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In the name of Allah

SEEDLING EMERGENCE AND GROWTH OF SUGARBEETS AS INFLUENCED BY SURFACE AND INCORPORATION APPLICATIONS OF PETROLEUM MULCHES[1]

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ABSTRACT

An experiment was conducted to study the effects of the cationic, anionic, and clay emulsions at surface application rates of 0, 2000, 4000, and 6000 liters/ha and at incorporation application rates of 0, 0.05, 0.10, and 0.15% (soil dry weight basis) on seedling emergence, early growth, and yield of sugarbeets in the greenhouse and in the field. Also, the effect of incorporation of Krilium Merloam (a copolymer of vinyl acetate and maleic acid) was investigated using the same rates of application. A local cultivar of sugarbeets was grown in a silty clay soil. Surface application of all types and rates of petroleum mulches significantly increased percentages of the emerged seedlings and their rate of emergence in both experiments. Incorporation application did not have any significant effect on seedling

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بنام‌خدا

اثرسطح پاشی وعمق پاشی مالچهـــــای نفتی برروی سربرآوردن جوانه‌ازخـــاک ورشدچغندرقند

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خلاصـــه

اثرات مالچهای نفتی (امولسیونهـــای کاتیونی ،آنیونی‌و رسی) بصـــــورت سطح پاشی‌با مقادیرصفر، ۲۰۰۰، ۴۰۰۰و۶۰۰۰ لیتردرهکتاروبصورت‌عمق پاشی بامقادیر صفر، ۰/۰۵، ۰/۱۰و۰/۱۵ درصد (برحسب وزن خاک خشک)برروی سربرآوردن جوانـــه‌از خاک وسرعت‌آن ،رشداولیه‌نهال ومحصول نهائی چغندرقنددرآزمایشی درگلخانـــه‌و مزرعه مطالعه‌گردید .علاوه‌براین، "کریلیوم مرلوم" (کوـ پلی مری ازوینیل استات‌و مالئیک اسید)بعنوان ماده‌اصلاح کننـــده همراه‌باسایرمالچهای نفتی با مقادیـــر مشابه‌درآزمایش‌عمق پاشی گلخانـــه‌ای بکاربرده‌شد .یک رقم‌چغندرقندمحلـــی در خاک رسی لیمونی کشت‌شد .درآزمایشات گلخانه‌ای ومزرعه‌ای ،سطح‌پاشی همه‌مواد بکاررفته‌درصدسربرآوردن وهمچنیـــن سرعت‌سربرآوردن رابطورمعنـــی داری افزایش‌داد .عمق پاشی همه‌مواد‌بکـــار رفته‌درگلخانه‌برروی درصدسربـــرآوردن جوانه‌ها وسرعت‌سربرآوردن اثـــــر معنی داری نداشت ،معهذادرشرائـــط مزرعه‌وتحت‌شرائط جـوی ورطوبتـی مساعدتری جهت دانه‌بندی،عمق پاشـــی مالچهای نفتی بمیزان۶۰۰۰ لیتـــردر هکتار (۰/۱۵درصد)درصدسربـــــرآوردن جوانه‌ها وسرعت‌سربرآوردن رابطـــور

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emergence and emergence rate in the greenhouse. However, in the field, application rate of 6000 liters/ha (0.15%) of all petroleum mulches significantly increased the percentage and rate of seedling emergence. In the greenhouse, incorporation of clay emulsion and Krilium Merloam at the rate of 0.15% had an adverse effect on the growth of sugarbeet seedlings and resulted in chlorosis of leaves. Petroleum mulches did not have any significant effect on yield and sugar content of sugarbeet in the field experiment.

معنی داری افزایش داد. درشرائط گلخانه‌ای ،عمق پاشی با امولسیون رسی وکریلیوم‌مرلوم‌با میزان ۱۵/۰ درصدبرروی رشدنهالهای چغندرقند اثرمنفی داشت وسبب زردی برگها شد .مالچهای نفتی اثرمعنی داری برروی محصول نهائی ودرصدقندچغندرقند درمزرعه نداشت .

INTRODUCTION

Calcareous soils with low organic matter contents are dominant in the arid regions of Iran (5). Low stability and physical degradation of these soils result in lower seedling emergence, smaller stands, and poor growth of crops. These soils develop surface crusts in a short time after irrigation which hinder the emergence of seedlings above the soil surface (2).

Many types of soil conditioners, including petroleum mulches, have been used as surface application for seedling establishment (1, 14, 22). Hatchett and Bloodworth (6) in Texas obtained increases in emergence of cotton seedlings of 118, 123, and 230% for application rates of 0.56, 1.17, and 1.59 m^3/ha of a petroleum mulch, respectively. Anter and Hilal (2) obtained 4.2 and 17.8 times more corn and barley seedling emergence, respectively, in soil treated with a film of 10 micron thick collodion. Furthermore, increases of 33, 100, and 130% in seedling emergence were obtained for lettuce, carrot, and onion, respectively, by petroleum mulching (17, 18).

Petroleum mulches influence the rate of emergence as well as emergence percentage (1, 17, 18). Sale (17, 18) reported that time required for 50% emergence of carrot and cauliflower seedlings was reduced by 80 and 85%, respectively, due to a petroleum mulch. Johnson *et al.* (11) indicated that plant growth was increased in the mulched

treatment and this growth advantage apparently declined later in the season.

In contrast to surface application of petroleum mulches, little data are available regarding their effects on the seedling emergence and their early growth when applied as incorporated soil conditioners. Chepil (4) reported an adverse effect of asphalt-in-water emulsion on corn and oats yield in laboratory.

The present experiments were designed to study the effects of three different types of Iranian petroleum mulches at four different rates applied as surface and incorporation applications on the seedling emergence, early growth, and yield of sugarbeets under greenhouse and field conditions. In the greenhouse experiment, a widely used soil conditioner, "Krilium Merloam", was used for comparison of the results with those obtained from the incorporation application.

MATERIALS AND METHODS

The Greenhouse Experiment

The soil used in this experiment was a Calcixerollic Xerochrept silty clay collected from the surface horizon of Bajgah Agricultural Experiment Station of College of Agriculture, Shiraz University, 16 km north of Shiraz, Iran. Selected physico-chemical properties of the soil are shown in Table 1. The soil samples were air-dried, crushed, and passed through a 2-mm sieve. The average maximum and minimum daily temperatures in the greenhouse were 34.2 and 13.7°C, respectively, during the experimental period. Plastic pots (19 cm deep) were filled with 4 kg of air-dried soil. Nitrogen and P in the form of urea and di-ammonium phosphate were thoroughly mixed with the soil at the rate of 57 and 12 mg/kg, respectively.

Thirty polygerm sugarbeet seeds (a local cultivar) were planted at 2-cm depth in each pot. Petroleum mulches (anionic, cationic, and clay emulsion) were sprayed on the

Table 1. Some physico-chemical properties of the soil used.

Sand (%)	5
Silt (%)	50
Clay (%)	45
Porosity (%)	45
Bulk density (g/cm^3)	1.46
Water content (weight basis) at -1/3 bar (%)	25.8
Water content (weight basis) at -15 bar (%)	16.8
Mean diameter of aggregates (mm)	0.169
pH (saturated paste)	7.9*
CEC (meq/100g)	17.4
$CaCO_3$ equiv., (%)	45*
Organic matter (%)	1.8*
EC_e, (mmhos/cm)	1.1*

*See (16)

soil surface at the rates of 0, 2000, 4000, and 6000 liters/ha. All three kinds of mulches were diluted three times in water at the time of application, as specified by the manufacturer. General characteristics of petroleum mulches used in this experiment are given in Table 2. The experiment

Table 2. Some general properties of petroleum mulches used.

Properties	Type of mulch		
	Anionic emulsion	Cationic emulsion	Clay emulsion
Asphalt (%)	50	60-64	48-50
Water (%)	45-47	33-40	48-50
Emulsifier (%)	2-3	0.5-1	2-3
Type of emulsifier	Vinsol resins	Fatty amine	Bentonite
pH	10-12	2-3	6-7
Hydrophobicity	Moderate	Moderate	Low

was completely randomized in a 3x4 factorial arrangements with three replications.

Soil water was raised to field capacity by irrigating with

tap water and the pots were irrigated when soil water declined to 60% of the available water capacity. Seedling emergence was recorded at 4, 5, 8, and 12 days after sowing. At this stage the number of seedlings in each pot was reduced to four. Irrigation was continued until 83 days after planting, when harvesting was accomplished by cutting the plants at the soil surface and washing the roots rree of soil. Tops and roots were then dried at 70°C.

For the incorporated treatment, mulches were mixed with the soil of the pots (prepared as before) to a depth of 15 cm by a mechanical mixer. The rates of application were 0, 2000, 4000, and 6000 liters/ha, equivalent to 0, 0.05, 0.10, and 0.15% dry weight of the soil, respectively. In addition, Krilium Merloam (copolymer of vinyl acetate and maleic acid) powder was also used with application rates of 0, 0.05, 0.10, and 0.15% dry weight of soil and its effect compared with the petroleum mulches. The experiment was completely randomized in a 4 x 4 factorial arrangement with three replications.

The Field Experiment

The field experiment was conducted at Bajgah on the same soil as used in the greenhouse study. Seed bed was prepared in spring and fertilized with 100 kg N and 20 kg P per hectare in the forms of urea and diammonium phosphate.

The experimental design was a split-split plot with four replications, consisting of three main plots (24 x 7 m) of different petroleum mulches and four subplots (6 x 7 m) of application rates 0, 2000, 4000, and 6000 liters/ha of the treated area. Each subplot consisted of two sub-subplots (2.5 x 7 m), one for surface application and the other for incorporation application of mulches. Five rows of polygerm sugarbeet seeds (a local cultivar) were sown at 2-cm depth and 50-cm intervals on each sub-subplot. The seeding rate was about 25 kg/ha.

In the case of surface application, mulches were applied on rows of planted seeds, 15 cm wide; but in the case of incorporation application, they were applied on rows of 25-cm width and were thoroughly mixed with the upper 15 cm of soil and the seeds were then sown.

Irrigation and other field operations such as thinning, weeding, and pesticide spraying were performed as required (15).

The average daily maximum and minimum temperatures during the growing season (May 5 to Nov. 1) were 32.1 and 3.1°C, respectively. The mean daily evaporation and relative humidity during growing season were 6.5 mm and 60.2%, respectively.

Seedling emergence was recorded at 8, 11, 17, and 24 days after sowing and the crop was harvested on Nov. 2. The tops and roots were weighed separately. Sugar content of the roots was determined by a saccharimeter in laboratory.

RESULTS AND DISCUSSION

The Greenhouse Experiment

Seedling emergence and rate. Data in Table 3 indicate the seedling emergence (%) and the emergence rate calculated as the number of days required for 50 percent emergence for surface application (D_{50}). Surface application of all of the petroleum mulches increased the percentages and the rates of emergence by 21 and 24%, respectively. However, there were no differences among the different surface application rates of different petroleum mulches in improving emergence percentages and rates under the greenhouse conditions (data not shown). Thus, applying 2000 liters/ha of any petroleum mulch on the soil surface will suffice and result in significant improvement of seedling emergence and rate. Furthermore, the effects of rate of surface application by type of mulch interaction were not significant for either emergence percentage or

Table 3. Final seedling emergence and rate of emergence (D_{50}) as affected by surface application, averaged over different petroleum mulches.

Rate of application (liters/ha)	Seedling emergence (%)	Rate of emergence (days)
0	59.3b*	6.7a
2000	72.2a	5.5b
4000	72.6a	5.6b
6000	70.4a	5.1b

*Means followed by the same letter in each column are not significantly different at the 5% probability level (Duncan's multiple range test).

rate of emergence.

The rapid seedling emergence due to the surface application of mulches is similar to the results reported by other investigators (1, 13, 22, 23). It is probable that the rapid emergence was mainly due to increased soil temperature and moisture at the seedling depth (1, 2, 11, 13, 17, 18). Increases in temperature and soil moisture were due to the greater effectiveness of the black mulch over the bare soil in absorbing radiation, and from the lower evaporation rate from the mulched surface, respectively.

In contrast to the surface application, none of the petroleum mulches or their rates in the incorporation treatment affected the percentages or rates of seedling emergence significantly (data not shown). It is therefore concluded that the surface application of these mulches is more beneficial than their incorporation into the soil. The ratio of percentages of seedling emergence in surface application to that in incorporation application was about

1.37. It is implied that on the average, 37% more seedlings emerged in the surface application than in the incorporation treatment. But the significance of this result was not tested.

Plant growth. No significant changes in top and root weights were observed with any of the petroleum mulches and rates used with the surface application (data not shown). This indicated that surface application of petroleum mulches with the rates used in this experiment had no adverse effects on the early growth of sugarbeets. Similar results were obtained for top weight of sugarbeets when different rates of mulches were incorporated into the soil (data not shown). Root weight was reduced significantly at 0.1% (dry weight basis) of application in the incorporation treatment (Table 4).

Table 4. Root dry weight of sugarbeets (total of 4 seedlings, g) as influenced by incorporation application of different rates of various petroleum mulches and Krilium.

Rate of application (%)	Type of mulch				
	Anionic emulsion	Cationic emulsion	Clay emulsion	Krilium	Mean
0	9.1	12.8	8.4	7.4	9.4a*
0.05	10.4	9.3	6.6	7.1	8.4ab
0.10	8.6	8.3	6.2	6.1	7.3b
0.15	8.4	8.7	7.4	5.7	7.6b
Mean	9.2a	9.8a	7.2b	6.6b	

*Means followed by the same letter in the marginal column or row are not significantly different at the 5% probability level (Duncan's multiple range test).

Different mulches had different effects when incorporated into the soil. Clay emulsion and Krilium decreased the top and root weights of sugarbeet seedlings significantly. Sugarbeet seedlings with reduced growth showed apparent symptoms of chlorosis (yellow leaves). Similar results were reported by Haise *et al.* (7) who observed N deficiency symptoms on sugarbeet leaves toward the end of the growing season and reduced yield with Krilium treatment at high rates. They reported that each 550 kg of Krilium added to the soil resulted in a decrease of 1.28 tons of sugarbeets per hectare. Leaf chlorosis observed could be due to Cu^{++}, Fe^{++}, and Zn^{++} deficiencies which caused suppression of growth (12, 20, 21). On the other hand, adverse effects of higher rates of Krilium on growth of sugarbeets might be due to an increase in aggregation of the soil (21). Hammerton (9, 10) showed that sugarbeet seedlings grown on a fine-textured soil (diameter< 1mm) produced a greater number and larger leaves than those grown on a coarse-textured soil. He suggested that this might have been due to more available water and better root-soil water contact in the fine-textured soil.

In field conditions, however, Sale (17, 18) reported a greater initial growth rate for seedlings of many vegetable crops on mulched compared with unmulched plots. The differences, however, tended to be small as the crop approached the marketable stage. Hale *et al.* (8) also found a small but significant increase in yield of cotton by mulching which might have been due to earlier germination and faster development.

The Field Experiment

Seedling emergence and rate. The effect of different mulches on final emergence was not significantly different (Table 5). However, surface and incorporation applications of all of the petroleum mulches increased the percentages of seedling emergence significantly. Average increases of

Table 5. Effect of surface (S) and incorporation (I) applications of different rates of petroleum mulches on final emergence of sugarbeets expressed as percentages of total number of seeds sown.

Rate of application (liters/ha)	Method of application	Type of mulch			Mean	
		Anionic emulsion	Cationic emulsion	Clay emulsion	Type of mulch	Method of application
0	S	11.5	10.3	11.3	11.0de	11.0a
	I	10.0	11.3	10.5	10.9e	
2000	S	16.3	15.8	17.3	16.5be	14.7b
	I	12.5	12.5	13.5	12.8de	
4000	S	18.0	19.0	16.8	17.9b	15.7b
	I	14.3	13.3	11.3	13.0d	
6000	S	23.5	25.0	18.3	22.3a	18.8c
	I	15.0	16.5	14.5	15.3c	
Mean		15.3a	15.5a	14.2a		

*Means followed by the same letter in the marginal columns or row are not significantly different at the 5% probability level (Duncan's multiple range test).

71.8 and 25.7% in seedling emergence percentages resulted from surface and incorporation applications of petroleum mulches, respectively. All rates of application increased the final emergence significantly as compared to unmulched plots. Application rates of 2000 and 4000 liters/ha of petroleum mulches on the soil surface increased seedling emergence significantly but their effects were significantly lower than that of the 6000 liters/ha rate. Application rates of 4000 or greater in incorporation method were required to result in higher seedling emergence (Table 5). Analysis of variance showed that surface application of petroleum mulches was more effective than incorporation

application (16.9 vs. 13.0%). The analysis also showed a significant interaction between the methods and rates of application. The incorporation application of 6000 liters of emulsions and surface application of 2000 liters of emulsions per hectare had a similar effect on seedling emergence percentage (Table 5).

The number of days required to obtain 10% seedling emergence (D_{10}) on mulched plots was approximately 10, and 5 days earlier than on unmulched plots at surface and incorporation applications, respectively (Table 6). Different

Table 6. Effect of surface (S) and incorporation (I) applications of different rates of petroleum mulches on the number of days required to obtain 10% sugarbeet seedling emergence (D_{10}) in the field experiment.

Rate of application (liters/ha)	Method of application	Type of mulch			Mean	
		Anionic emulsion	Cationic emulsion	Clay emulsion	Type of mulch	Method of application
0	S	20.4	23.9	21.0	21.8ab	22.1a
	I	22.6	20.6	23.6	22.3a	
2000	S	12.2	11.7	14.8	12.9ef	15.2b
	I	17.3	18.6	16.3	17.4cd	
4000	S	9.9	11.2	13.5	11.5fg	14.9b
	I	15.7	17.3	21.7	18.2bc	
6000	S	8.9	8.5	12.6	10.0g	12.8c
	I	14.4	12.6	19.6	15.5de	
Mean		15.2a	15.6a	17.9a		

*Means followed by the same letter in the marginal columns or row are not significantly different at the 5% probability level (Duncan's multiple range test).

types of emulsions were not different in thier effects on the rate of seedling emergence. However, all rates of application increased the rate of seedling emergence significantly, but application rates of 2000 and 4000 liters/ha were significantly less effective than 6000 liters/ha (Table 6). In general, initial emergence occurred 1 to 3 days earlier on the treated as compared to the control plots. Analysis of variance showed a significant method x rate of application interaction.

The results of field experiments were similar to those of the greenhouse study which confirmed the results obtained by previous investigators (1, 14, 17, 18, 22). Earlier and faster emergence obtained from surface application of petroleum mulches was probably related to higher soil temperature and soil moisture content under a layer of petroleum mulch than in bare control. The effects of these two factors on seedling emergence have been widely studied (1, 3, 11, 17, 18, 19, 22).

Plant growth and yield. Seedling growth in different plots indicated that surface application of petroleum mulches promoted rapid growth of sugarbeet seedlings because of earlier emergence (Table 6) which might in part be due to the higher moisture content in the root zone (2, 11). The differences in growth tended to decrease towards the end of the growth period as observed by other investigators (17, 18).

No significant differences in yield were observed from any of the mulches, methods, or rate of application (data not shown). Similar results were also reported by Takatori *et al.* (23). Sugar content did not show any response to petroleum mulch application (data not shown). It can be concluded that the surface and incorporation treatments of the soil with the petroleum mulches did not have any adverse effects on total yield and sugar content of sugarbeets in the the field, as reported by Haise

et al. (7).

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