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EFFECTS OF SOIL TYPE, SOIL MOISTURE AND SEED VIGOR LEVEL ON SUNFLOWER AND SAFFLOWER SEEDLING EMERGENCE

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SUMMARY

This research was conducted to determine the relationships among soil type, soil moisture and various level of seed vigor of sunflower (*Helianthus annuus* L.) and safflower (*Carthamus tinctorious* L.) pure live seed emergence (PLS). Experiment included three soil types were; silty clay (Vertic Haplaquols, fine montmorillonitic, frigid) which contains 11% sand, 42% silt, 47% clay; silt loam (fine silty, mixed Udic Haploborals) which contains 30% sand, 45% silt, and 25% clay; maddock sandy loam (sandy, mixed Udorthenic Haploboroll) which contains 57% sand, 30% silt, and 13% clay. Soil types were equilibrated to 15%, 30%, and 45% of the moisture holding capacity.

Results indicated that soil type (silty clay, silt loam, and sandy loam) and soil moisture level (15, 30, and 45% water holding capacity) had a significant ($P \leq 0.01$) effect on seedling emergence of both crops. Percent pure live seed emergence of low vigor seed lots of both crops was significantly ($P \leq 0.05$) reduced to a greater degree than was high vigor seed lots at low soil moisture content, and silty clay soil type.

Key words: Sunflower, safflower, seed vigor level, soil type, soil moisture, pure live seed emergence.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) and safflower (*Carthamus tinctorious* L.) are annual crops and adapted to semiarid and irrigated areas (Schuler et al., 1978). Stand establishment of both crops can be a problem for dryland growers in semi arid regions of the world (Somers et al., 1983). In these areas, moisture stress may often limit stand establishment of both crops.

Moisture for germination is adequate in soil that contains 50 to 70% water holding capacity (WHC). Germination is initiated when seed moisture content (on a dry weight basis) reaches 26 to 75%; e.g., 26% in sorghum (*Sorghum bicolar* L. Moench) and pearl millet (*Pennisetum glaucum* L. R.Br.), 45 to 50% in small grains, and 75% for soybeans (*Glicina max* L. Merr.) (Martin and Leonard, 1967).

Moisture stress often limits emergence of crops in semiarid regions. Germination percentage and seedling growth rate have been reported to decrease with decreased available soil moisture. Rate of decline in germination percentage and seedling growth has been reported to be genetically inherited and will vary with crop species and cultivar (Schneider and Gupta, 1985; Rao and Dao, 1987). Smith et al., (1989) reported that germination percentage of pearl millet seed was higher than that of sorghum seed under drought and low temperature stress. The ability to germinate under stress conditions would give pearl millet an advantage in stand establishement under less than ideal conditions, which frequently occur in semiarid regions.

Hadas and Russo (1974) reported that slower rates and lower levels of emergence of chickpea (*Cicer arietinum* L.), pea (*Pisum sativum* L.), and vetch (*Vicia faba* L.) seed in soil media were related to hydraulic conductivity and the wetted seed contact area. The net result was a reduced rate of water uptake, which in drier soils would delay or prevent rapid germination. Ashraf and Abu-Shakra (1978) reported that total germination of several wheat (*Triticum aestivum* L. and *Triticum durum* L.) cultivars was not affected by moisture stress levels up to 12 atm but was reduced at 15 and 18 atms osmotic tensions. Rate of root growth, speed of germination, and respiration rate were inversely related to moisture stress.

The objective of this research was to determine the relationships among soil type, soil moisture and various level of seed vigor of sunflower and safflower pure live seed emergence.

MATERIALS AND METODS

This research was carried out at the NDSU, Crop & Weed Sciences Dept., Fargo, USA, in 1989 and 1990. Six levels of sunflower hybrid "Interstate 7101", and five levels of safflower "Girard" seed vigor were developed by accelerated aging (AA). In order to do this seeds were treated in a chamber at 41°C for either 2,3,4,5,6,7 days and then removed. Seed from treated lots were evaluated with following experiment.

Experimental design was a split-split plot arrangement in RCBD with four replications.

The soil types compared were:

a) Silty clay (fine, montmorillonitic, frigid Vertic Haplaquols) which contains 11% sand, 42% silt, 47% clay. The sample was obtained from the Fargo Experiment Station.

b) Silt loam (fine-silty, mixed Udic Haploborols) which contains 30% sand, 45% silt, and 25% clay. The sample was obtained from the Prosper research site, ND.

c) Maddock sandy loam (sandy, mixed Udorthenic Haploboroll) which contains 57% sand, 30% silt, and 13% clay. The sample was obtained from the Oakes Research Station, Oakes, ND.

Soil types were equilibrated to 15%, 30%, and 45% soil moisture holding capacity (WHC). Moisture holding capacity of the soil types was determined using a pressure plate (Somers et al., 1983; Rao and Dao, 1987; Smith et al., 1989). Containers (5cm diameter) with a hole in the bottom were filled with a representative sample of each soil type and flooded until they were saturated. The containers were placed in a pressure cooker and allowed to drain under 1/10 bars pressure for 24h, after which soil samples were weighed and placed in an oven at 105°C for 24h. After 24h, dry weight was determined. Water holding capacity was calculated by dividing the amount of water lost by the soil dry weight times 100 to obtain a percent value (AOSA, 1983). The ratio of water (liter)/dry weight of soil (g) for 15%, 30% and 45% moisture holding capacities was calculated for each soil type using the formula "weight of air-dried soil (g) x moisture holding capacity (%) x the desired moisture (%)". The air-dried soil and appropriate amount of water were mixed for one h in a blender. The mixed soil was stored in a double plastic bag for one week to allow equilibration (AOSA, 1983).

To evaluate the interaction of seed and soil moisture level as they influence emergence, 10 seed of each lot were placed at a depth of 5cm in a round plastic pot (11.3 cm diameter) containing the equivalent of 0.5kg of the equilibrated soil. Each pot was considered as an experimental unit. Pots were covered with films of Saran^{R} wrap secured with a rubber band to prevent evaporation. The pots were then randomized and placed in a darkened growth chamber at a constant temperature 24°C. A sedling was considered emerged when the hypocotyl became visible above the soil surface. Determination of emergence was made 14 days after planting.

RESULTS AND DISCUSSION

The mean values for PLS emergence of sunflower hybrid IS-7101 and Girard safflower at three soil types, three levels of soil moisture and seven levels of seed vigor are presented in Tables 1 and 2. PLS emergence of IS-7101 sunflower and Girard safflower averaged across three soil types as related to soil moisture and level of seed vigor (AA days) are given in Figures 1 and 2.

The effects and interactions among soil types, soil moisture levels, and the level of seed vigor on the PLS emergence of both crops were determined by the analysis of variance. Results indicate that all main effects had a significant ($P \leq 0.01$) effect on PLS emergence of both crops.

Table 1: Mean values for percent pure live seed (PLS) emergence of sunflower hybrid IS-7101 and Girard safflower at three levels of soil moisture and seven levels of seed vigor.

	IS-7101 (Sunflower)			Girard (Safflower)		
	Percent WHC[2]			Percent WHC[2]		
Main Effect	15	30	45	15	30	45
Days of AA[1]	% Emergence			% Emergence		
0	21.9	80.4	95.3	21.1	86.3	96.0
2	23.1	65.2	73.4	12.8	65.9	87.6
3	18.2	65.9	75.0	3.2	40.2	62.0
4	0.0	67.6	70.9	0.0	41.1	66.2
5	0.0	34.1	60.6	0.0	47.3	47.3
6	0.0	22.3	53.6	-	-	-
7	0.0	0.0	0.0	0.0	31.2	31.2

LSD1 (0.05): 11.2 within each column (moisture level) and,
30.8 within each row (d of AA) for Hybrid IS-7101.
10.9 within each column (moisture level) and,
26.7 within each row (d of AA) for Girard.

[1] Accelerated aging treatment
[2] Water holding capacity

There was a significant ($P \leq 0.05$) difference between silty clay and the other soil types for PLS emergence of both crops. Differences between silt loam and sandy loam soil types for percent PLS emergence of either crop were nonsignificant.

Percent PLS emergence of both crops was influenced significantly ($P \leq 0.05$) by differences in soil moisture level. Percent PLS emergence of both crops decreased as

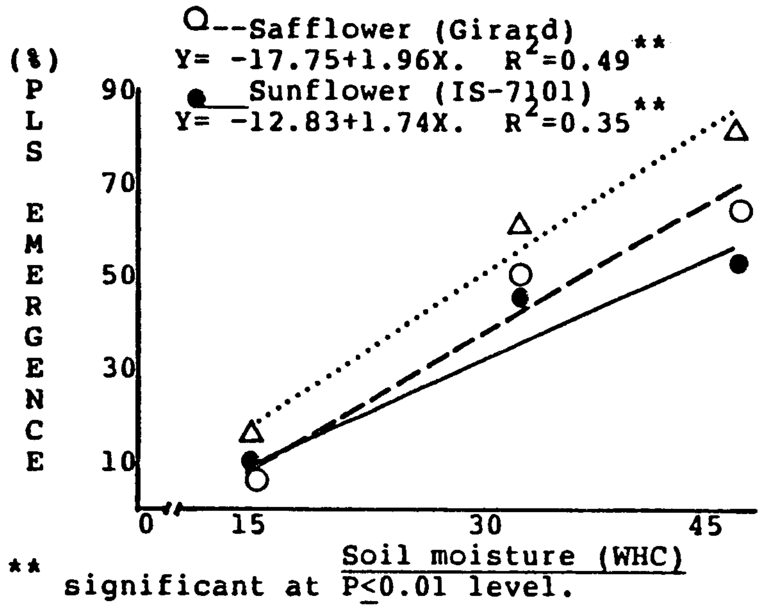

Figure 1: Pure live seed (PLS) emergence of sunflower and safflower averaged across three soil types as related to soil moisture (WHC).

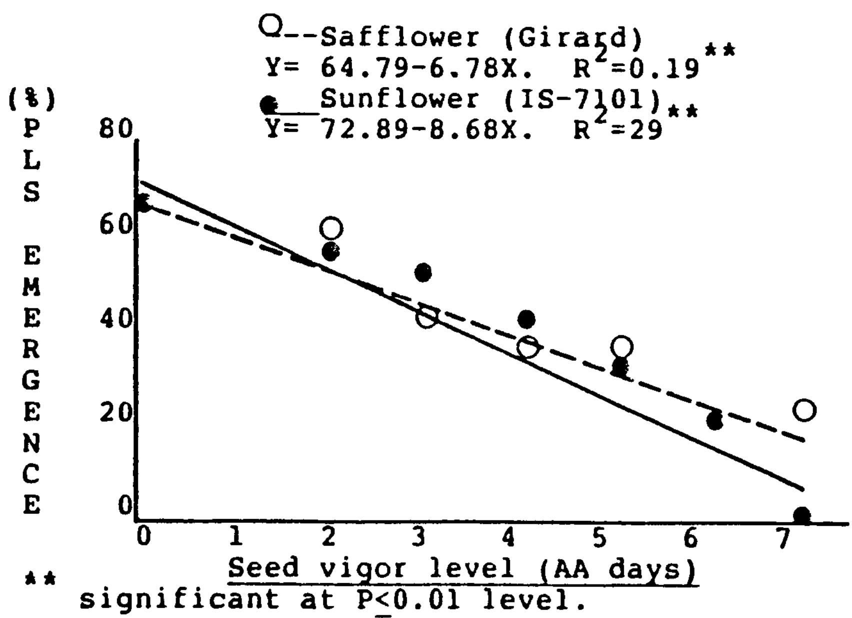

Figure 2: Pure live seed (PLS) emergence of IS-7101 sunflower and Girard safflower averaged across three soil types and three soil moisture levels as related to the level of seed vigor (AA days).

percent water holding capacity (WHC) decreased. This is illustrated in Figure 1. The data suggest that as soil moisture content increased from 15% to 45% WHC there was a significant ($P \leq 0.01$) increase in percent PLS emergence of both crops. This indicates that low levels of soil moisture ($\leq 15\%$ WHC) reduce stand establishment significantly ($P \leq 0.05$).

Seed vigor level was negatively related to percent PLS emergence of sunflower hybrid IS-7101 and Girard safflower (Figure 2). This relationship was significant as the longer seed was treated by accelarated aging the lower the level of vigor and the lower the PLS emergence. This was expected, because the reason for treating seed by accelerated aging was to establish seed lots having different levels of vigor.

Table 2: Percent pure live seed emergence of sunflower hybrid IS-7101 and Girard safflower at three soil types, three levels of soil moisture, and seven levels of seed vigor.

Treatment levels		Sunflower IS-7101			Girard safflower		
		Percent water holding capacity					
Soil type	Days of AA[1]	15	30	45	15	30	45
		% Emergence			% Emergence		
Silty clay	0	0.0	70.8	94.4	0.0	76.6	92.4
Silty clay	2	0.0	53.0	69.3	0.0	50.2	88.6
Silty clay	3	0.0	47.7	68.2	0.0	32.6	62.0
Silty clay	4	0.0	50.7	60.8	0.0	42.9	58.9
Silty clay	5	0.0	0.0	56.8	0.0	50.7	20.3
Silty clay	6	0.0	13.4	40.2	-	-	-
Silty clay	7	0.0	0.0	0.0	0.0	13.4	40.2
Silt loam	0	28.8	91.8	94.4	21.1	89.8	100.0
Silt loam	2	32.6	69.3	69.3	14.8	73.8	82.7
Silt loam	3	20.5	75.0	74.9	3.3	42.2	61.9
Silt loam	4	0.0	81.2	81.2	0.0	32.1	69.6
Silt loam	5	0.0	45.5	56.8	0.0	50.7	50.7
Silt loam	6	0.0	26.8	67.0	-	-	-
Silt loam	7	0.0	0.0	0.0	0.0	53.6	13.4
Sandy loam	0	36.7	78.7	97.0	42.3	92.4	95.1
Sandy loam	2	36.6	73.4	81.5	23.6	73.8	91.5
Sandy loam	3	34.1	75.0	81.8	6.5	45.7	62.0
Sandy loam	4	0.0	70.9	70.9	0.0	48.2	69.6
Sandy loam	5	0.0	56.8	68.2	0.0	40.5	70.9
Sandy loam	6	0.0	26.8	53.6	-	-	-
Sandy loam	7	0.0	0.0	0.0	0.0	26.8	40.2

LSD =(0.05) 53.4 within each column (moisture level) and
19.4 within each row (soil type x days of AA) for sunflower hybrid IS-7101.
46.1 within each column (moisture level) and
18.8 within each row (soil type x days of AA) for Girard safflower.

[1] Accelerated aging treatment.

The interaction of soil moisture with the level of seed vigor was significant at $P \leq 0.01$ for both crops. The data indicated PLS emergence of both crops from low vigor seed decreased to a greater degree at the lower levels of soil moisture (Table 1). This suggests that the additional stress imposed by low soil moisture is an important factor which may decrease the emergence of low vigor seed.

The interaction among soil types, soil moisture levels, and seed vigor was significant ($P \leq 0.01$) with both crops (Table 2). This interaction occured because there was a higher percent of PLS emergence at the 30%, and 45% WHC levels in the loam than in the clay soil types. Similar results on the effect of low soil moisture have been reported on emergence of sunflower (Somers et al., 1983); sorghum, pearl millet, soybeans (Martin and Leonard 1967; *Brassica* cultivars, Rao and Dao, 1987).

CONCLUSIONS

Soil type, soil moisture and seed vigor level had a significant ($P \leq 0.01$) effect on percent PLS emergence of both crops. Soil moisture and the percentage of PLS emergence for both crops were positevely related ($P \leq 0.01$) within the limits tested. As soil moisture increased from 15% to 45% WHC there was a significant ($P \leq 0.01$) increase in percent PLS emergence of both crops. This indicates the importance of available soil moisture for uniform stand establishement. Percent PLS emergence at 15% WHC of both crops sown in silty clay was lower than that for any other soil type or soil moisture level. The results indicate that percent PLS emergence of sunflower hybrid IS-7101 and Girard safflower from low vigor seed decreased to a greater degree at low levels of soil moisture.

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EFECTOS DEL TIPO Y HUMEDAD DEL SUELO Y VIGOR DE LA SEMILLA SOBRE EMERGENCIA DE PLANTULAS EN GIRASOL Y CARTAMO

RESUMEN

La presente investigación se llevó a cabo para determinar la relación entre el tipo de suelo, humedad y varios niveles de vigor de la semilla del girasol (*Helianthus annuus* L.) y cártamo (*Carthamus tintorius* L.) sobre la emergencia de semilla.El experimento inolyó tres tipos de suelo: arcilloso, limosoa (Vertico-Haplaquols, fino montmorillonitico) que contiene 11% arana, 42% limo, 47% areilla, franco limoso (limoso fino mezela Udertemetico, Haplo boroll) que contiene 57% de arena 37% limo y 13% arcilla. Los tipos de suelos fueron equilibrados al 15%, 30% y 45% de la capacided de retencion de aqua.

EFFETS DE LA NATURE, DE L'HUMIDITÉ DU SOL ET DE LA VIGUEUR DES GRAINES SUR LA LEVÉE DE SEMIS DE TOURNESOL ET DE CARTHAME

RÉSUMÉ

Cette étude a été menée afin de déterminer les relations existant d'une part entre la nature du sol, l'humidité du sol, la vigueur de graines de tournesol (*Helianthus annuus* L.) et de carthame (*Carthamus tintorius* L.) et d'autre part le taux de plantules levées et viables. L'expérimentation comportait trois types de sol: des argiles limoneuses (Vartio Haplaquols, montmorillonites fines) contenant 11% de sable, 42% de limons, 47% d'argiles; un terreau limoneux (limons fins, mélange Udic Haploborals) 30% sable, 45% limons et 25% argiles; un terreau sableux (sables, mélange Udic Haploboroll) 57% sable, 30% limons et 13% argiles. Ces différents types de sol étaient stabilisés à 15%, 30% et 45% de leur capacité de rétention en eau.

Les résultats indiquent que les paramétres types de sol (argiles limoneuses, terreau limoneux, terreau sableux) et niveau d'humidité des sols (15, 30 et 45% de capacité en rétention d'eau) ont un effet significatif (P=0.01) sur la levée des semis des deux cultures. De même pour les deux cultures, le pourcentage de plantulas levée et viables des lots de semences de faible vigueur était réduit dans des proportions plus importantes comparé aux lots de fortes vigueur dans des sols à faibles humidité ou des sols limono-argileux.