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SMR/147-15

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15 April - 3 May 1985

COLLOQUIUM ON ENERGY FLUX AT THE SOIL ATMOSPHERE INTERFACE

6 - 10 May 1985

EFFECTS OF BITUMEN EMULSION ON SOIL PHYSICAL PROPERTIES

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Abstract

Bitumen emulsion used as mulching and soil conditioner can produce favourable effects on soil physical properties and crop yields.

It inhibits soil water evaporation: The rate is 7.8-29.7%. The soil moisture tends to be gathered to the top layer of the soil.

It increases soil temperature: The average increased temperatures per day at 5, 10, 15 and 20 cm were respectively 2-2.5°c, 1.5-1.7°c, 1°c and below 1°c.

It improves soil structure: Bigger than 0.5 mm water stable aggregates of sandy, clay and moderate saline soil increased by 40.9—600%, 11.9—15.1% and 8.3%.

Because of the improvement of soil moisture, temperature and structure, the yield of winter wheat increased by 10.7-27.2% and the yield of spring corn by 15.3-39.3%.

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Bitumen emulsion consists of bitumen, emulsifying agent and water. It is an emulsion after bitumen is emulsified. It contains fifty percent bitumen. Under normal temperature it can be mixed with water at any proportion and sprayed on soil surface. After its water evaporates, the bitumen granules condense and form a mulching. It can also be mixed with cultivated soil as soil contitioner. These two methods can produce favourable effects on soil physical properties and crop yields.

In 1930s some countries began to study the application of bitumen emulsion to agriculture. In the beginning, bitumen emulsion was used for sand-fixation and forestation in some countries. In America, it was used in planting grass sod to prevent soil erosion and good results had been achieved. In the sixties more and more countries used bitumen emulsion to increase soil temperature, preserve soil moisture and improve soil physical properties and achieved good results in increasing production.

In dry and semi-dry loess plateau, water is the main factor restraining crop and animal production. On the basis of the present level, increasing the content of soil moisture and the utilization of water is one of the urgent problems to be solved in agricultural production. Several years tests have proved that bitumen emulsion can increase soil temperature, preserve soil moisture, make soil moisture gather at the top soil layer and increase water stable aggregate of the soil.

I. The effect of bitumen emulsion on soil moisture

1. Bitumen emulsion can restrain the evaporation of soil moisture when it covers the surface of the soil. The evaporative intensity can be tested by the weighing method. It lasts six months. Changes of soil evaporative intensity and soil water loss can be seen in Fig.I. At the evaporative three stages, the effects of restraining the evaporation are different. The first stage (25-30 Oct.) is the stage of the control of atmospheric evaporative power, at which, the contrast evaporative intensity is increased, because of intensified atmospheric evaporation. With the treatment of bitumen emulsion mulching, the evaporative intensity remains unchangeable. The second stage (30 Oct. to 24 Nov.) is the stage of control of soil water conduction, at which,

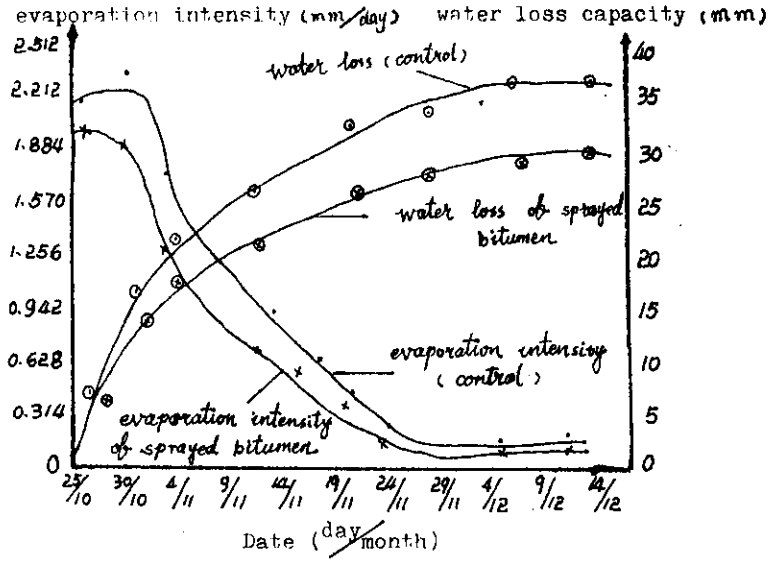

Fig.I. Changes of soil evaporative intensity and soil water loss

the evaporative intensity of the two treatments falls immediately. But the control evaporative intensity and water loss were higher then those of the bitumen emulsion mulching treatment. The third stage is the diffusion control stage (after 24 Nov.),at which,the evaporative rates are almast the same. In the whole evaporative process,the water content of the bitumen emulsion covering soil has been higher than that of the control. at the first and the second stages,the soil evaporative rates restrained by bitumen emulsion reach 7.8-29.7%.

2. With bitumen emulsion covering the soil surface,soil

water content and the utilization efficiency of soil water can be increased. Through the tests from 1982 to 1984 and measurement of water content in soil from field samples, the results have proved that soil water content covered by bitumen emulsion has increased in varying degrees. After the bitumen emulsion was sprayed on 16, Oct. 1982, the soil samples were taken in different periods and soil water content was measured by oven drying (Table 1). After the

Table 1. The increase of water content of the soil covered by bitumen emulsion

soil layer(cm) / water content(%) / treatment	soil sample on 27 oct. 1982				soil sample on 21 March. 1983				soil sample on 15 Appil. 1983			
	0-15	15-50	50-100	0-100	0-15	15-50	50-100	0-100	0-15	15-50	50-100	0-100
control	17.50	14.45	16.98	15.62	10.13	15.29	15.07	14.71	11.07	14.41	14.56	13.98
spraying bitumen	16.11	16.16	17.96	17.05	12.91	16.59	17.61	16.55	10.93	14.80	14.48	14.48
increase (%)	19.33	11.83	7.00	10.57	27.46	8.52	12.20	12.51	29.47	2.67	0.24	5.00

bitumen emulsoin was sprayed, the water content within one meter soil layer was increased remarkably and the soil water tended to be gathered at the top layer. At the lower layer the value of the soil water difference of the two treatments was decreased,but the value of the soil water difference at the top layer became greater and greater,from 2.61% to 2.78% and at last to 3.36%. The utillzation efficiency of water at the lower layer was increased.

II. The effect of bitumen emulsion on soil heat regime

Our province lies not only in a semi-dry area,but part of it is at high altitude. Crop production suffers greatly from freeze injury. After bitumen emulsion is sprayed on the soil surface,it will form a black film soon,and make

the ground reflection against the solar radiation fall from 35% to 10%. Thus the utilization and absorption of the solar energy is greatly increased. In addition to the decrease of soil moisture evaporation, the loss of latent heat decreases correspondingly and the soil temperature increases. The changes of the soil temperature at 10 cm depth within 24 hours were measured on 7 May 1983 (Fig.II.). It proved that

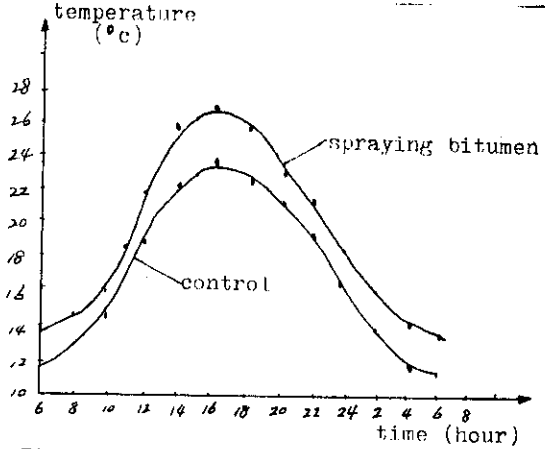

Fig.II. Changes of soil temperature within 24 hours

in the soil covered by bitumen emulsion, the temperature within 24 hours is higher than that in the control. When the atmospheric temperature is a bit lower, the soil temperature can increase by 1.5°c. When the atmospheric temperature is a bit higher, the soil temperature can increase 2.4°c. In daytime bitumen film can lower the ground reflection against sunlight , absorb more sun energy and increase soil temperature. So the effect of increasing soil temperature in daytime is better than that at night. Beginning from the

last ten-day period of October 1982, the changes of soil temperature were measured. It lasts one month. The results proved that the average day temperature at 5 cm soil depth increased by 2-2.5°c and the highest reached 7°c. At 10 cm soil depth it increased by 1.5-1.7°c and the highest reached 3°c. At 15 cm soil depth it increased about 1°c and the highest reached 2.5°c. At 20 cm depth it increased below 1°c and the highest reached 2°c. Temperature effects the activity of water. When temperature is higher, the flow of soil water increases and soil water content increases relatively.

III. The effect of bitumen emulsion on soil strcture

Bitumen emulsion is a good agent for improving soil structure. In November 1984, taking bitumen emulsion as soil conditioner, we experimented on sandy, clay and moderate saline soil. After one week, water stable soil granular structure was tested by static water method (Table 2).

Table 2. Effect of bitumen emulsion on water stable granules bigger than 0.5 mm

TREATMENT \ WATER STABLE GRANULE (%) \ TYPE OF SOIL	sandy	clay	moderate saline
CK	4.86	67.09	51.39
I	6.85	—	—
II	23.72	77.21	59.69
III	37.67	75.10	—

Note: CK. without bitumen emulsion
I. add 0.1% bitumen emulsion of the soil weight
II. add 0.2% bitumen emulsion of the soil weight
III. add 1% bitumen emulsion of the soil weight

Compared with the CK treatment, water stable granules bigger than 0.5 mm increased by 40.9-600% in sandy soil, 11.9-15.1% in clay soil and 8.3% in moderate saline soil. Good soil atructure can regulate soil water and temperature, and increase the soil ability of storing water. After bitumen emulsion is used on clay soil, and when the water content is 40%, the loss of water is less than 1.8 mm after 4 days evaporation.

After bitumen emulsion is sprayed, the soil water and temperature are improved and water stable aggregate increased. It creates a favourable soil condition for the growth of crops. After sprayed with bitumen emulsion, the growing period of winter wheat shifts to an earlier date, the death rate of overwintering wheat seedlings is decreased, the seedlings grow well and more products of photosynthesis are accumulated. The range of the increase in winter wheat production is 10.7-27.2%. After spring corn is sprayed with bitumen emulsion, the range of the increase in production is 13.5-39.3%.