and the length of day varies accordingly. It is an interesting question whether a connection between the effect of mulch and the length of day exists. But as we anticipated from the beginning it is hard to assess such an effect because other factors e.g. temperature and the amount of sunshine, may modify or even nullify the effect of the day length. In general the results of the experiments in 1963 did not give quite the same picture with reference to the positive effect of Encap as the 1962 trials did. The temperatures, at least in the southern part of Norway, were this year the highest of the trial period. A questionnaire was sent to growers who had used Encap on a trial basis in 1963. The following questions were asked:

1. Effect on the rate of germination
2. Effect on the stand (number of plants)
3. Effect on the earliness
4. Effect on the size of the crop
5. Effect on the quantity of weeds
6. Effect on the wind erosion

In setting together the results, the answers were given the following marks:

Answer - negative effect	= -1
" - no effect	= 0
" - somewhat better	= +1
" - decidedly better	= +2

The answer on the various questions were then as follows:

1. Effect on the rate of germination

11 answers marked	+2
14 " "	+1
4 " "	0

2. Effect on the number of plants

9 answers marked	+2
7 " "	+1
12 " "	0

3. Effect on the earliness

6 answers marked	+2
12 " "	+1
7 " "	0
1 " "	-1

4. Effect on the size of the crop

	5 answers marked	+2
14	" "	+1
5	" "	0
1	" "	-1

5. Effect on the quantity of weeds

10 answers indicated that mulched plots had more weeds than unmulched

2 answers that mulched plots had less weeds whereas

12 answers indicated no difference

6. Effect on the wind erosion

The question was only answered by a few of the growers, 6 gave it mark, probably the growers who had definite erosion difficulties.

By and large, the answers indicated a favourable impression. Note especially the effect on germination and wind erosion. From such a questionnaire it is of course difficult to assess the economical value of Encap. However, the data of 1964 may be more helpful in this respect and the results from this particular season are given in tables 1 and 2:

Table 1 - Effect of Encap on early carrots 1964 (sowing before May 1st. 7 experiments in various parts of the country)

<u>Treatment</u>	<u>Relative yield</u>	<u>Relative no. of plants</u>
(a) Control	100	100
(b) Asphalt mulch ^(x)	129	107
(c) Linuron at a rate of 500 g/haa.	108	94
(d) c + b		

(x) = When no more is mentioned the treatment is based on an application rate of 2000l/haa. and 15-20 cm strips

Table 2 - Effect of Asphalt much on carrots in 1964. Total average of 21 experiments from various parts of the country

<u>Treatment</u>	<u>Relative yield</u>	<u>Relative no. of plants</u>
(a) Control	100	100
(b) Asphalt mulch	118	102
(c) Linuron at a rate of 500 g/haa,	111	99
(d) c + b		

The average figures 1964 carrot experiments indicate that the greatest yield response of Encap one gets is from the early sowing usually followed by an early cropping. Earliness and yield increase may then be two sides of the same phenomenon. When discussing these figures one may take into account that in most experimental locations the temperatures in June-July was extremely low and this may have had an effect on the response of the early crop.

Later we are going to discuss the use of soil herbicides in connection with the mulch. In these experiments Linuron is used at a low concentration and it has been useful alone and in combination with Encap. It appears that the positive effects of mulch and Linuron are additive. The relative figures indicating the number of plants in "Tables 1 and 2" may be of less importance because some uncontrolled thinning of the plots may have taken place. In all cases, the improvement of plant stand has only, under certain conditions, any real importance. The results in 1964 indicated that asphalt mulch gave a more favourable impression at experimental fields in Northern Norway than in the Southern part of the country.

In 1965 field experimentation with asphalt mulch on carrots was only continued to a small extent, and the general impression of the trials is the same as years before.

In this series of experiments there has also been some single experiments with no effects and even negative effects. There may be several reasons for these results. It is clear that the more optimal the growing conditions are, the less effect is to be expected from the mulch. There have been fields with heavy weed growth where the results have been negative. The reason may be that the weeds also grow much faster on the Encap and may be more harmful to the young carrot plants by shadowing and using the water reserve than on untreated plots. The use of an effective chemical weed killer is an imperative. Carrots do not seem to take much heat at the time they get their true leaves.

Occasionally a black film on the soil will raise the temperature far beyond the optimum and even kill the plants. This observation may have a special bearing on the growing of carrots under plastic or glass covers where the temperature increase can be higher than in the open. In general, one may point out that asphalt mulch is primarily a means not help to correct nutritional disorders and prevent damage by pests and diseases. Theoretically at least one may even assume that sometimes a higher temperature may accen-

tuates disorders of this kind.

A very limited amount of early carrots are grown in frames in Norway. The high cost of production in frames makes it important to be able to, as early as possible, hit the early market when the prices are good. Observations on the use of mulch in frame-growing carrots indicate that one may get a considerable increase in growth, but here again the effects are not constant from trial to trial. Furthermore there is also a possibility that because of the slow breakage of the asphalt emulsion under cover, some of it will stick to the growing carrot roots and therefore destroy their market value. It can be assumed, however, that this drawback can be corrected by changing the composition of the emulsion.

In conclusion, concerning the asphalt emulsion with carrots, one may state that the information from our four year trials points out:

- (a) In general one may expect a yield increase by using Encap when growing early carrots. On average the net income from this yield increase will probably outweigh the expenses of material and application. If one assumes that the average yield of early carrots is 20000 kg/haa. the expected yield increase may be in the order of 20% i.e. approx. 4000 kg.
- (b) In two years, 1963 and 1965, we have especially asked growers to assess the effect on the prevention of wind erosion. The information collected points out that Encap seems to be a helpful tool. As a matter of fact, the growers have taken a great interest in this mulch with consideration to the prevention of wind erosion. From an economical aspect one may expect that this safeguarding of the crop will pay.
- (c) To avoid limited extent asphalt mulch is tried in connection with carrot production under plastic and glass covers. Although beneficial effects are observed however, we do not recommend commercial use of Encap under covers. A critical point is the sticking of the mulch to the carrot roots which makes them unattractive for the market. That the temperature may also go considerable beyond the optimal from time to time may also play a role. Altogether, we do not think we have enough observations to make any recommendations for this kind of production.

(d) For whatever purpose asphalt mulch is used with carrots one cannot predict with certainty the results. There are chances for no results and even negative results. The reason for the latter is that the Encap chiefly increases the temperature. Certain disorders of the crop may even be enhanced by the increase in temperature. But on the average the results point to the fact that there is an economical basis for the use of asphalt mulch for early carrots and in localities where wind erosion is a problem.

2.2. Onion and Leek

The production of onion in Norway covers about 200 haa. The Norwegian-produced onion has steadily increased in tonnage. Onion is, in general, a more demanding crop than carrot when temperature is concerned. The warmest localities and the lightest soil are allocated for the onion production and 50% of our onions are produced on sets in order to secure a better yield. The use of sets means much higher production costs compared with direct sowing and is a more likely basis for the spread of diseases such as white root and nematodes.

With reference to Encap, we have the idea that it would help in extending the onion production by using marginal land where the mulch could improve the temperature conditions. Furthermore, there is a possibility that Encap might give the basis for replacing the use of sets with direct sowing. In the first trials in 1962 and 1963 all plots showed a considerable benefit of the use of the mulch. In the last two years however, the results have not been too consistent. In table 3 results are included of 7 experiments in 1964 where the weed chemical FW925 was used.

Table 3 - Effect of asphalt mulch on onions 1964.

The results of 7 experiments in the Southern part of Norway. Relative yields when the control = 100.

<u>Treatment</u>	<u>Experimental places</u>							
	1	2	3	4	5	6	7	X
Mulch	120	115	105	135	150	176	70	124
FW925 (x)	100	10	100	100	100	90	80	102
FW925 +	120	115	100	135	116	211	100	128

(x) Recommended dosage.

One out of the 7 experiments gave a negative result. It was observed that on this particular field there was a severe attack of onion mildew, and the attack might have been worse on the fastest onions on the Encap bands.

A special part of onion production is to make sets. We feel it is an advantage to produce our own sets. We feel it is an advantage to produce our own sets in Norway, because imported sets are more likely to be infected by some disease or other. But here again the localities for this production are very limited, and Encap may be of some help to extend the growing areas. Actually one of the experimental places in table 3 was for production of sets (No 5). It was located on a heavy soil and the sets were clearly improved by the treatment. The importance of set production is to get an early start so that the sets can mature during the long days in the summer.

Leek is a minor crop for us, but it seems that it may become of growing importance especially if we can rely on direct sowing. The Southern part of Norway is just on the borderline for this production. A feature of our Encap investigations has been to see if mulch application might make this production more stable. The results with leek however, have been very variable. It looks as if there are major factors involved which we have no control over. Furthermore, thinning of leek on a mulch plot is very tedious work. In conclusion, our observations on the use of Encap with onions, points out:

- (a) By direct sowing of onions one may expect an increase in yield of a size which more than makes up for the cost of material and work with mulch application. On an average, one may expect a yield of 20000 kg. 1 grade onions per haa. By direct sowing, the increase of yield brought about by Encap may be in the region of 4000 kg./haa.
- (b) It is likely that asphalt mulch will prove useful in the production of onion sets, but so far our observations on this point are very restricted.
- (c) In general, asphalt mulch may be a tool in increasing the total production of onion in Norway because this may give us a means to use more marginal land for this production.
- (d) Our experiments with asphalt mulch on direct sowing of leek have given variable results, and we have no basis for a general commercial recommendation.

2.3. Some other crops

In general asphalt mulch is to be regarded as a means to speed up a crop when earliness is of importance, or to improve the temperature for heat-demanding crops. Early, directly-sown crops in Norway are for instance radish and Milan turnip. Our observations however, do not justify the use of the mulch on these crops. As for radish, the root growth is so rapid that it is a possibility that some asphalt material may stick to the roots and therefore destroy the market value. As for turnip, the effect of Encap on the speed of the growth has turned out to be so insignificant that here is no economical basis for the use. The prospects are somewhat better when it comes to early crops of lettuce, spinach, and sugar peas, but even here the results of the trials do not justify a clearcut recommendation, partly because the market value of the crop is very flexible.

As for spinach, the production for the open market is very small, and the contract farmers get no price premium for the early crop, which makes the use of Encap unattractive. Farmers producing early lettuce and sugar peas may be interested in limited application on their own land to test how it works under their growing conditions. If the trials are met with success this may lead to a more general use. For lettuce, not only does economy play a role, but on an asphalt film, it is possible to obtain a cleaner crop because the film, to a certain extent, will protect the crop from dust and dirt. This may also be true for spinach. The canneries have asked me to conduct trials in canning peas. These trials have however, not given an effect with asphalt mulch which makes it practically interesting.

Minor crops such as dill and root and leaf parsley are likely to react positively to the use of Encap but we are not able to give figures explaining anything of the economy of the application. As for the heat-demanding summer crops, asphalt mulch has been tried for beans, pickling cucumber and sweet corn. Early bush beans of various types (green and wax) have been included in the trials.

In general, one may expect a yield increase, but not always. On the average, one may expect a yield increase of approx. 15-20% and probably some improvements in quality in addition, because earlier yield usually means better quality. An average yield figure without treatment may be in the region of 8000 kg./haa which means an expected increase with treatment of approx. 1200-1500 kg./haa.

Under the prevailing market prices the commercial use of asphalt mulch may be justified. Pickling cucumber has reacted very variably to the treatment of Encap and the use is not recommended. It seems as if there is a far better economy in the use of clear plastic mulch. Directly sown corn is the crop which has been most stimulated by the use of asphalt mulch. However, in Norway there is a very limited production of sweet corn, and the practice is to start in the open with transplants from frames. Our observations on the sweetcorn may, therefore, have no practical value in Norway.

In conclusion, for the early minor crops mentioned above, lettuce spinach and sugar peas react positively to Encap treatments, to the extent that practical trials by the farmers are justified. This may also be the case for crops like dill, root and leaf parsley.

As for the heat-demanding crops, bushbean and sweetcorn have reacted so positively to the treatment that a practical recommendation should be justified. However, direct sowing in sweetcorn may not altogether be practicable.

3. THE USE OF ASPHALT EMULSION IN CONNECTION WITH TRANSPLANTS

In the open, the observations do not justify the use of asphalt emulsion in transplanted crops, for instance of cabbage, cauliflower, celery and leek. It is an indication that asphalt emulsion is more helpful for very early transplanted crops under covers, e.g. in frames, but our investigations are not sufficient for practical recommendations, and the potential need, for this purpose, would in any case be very restricted. In conclusion, we do not recommend Encap for transplanted crops.

4. THE USE OF ASPHALT EMULSION UNDER COVERS

Previously, we have mentioned that some precautions have to be taken when it comes to root crops under covers. The disintegration of the asphalt emulsion takes much longer. Also, as mentioned earlier, we are of the opinion that the demand for this purpose would at any rate be very limited. More as a curiosity we may mention that transplanted mulched sweetpepper in 1962 and 1965 gave considerable higher yield than untreated plots.

5. THE USE OF HERBICIDES IN CONNECTION WITH ENCAP

The use of good chemical weed killers is a necessity for practical application of Encap. Chemical weeding can be administered at various stages:

- (a) Before mulch application
- (b) Mixed with the mulch
- (c) After the mulch, as a soil herbicide or as a leaf herbicide, eventually as a selective chemical after the crop has germinated

Usually, it is a question of treatment a., and sometimes a combination of a. and c. is required. Mixing the weed killer with the mulch is rather impractical and not always possible. The reason for this is that we usually want to weed a larger area than we wish to mulch, and also one has to take care that the additive to the mulch does not break the mulch, for instance, only an acid additive goes with an acid emulsion.

In many experiments, it has been observed that the harmful effect of the weed killer from penetrating deep into the soil by the downwards waterstream and this reaching the germinating seed. Also the improvement of temperature and soil humidity just after mulch treatment may play a role in this respect.

Possible weed killers for the various crops in connection with the use of Encap:

5.1. Carrot

Linuron both on stage a. and c. has given satisfactory results. Rate: 1000 gm. active chemical/haa. On stage c., also white spirit at a rate of 600 - 800 l/haa.

5.2. Onion

Diquat on stage a. at a rate of 1000 gm. active chemical/haa. (As a selective spray fluid Ca - Cyanamide may be of interest for trials but it has not been tested sufficiently.)

5.3. Lettuce

CIPC at a rate of 3000 gm/haa. at a stage a. has proved satisfactory.

5.4. Spinach

Alipur at a rate of 4000 gm/haa. at a stage a.

5.5. Peas

Linuron at a rate of 1000 gm/haa. at a stage a.

5.6. Beans

Linuron. Monolinuron at a rate of 1000 gm/haa. at a stage a.

5.7. Sweet corn

Atrazin at a rate of 500 gm/haa. at a stage a.

In conclusion, one can say that today there are many good weed chemical which can be used in connection with Encap, and there is a good chance for steady improvements in this sphere of biological science. For the practical use of asphalt mulch, it is important that more work is put into solving the many problems connected with the weeding, as this is a fundamental basis for its practical application.

6. ANY HARMFUL EFFECTS OF ENCAP

So far, the positive side of the use of Encap only has been mentioned. Are there any harmful effects, to the soil, plants or consumers? As to the effect on the soil and the plants, we have indirectly tried to get an answer by applying quantities which might be accumulated during up to 100 years of use without taking into account the loss by leaching and chemical and biological decomposition. This heavy dosage did not seem to effect the growth of the tomato plants. In two independent tests with tomato plants, where a balanced nutritive was given to the plants, we got the the following results:

<u>Growing medium</u>	<u>Growth response</u>
100 % Encap crust	1/3 normal growth
10 % " "	Normal growth
1 % " "	"
0,1 % " "	"
0 % " "	"

Investigations on the uptake of Encap material by the plants have not been conducted, but we would like to give warning against any residues adhering to root crops grown under covers. Market vegetables must not be spoiled in this manner.

SUMMARY

Our investigations give support to the theory that liquid mulch, like asphalt mulch, may have some practical and commercial value for vegetable growers in Norway. After four years trials in various parts of the country, we can recommend Encap for:

- (a) Early carrots
- (b) To prevent wind erosion in carrot and onion production
- (c) For directly sown onions, particularly with a view to extending the growing area
- (d) For the production of onion sets, although our investigations into this problem are rather limited
- (e) For limited use on a trial basis, growers may apply asphalt emulsion on early crops of lettuce and sugar peas. The same may be said for heat-demanding crops such as beans and sweetcorn.
- (f) Asphalt emulsion must always be used in conjunction with appropriate weed chemicals. In most cases it is a question of a soil herbicide to be used before mulch application

Finally, we would like to state that the use of liquid mulch seems to fit well into the modern mechanized vegetable production. With the further development of mechanization, for instance in the line of precision seed drilling, the Encap might be a more useful tool than it is today. Also further developments in connection with the chemical weeding may point in the same direction.