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SHORT COMMUNICATION

Effect of soil temperature on seedling emergence in different crops

Summary

Seedling emergence in different crops was studied in the soil temperature range of 5°C to 45°C. In peas and turnips seedling emergence stopped at a soil temperature of 35°C and in other crops at 45°C. The minimum temperature for seedling emergence was above 10°C in case of cotton, sorghum, rice, maize and musk melon and above 15°C in case of squash, bottle gourd and okra. Winter crops like wheat, gram, peas, and turnips emerged at 5°C but the percent emergence was low. The optimum range for seedling emergence was narrower for vegetable crops as compared with cereals.

Introduction

Terrestrial as well as seasonal distribution of many plants is governed by the fact that seeds will germinate only when the prevailing soil temperature is suitable. Dubtez *et al.*[2] for example, reported that maize germination at 6°C was very low and the seedling was delayed until the soil temperature was 13°C. They found no difference between temperatures of 13° and 18°C. The optimum temperatures reported by some other workers [1 7] ranged from 26.5°C to 30°C. A similar lack of agreement is seen for the optimum temperature requirements for the growth of rice seedling. Whereas optimum temperature suggested by Matsuo [5] was 23°C, Herath and Ormrod [4] and Mayer and Mayber [6] reported 32°C to be the most favourable temperature.

The paucity of controlled studies to evaluate soil temperature as an edaphic factor, varietal differences, presowing condition of seeds and the use of different standards for germination and emergence counts have resulted in wide variations in optimum soil temperature reported in the literature. Many studies have emphasized the magnitude but ignored the rate of emergence. The results reported in the present study consider both aspects.

Material and methods

Ludhiana sandy loam soil used for these replicated studies is a well-drained, salt-free soil with a low organic carbon content. Two kg of soil, passed through a 2-mm sieve and spray-moistened to achieve a soil moisture tension of 0.5 atmospheres was packed in metal pots to a uniform bulk density of 1.45 g/cm^3. Pots were placed in temperature control water baths and soil temperature

was regulated with a dry run. Soil temperatures were maintained from 5°C to 45°C. Seeds were then placed on the soil equidistantly and covered with 2.5 cm thick soil of the same bulk density. The moisture loss from the pots was daily made up by adding water of the same temperature as the soil itself.

Crops and their varieties studied were cotton (*Gossypium hirsutum*, F-320); maize (*Zea mays*, Ganga-105); rice (*Oryza sativa*, J-349); gram (*Cicar arietinum*, local); wheat (*Triticum aestivum*, K-227); sorghum (*Sorghum vulgare*, hybrid); okra (*Hibiscus esculentus*, Pusa); bottle gourd (*Cucurbita pepo*, early long); musk melon (*Cucumis melo*, local); peas (*Pisum sativum*, P-23); turnip (*Brassica rapa*, White-4); and squash (*Cucurbita maxima*, light green). The first emergence count was taken 24/48 hours after sowing but the subsequents counts at 12-hour intervals. Since the seeds were 100 per cent viable, any reduction in emergence was considered to be the treatment effect.

In order to study the effect of soil temperature on the rate of seedling emergence, probits of the per cent emergence were plotted against the time. As out lined by Goulden [3] a smooth regression line of the form:

$$Y = a + bT$$

was fitted to the data for each temperature. Y in the above equation refers to the probit of per cent emergence, a is a constant and T the time in hours after sowing. The slope of the line b was taken as an index of emergence rate. The value of T was selected to obtain near maximum emergence and any deviation from this maximum was considered a slower rate of emergence.

Results and discussion

The results in Table 1 show that no seedling emerged at a soil temperature of 45°C. The seedlings emerged over the temperature range of 15 to 40°C in case of cotton, sorghum, rice, and maize and in between 5–40°C in wheat and

TABLE 1

Effect of soil temperature on final counts of seedling emergence

Crops	Soil temperature °C								
	5	10	15	20	25	30	35	40	45
Gram	35.0	97.5	100.0	100.0	100.0	100.0	100.0	55.0	0.0
Wheat	40.0	97.5	97.5	100.0	100.0	97.5	85.0	17.5	0.0
Peas	37.5	97.5	100.0	97.5	97.5	62.5	0.0	0.0	0.0
Turnips	15.0	72.5	90.5	100.0	87.5	47.5	0.0	0.0	0.0
Cotton	0.0	0.0	17.5	92.5	95.0	97.5	97.5	42.5	0.0
Sorghum	0.0	0.0	55.0	95.0	97.5	97.5	92.5	82.5	0.0
Rice	0.0	0.0	85.0	97.5	97.5	100.0	97.5	17.5	0.0
Maize	0.0	0.0	92.5	100.0	100.0	95.7	85.0	60.0	0.0
Musk melon	0.0	0.0	55.0	82.5	97.5	97.5	92.5	75.0	0.0
Squash	0.0	0.0	0.0	35.0	75.0	97.5	90.0	62.5	0.0
Bottle gourd	0.0	0.0	0.0	43.9	96.7	96.7	96.7	52.8	0.0
Okra	0.0	0.0	0.0	72.5	100.0	97.5	100.0	85.0	0.0

TABLE 2

Effect of soil temperature on probable percent emergence of various crops at a given time

Crop	Time hours	Soil temperature °C						
		10	15	20	25	30	35	40
Wheat	150	—	5.2	—	97.9	91.8	42.2	16.6
Gram	100	0.5	2.9	13.2	89.4	95.3	94.6	26.3
Peas	150	21.0	71.2	83.8	90.9	58.5	—	—
Turnips	150	36.9	67.4	93.9	82.9	56.2	—	—
Rice	150	—	16.8	27.0	69.3	100.0	95.9	9.9
Maize	100	—	—	48.4	—	92.0	88.3	62.3
Cotton	100	—	1.2	22.6	94.6	81.7	35.2	11.1
Sorghum	100	—	48.1	64.8	97.5	96.9	78.0	12.0
Squash	150	—	—	2.8	18.4	87.6	85.0	53.1
Okra	100	—	—	59.5	64.7	82.9	99.9	81.1
Bottle gourd	150	—	—	12.2	61.6	93.5	94.9	53.2
Musk melon	100	—	22.4	47.0	91.9	97.3	78.5	—

gram. Vegetable crops, in general, showed a narrower range of soil temperature for seedling emergence. Okra, bottle gourd, and squash, for example, emerged in the temperature range of 20°C to 40°C and musk melon between 15°C to 30°C. In all crops initiation of emergence was invariably delayed at the coolest end. At the warmest end, emergence generally started along with the optimum temperature but its rate sharply dewindled within 48 hours.

The temperature effects were more remarkable on the rate of seedling emergence than on the final count. For example, in gram, the percent emergence was equal in the temperature range of 10°–35°C but a great lag in the time of emergence was noticed in this range. At 25°, 30° and 35°C, the seedling emergence started between 72 to 84 hours after sowing and completed within 108 hours. At lower soil temperatures the time lag increased from 12 to 24 hours at 20°C, to 400 hours at 5°C. Seedling emergence in wheat compared closely with that in gram. In maize, cotton and sorghum, the time lag in emergence was not appreciable but a significant delay in time of emergence was observed at 15°C. The variation in percent emergence was, however, relatively small in case of vegetable crops.

The results indicate that for most of these crops, the lower limit of favourable temperature range lies between 15°–25°C and the higher limit extends up to 35°C. Emergence was greatly reduced at 40°C. The reduction in emergence could be due to poor germination combined with improper development of seedling. Increase in the rate of respiration [8] and metabolic failure of seeds at high temperature also result in reduced emergence. At minimal temperatures sub-optimal metabolic activity could result in prolongation of germination period and decreased vigour of seedling resulting in lower emergence. The optimal temperature may thus be the temperature at which the highest percent emergence is obtained in the shortest time as shown in Table 2.

It is seen that percent germination values are low at the lower end of the temperature scale, reach a certain maximum and then decline at higher temperatures. The peak values would thus give the most suitable temperature. Below this temperature metabolic activity could be slow and above this temperature metabolic failure might result in decreased emergence. These data also show that the rate of emergence is highest in temperature regimes where final emergence counts were higher.

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References

1 Allmaras, R. D. *et al.*, Soil Sci. Soc. Am. Proc. **28**, 271–275 (1964).
2 Dubtez, Z. *et al.*, Can. J. Plant Sci. **42**, 481–487 (1962).
3 Goulden, C. H., Methods of Statistical Analysis. John Wiley and Sons, Inc. New York (1952).
4 Herath, W. and Ormrod, D. P., Agron. J. **57**, 373-376 (1965).
5 Matsuo, T., Rice Culture in Japan. Ministry of Agriculture and Forestry, Japanese Government, Tokyo (1957).
6 Mayer, A. M. and Mayber, A. P., The Germination of Seeds. **The MacMillan Co.** New York (1965).
7 Mederski, H. J. and Jones, J. B., Soil Sci. Soc. Am. Proc. **27**, 186–189 (1963).
8 Toole, E. M., Ann. Rev. Plant Physiol. **7**, 299–324 (1956).