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SOME EFFECTS OF CULTURAL PRACTICES ON GROWTH AND YIELD OF PEPPERS (*CAPSICUM ANNUM* L.)

by

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INTRODUCTION

Scientists have attempted to modify plant-life through different cultural practices to increase yields to meet ever-increasing demand for food. The importance of good cultural practices to grow vigorus, healthy and competitive transplants to maximize yield has long been realized by vegetable-crop growers. These practices emphasize the importance of adjusting ecological factors during the juvenile stage of plant-growth so that quality plants will attain field setting size in a short time. Furthermore the plants would be competitively stronger in the plant community and withstand the field conditions after transplanting.

Pepper (Capsicum annum. L.) is an economically important vegetable crop. It is a member of the Solanaceae or nightshade family. Undoubtedly of American origin, it was widely cultivated in Central and South America. It seems probable that the first peppers grown in the United States came directly from Europe (13, 47, 48, 51).

Peppers are grown for their fleshy fruits, used either green or ripe. Sweet varieties are used for salads, pickles, and stuffing; hot ones for relishes, seasoning, and sauces. Peppers are a source of various ointment preparations such as those for dropsy, colic, ague, and tooth-ache (13, 47).

The recognition of high nutritive value of peppers creates a constant demand from the market. Peppers are a good source of vitamin A, ascorbic acid, potassium, phosphorus and calcium (3, 13, 47, 52). Furthermore, they are available in red, green or brown colors and possess a unique flavor.

Fundamental research on the morphology and physiology of the pepper plant was undertaken by Cochran (7, 8, 9, 10, 51). It was observed that speed of pepper seed germination is greatly influenced by temperature. The number of days required from planting until first seedling emergence decreased rapidly as the temperature was raised from 50 to 60 to 90 to 100 F (7). Climatic conditions during growth and blossom development have a marked influence on fruit-setting in the pepper (8, 10, 51). Lack of stigma receptivity at the time of pollination was found to be responsible for poor fruit-set in pimentoes (9).

Most pepper varieties require slightly warmer temperatures than tomatoes--a daily average temperature of about 75 F. Despite the pepper's need for plenty of warm weather, extreme heat of mid-summer in many parts of the South and South West is too high for fruit-setting in most varieties (3).

Went, Dorland, and Wells studied the importance of night temperature on vegetative growth and flowering in peppers (16, 55, 56). The optimal temperature was found to be 79 F to 86 F for pepper seedlings but the optimum temperature decreased for later growth (56). Most abundant flowering and fruit-set was found to occur between 60 F and 69 F night temperature (16). The greatest number of flowers per plant was found at 60 and 70 F night temperature. The greatest number of fruits and the highest percent fruit-set were found at night temperatures of 50 and 60 F (55).

The stage of development and the spacing in the flat at transplanting time were found to influence the yield characteristics in pepper (15, 16, 32).

The pepper is a frost sensitive plant and it requires a long growing season to produce profitable yields. In order to lengthen the growing season, the seed is usually sown in greenhouses or other forcing structures during late winter or very early spring. It is also desirable to grow large, thrifty plants to transplant in the field because early peppers command the highest prices. Lack of early fruit-set is a common phenomenon of garden or field grown pepper-transplants in Kansas resulting in lower yields and reduced prices.

This study was undertaken in an attempt to determine the influence of greenhouse night temperature, pot-size, spacing and age or size of transplants on yield of pepper in the field.

REVIEW OF LITERATURE

A survey of the literature indicates that the growth and fruit-setting in pepper is influenced by various factors. It has been attributed most frequently to unfavorable weather during blossoming period and pollination, improper nutrition of the plant, injury of the blossoms by insects and competition of the individual blossoms for nutritive material.

Temperature

Boswell *et al.* (3) recommended a temperature of 65 F at night and 75 F during the day after plant emergence. Heat injury to the blossoms was noticed above 90 F when fruit-dropping became excessive in peppers.

Rylski (42) reported the effects of the early environment on flowering in pepper. The number of leaves prior to anthesis was inversely proportional to night temperature, the lower the temperature, the more leaves. A night temperature of 68 F delayed flowering 10 days as compared with 77 F night temperature. High night temperature (64-68 F) during flower development was a prerequisite for the formation of good shaped, elongated fruit (41).

Cochran (7) found a great influence of temperature on pepper seed germination and explained that the speed of germination may depend largely on the velocity of certain chemical reactions within the seeds, responsible for the metabolic activity of the young embryoes.

Pepper plants were not sensitive to light intensity or length of daily illumination (8, 10, 51) and produced a larger total number of flowers in the warm greenhouse (70-80 F) compared to the cooler greenhouse. There was a progressive decrease in receptivity with each day's increase in stigma age from the day of anthesis in pimentoes when the mean temperature was above 72 F (9).

Deli and Tiessen (14) obtained more flowers in peppers at the night temperature of 54 F than at 64 F. The low temperature, 54 F induced a significant reduction in plant height but light intensity had no influence on height. They reported that pepper plants exposed to temperatures of 54°F commencing at the third true leaf stage for a 3-week period resulted in higher early yields. The early yield was associated with a more heavily branched plant with fewer nodes preceding the first axil where the flowers are borne.

Went and Dorland (16) noticed a gradual decrease in the optimal night temperatures for stem elongation from 86 F to 47 F as the pepper plants progressed to maturity. At the highest night temperatures, the number of leaves increased but they were yellow and smaller. No flowers developed at 86 F night temperature. Flowering was most abundant at 60 to 69 F night temperature for young plants, but in older plants the optimum night temperature shifted to 47 F. The same was true for fruit-set.

Night temperatures below 61 F and day temperatures above 90 F were found to prevent fruit-set. Low humidity and high temperature resulting in excessive transpiration caused a water deficit in bell-peppers. This ultimately resulted in formation of abscission layers on buds, flowers, and small fruits (13).

Kato and Tanaka (24) observed increased rate of fruit development with increases in night temperature in the range 61 -72 F, in capsicums, day temperature was less important.

Wells (55) found the greatest number of flowers per plant at 60 and 75 F night temperature and the highest percent fruit-set at night temperatures of 50 and 60 F. The cyclic habit of flowering and fruiting in peppers was cited as supporting evidence that within the genetic capacity of plant-growth, growth substances - possible carbohydrates - become a limiting factor during a period of vigorus flowering, fruiting and vegetative growth. The differences in flowering and fruiting at the varying night temperatures was attributed to the competition for an available supply of food materials and/or growth substances (24, 55).

Temperatures of over 68 -72 F were most suitable for the so called vernalization phase in the development of pepper (26). The day length of 12-hours was found to be desirable for early flowering and increase in yield by 20 to 37% (2).

Moisture stress at the first flower bud differentiation stage delayed leaf emergence as well as the "ripeness-to-flower" condition resulting in a highly significant decrease in yield of pepper (15).

A night temperature of 68 F was found most favorable for growing the pepper variety 'Cecei' under glass. At 59 F both early and total yields were reduced (17).

Went did extensive work on thermoperiodicity of tomatoes in growth and fruiting (58, 59, 61). He suggested that thermoperiodicity is a general phenomenon in higher plants. It has been determined that tomatoes at 64 F night temperature did best and potatoes formed tubers at the optimum range of night temperature between 50 and 70 F (57, 60).

The hardening of young tomato plants, even to a moderate degree under greenhouse conditions resulted in lower early yields of fruit of lighter weight (4). Differential exposure of tops and roots of seedlings revealed that top temperatues determine the position, as to node number of the first inflorescence, while root temperatures influence the number of flowers in the first inflorescence (37). Plants of a given age grown at cooler temperature produced a higher percentage of plants with buds or open flowers and fruit size was larger at the warmer (60 -70 F) plant growing temperature (33).

Wittwer and Teubner (62) subjected tomato seedlings to night temperature of 50 -55 F and obtained significantly more flowers in the first cluster. Highest growth rate was achieved in winter at the night temperature, not lower than, 64 F and the day, not lower than 68 F (5).

Hurd and Cooper (22, 23) increased the number of flowers on the first inflorescence by exposing tomato plants to 50 F during the early growth period. Chilling (50 F) delayed anthesis by up to 10 days, the delay being proportional to the duration of chilling.

Schaible (45) identified substantial levels of heat tolerances in the tomato varieties, Narcalang and Porter, which enabled them to set fruit abundantly at night temperatures of 73 F and 80 F. Fruit-size decreased as night temperatures were increased and fruit seediness was related to its degree of heat tolerance.

Curme (11) demonstrated that normal fruit-set in tomatoes may occur at night air temperatures as low as 45 F.

Between emergence and flowering the mean rate of development of maize per day was found to be related by linear correlation analysis to mean air temperature, solar radiation and potential transpiration estimated from weather data. All correlations were significant but the parameter which combined radiation and temperature was statistically better (20).

It was shown in Cestrum nocturnum, a long-short day plant, that the phototemperature (73.4 F) had the greatest effect upon long-day induction and that the nyctotemperature (68 F) had the greatest effect upon short day induction (43). The optimum night temperature, in some cases, was found to decrease with light intensity, while in other cases more growth might take place at higher temperature, in small snap-dragon plants (30).

Pot Size

Angeli (1) reported higher yields with pepper seedlings grown in 4" x 4" peat-pots than those grown in 3" x 3" pots. Casseres (6) obtained similar significantly higher early and total yield of tomatoes using a spacing of 4" x 4" in flats.

Spacing

Pepper plants spaced at 12" x 12", 24" x 24" and 36" x 36" in the field demonstrated that high density planting offered a promising method of increasing both total and marketable yield of the standard early cultivar, Vinedale. Plants were smallest in the most closely spaced plots (25).

In some of the warmer areas, pepper seeds are thinly drilled directly in the field in rows 42" apart and later thinned to stand 30" to 36" apart in rows, in Georgia and 18" apart in the rows, in California (3).

Most varieties of pepper are planted about 24" apart in rows 36" apart. Small growing varieties may be planted as close as 18" apart in the row. Very large growing varieties sometimes are planted 30" x 36" (51). A 12" x 12" spacing gave heavier fruit than spacing either of 4" x 4" or 8" x 8" in the field (13).

Nicklow (32) showed that a fewer number of leaves from the main stem to the first cluster on laterals might be a factor for the early yields of pepper resulting from wide spacing per plant in the flat.

The pepper variety "Kalinkov" performed well when sprinkle-irrigated and spaced singly at 24" x 10" (49).

Ozaki (35) found 3" spacing of plants in the row resulted in the highest total yield of peppers with un-effected fruit quality.

Stoicescu (50) reported that the best planting system for peppers was on ridges with 24" x 6" spacing between the plants.

A spacing of 14" x 8" with one or two plants per hill with the variety Dzuljunska Sipka and a spacing of 13" x 12" with two plants per hill with Rumanska Sipka gave higher yields (21).

The highest yields of red pepper were obtained at density of 26.7 plants per 10.76 square feet (36). Reducing the plant population increased total seed weight but lowered seed production per plant and per fruit (12).

The optimum density for green pepper cultivation in soils fertilized with ammonium nitrate and super phosphate was found at 16" x 20" (18).

A number of experiments were conducted with different spacings in tomato (34, 39, 40, 53). Nicklow and Minges (33) observed more leaves to the first cluster, a bushier plant, and earlier flowering resulting in a higher early yield with greater space per plant. The larger yield in Gem tomatoes was primarily a function of the large number of plants per acre (53). A 48" x 24" spacing was found to be the most favorable in producing highest yields in Marglobe Sabour (40). Highly significant increases in both early and total yields were obtained by reducing the space between plants in 44½" rows from 48" to 24", but fruit size was reduced. Blossoms per truss, number of fruitset per truss and percent fruitset were all higher for the plants in the wider spacing (39).

Spacing trials were conducted in ginger (38), spinach (28), pea (27), beet (54), carrots (19, 54), and broccoli (63) for increasing the yield.

Age of Transplants

Boswell *et al*. (3) recommended large plants, seven to eight week old suitable for transplanting in the field.

Dorland and Went (16) believed that stage of plant development rather than age determined response to temperature and observed the first flower formation at the 9th to 11th node in pepper.

Thompson and Kelley suggested to sow seeds usually seven to eight or ten weeks before time for planting in the open (51). The general effect of transplanting was found to retard development, the seriousness of such retardation depended upon the plant, its age and the conditions of transplanting (29).

Angeli (1) obtained higher early and total pepper yields with 2½ and 3 month old seedlings.

Stoicescu (50) observed good results with two month old seedlings using proper date of planting, spacing and fertilizer.

Nicklow and Minges (33) noticed an increase in total yield and fruit size, utilizing tomato transplants five weeks of age or younger.

Casseres (6) demonstrated early yields and larger total yields with tomato transplants of seven week age.

MATERIALS AND METHODS

Pepper cv. "Tasty Hybrid" seeds were sown in wooden flats of dimension 24 x 16 x 14 inches, containing washed river sand, in a greenhouse maintained at 70 F night temperature, on April 6, 1973. The flats were sprinkle-irrigated daily.

Seedlings were transplanted singly into peat-pots of either 2½" or 3" diameter, containing a potting mixture of peat-moss, loam soil and sand in 2:2:1 ratio, on April 25, at the stage of unfolding cotyledons. The pots were arranged in the flats and moved to two different greenhouses maintained at either 50 F or 55 F night temperature. The transplants were grown under these conditions until the day of field setting.

The plants were watered as necessary and sprayed twice with Thiodan (50%) WP.) by means of a compressed air sprayer to control the incidence of aphids and white flies. Plant height was measured and number of leaves counted on May 20, and May 27, 1973.

The first field-setting of the transplants was completed on May 23, and the second on May 30, 1973, in a sarpy, fine sandy loam soil at Ashland Horticultural Farm. The field was prepared well in advance for transplanting with thorough incorporation of 50 lbs. of nitrogen and 38 lbs. of P_2O_5/acre. The plants were set in the field at two different spacings of 36" x 18" and 36" x 24". A factorial design was used with four main factors at two different levels with four replications for this experiment. Each plant received a cup of starter solution at the time of transplanting prepared by mixing 3 lbs. of 18-46-0 per 50 gallons of water. Diphenamid, at 5 lbs. per acre was applied after transplanting to the field, but before emergence of weeds, on May 31, 1973 as a herbicide. The crop was surface irrigated when needed by means of gated-pipe system. The planting was sprayed at 10-14 day intervals with Thiodan (50% WP.) as a prevention against aphids and other insects and Maneb or fixed copper was used as a fungicide. The plants were side-dressed on August 9, 1973, with nitrogen at 50 lb. per acre. Plant height was measured in the field on July 5, 1973.

The planting was harvested four times during the season. The first harvest, on August 29, 1973, constituted the early yield of the season. The last harvest was completed on October 3, 1973.

The yield was graded into marketable or culls. Marketable yield consisted of fruits which were green, firm, free from insect, disease or sun scald damage and well shaped or fairly well shaped, at least 2½" in length and 2½" in diameter. Culls were those that were smaller than described, rotted, sun scalded, worm damaged, blossom-end rotted, or badly mis-shapened.

The treatment effects were observed for early marketable yield, total marketable yield, total yield, and season's average marketable fruit weight. The yield data was further analysed for early marketable yield per plant, total marketable yield per plant, total yield per plant for the entire season, and season's average marketable fruit weight per plant.

The data was analysed statistically and tested for significance at 5% level.

EXPERIMENTAL RESULTS

Greenhouse Results

The data recorded on May 20, 1973, showed no significant effect on number of leaves or plant height with any factor or their interaction. Significant results were observed one week later (Table I and II).

The plants growing at 55 F night temperature were significantly taller with a larger number of leaves. The small pots had significantly taller plants with a larger number of leaves.

The interaction was insignificant between pot size and night temperature.

Pepper seedlings grown at 55 F night temperature using 2½" pots resulted in taller plants with more nodes and leaves than other regimes tested.

Field Results

Night temperature had a significant effect on plant height and diameter of fruit (Table III). Seedlings exposed to 55 F night temperature were taller; however, fruits with larger diameter were produced on plants exposed to 50 F night temperatures. Pot size did not significantly effect yield. Significant age times pot size interaction occurred for total yield and total marketable yield per plant.

Spacing had a significant effect on early marketable and total yield (Table IV). A spacing of 36" x 18" gave higher early marketable and total yields. Significant spacing times age interaction occurred for early marketable yield.

Spacing resulted in significant differences in total marketable yield per plant, total yield per plant, and season's average marketable fruit weight

TABLE I

Effect of night temperature and pot size on pepper plant height after three and one-half weeks growth in the greenhouse

Night temp. (F)	Pot size	
	2½"	3"
	cms	
50	14.82	9.73
55	17.57	15.05

LSD 0.05
Night temp. 1.71
Pot size 1.71
Interaction was insignificant.

TABLE II

Effect of night temperature and pot size on number of leaves of peppers after three and one-half weeks growth in the greenhouse.

Night temp. (F)	Pot size	
	2½"	3"
	Number of leaves	
50	7.73	7.13
55	8.66	7.83

LSD 0.05
Night temp. 0.47
Pot size 0.47
Interaction was insignificant.

TABLE III

Effect of night temperature on pepper plant height in field and fruit diameter at first harvest

Night temp. (F)	Plant height	Fruit diameter
	cms	
50	31.18	7.26
55	33.29	7.04
LSD 0.05	1.17	0.19

TABLE IV

Effect of field spacing of pepper transplants on early marketable yield, total yield, total marketable yield per plant, total yield per plant and season's average marketable fruit weight per plant.

Spacing	Early marketable yield/treatment	Total yield /treatment	Total marketable yield/plant	Total yield /plant	Season's average marketable fruit weight/plant
(inches)	(lb)	(lb)	(lb)	(lb)	(lb)
36 x 18	4.07	26.47	1.49	3.31	0.030
36 x 24	2.97	24.26	1.78	4.01	0.039
LSD 0.05	0.65	1.65	0.21	0.26	0.001

per plant. The 36" x 24" spacing was found to be superior to the 36" x 18" for these yield-characteristics.

Age of Transplants

Age of transplants significantly affected early marketable and total marketable yield. The oldest transplants produced taller plants. Significant age times spacing interaction occurred for early marketable yield (Table V).

Significant age times pot size interaction also occurred for total yield.

Age had a significant effect on plant height. Young transplants were found to be taller.

Significant effect of age was observed for early marketable yield per plant and total marketable yield per plant. The oldest transplants produced increased yields. Significant age times pot size interaction occurred for total marketable yield per plant.

Significant age times pot size times spacing times night temperature interaction occurred for early marketable yield, plant height and early marketable yield per plant.

Early marketable yield showed a significant positive correlation with length of fruit, season's average marketable fruit weight, total yield, and total marketable yield. It had a higher co-efficient of correlation value (r = 0.583) with total marketable yield.

Total marketable yield indicated a significant positive correlation with total yield and length of fruit. It showed a higher co-efficient of correlation value (r = 0.695) with total yield (Appendix III).

The culls were predominantly small in size. Rot and sun-scald damage was observed occasionally but worm and blossom end-rot rarely.

TABLE V

Effect of age of pepper transplants on early marketable yield, total marketable yield, plant height, early marketable yield per plant and total marketable yield per plant

Age of trans-plants	Early marketable yield/treatment	Total marketable yield/treatment	Plant height /treatment	Early marketable yield/plant	Total marketable yield/plant
(days)	(lb)	(lb)	(cms)	(lb)	(lb)
48	3.06	10.38	33.07	0.44	1.51
55	3.98	12.22	31.40	0.56	1.77
LSD 0.05	0.66	1.43	1.17	0.09	0.21

DISCUSSION

The pepper seedlings responded to cultural treatments during vegetative growth in the greenhouse. The low night temperature of 50 F caused a significant reduction in the number of leaves per plant within 33-days after the cotyledon unfolding stage. Irena Rylski (42) noticed a slight, though non-significant, tendency toward reduction in number of leaves prior to the first flower when the cold treatment of 39 F night temperature was given for 21 days.

Results from the present work were contrary to Irena Rylski's (42) observations of insignificant differences in number of leaves at 50 and 59 F night temperature. This might be a result of longer duration of treatment in his experiment.

High night temperature of 55 F showed a significant increase in the number of leaves. Similar results were obtained by Dorland and Went (16) but at a high night temperature of 85 F.

The effect of low night temperature in reducing plant height is in agreement with the results obtained by Deli and Tiessen (14) at low night temperature of 54 F.

Temperature, as it affects growth, is defined over a desirable range of cardinal points from minimum through optimum to maximum. Cardinal temperatures differ between crops as well as different organs of a crop plant and for the various stages of development. The optimum values suggest the desirable temperatures for maximum productivity (31).

The plants growing in 2½" pots were significantly taller with a larger number of leaves. This difference may be attributed to shading due to overcrowding.

The way light retards stem elongation is not yet understood but evidence shows that it reduces the effective gibberellin supply in growing region (31, 44).

Schoch (46) observed shading during seedling growth encouraged not only cellular expansion in sweet pepper but also intensity of cell division and reduced considerably the density of the stomata. The photosynthesis process (31) is more active in shade due to better hydrous conditions of the leaves. In brief, dry matter in leaves under shade is greater than that in full sun.

A large number of leaves at transplanting time was in fact beneficial for production of large total yields in peppers (32).

Plants exposed to 55 F night temperature in greenhouse prior to field-setting resulted in taller plants before flowering and fruit setting. This phenomenon no longer existed after the plants began to set fruits. All the plants appeared to have attained nearly the same height as fruit-set and development progressed.

The reduction in plant height was also observed by Deli and Tiessen (14) at low night temperatures.

The plants exposed to high night temperature of 55 F in the greenhouse had light green leaves. Dorland and Went (16) reported deleterious effects of high night temperature in peppers; complete bleaching of leaves occured in a regime of 65 day - 86 F night temperature. The plants after field setting never experienced such high night temperature in the present experiment.

The unfavorable daily temperatures prevailing in the field during flowering and fruit setting--from the day of field setting till the first harvest--

might have overcome the effects produced by night temperatures during early growing stage of the plants.

The plants set earlier in the field experienced a daily average maximum-minimum temperatures of 87.8 - 65.6 F, whereas the plants set later experienced temperature regime of 89.9 - 66.6 F.

Cochran (8) reported that plants grown in the warm greenhouse (70 - 80 F) produced a larger total number of flowers, likewise, larger total number of flowers dropped. The same cause may be possible in the present experiment because the average minimum-maximum temperature prevailing on the field was 65.6 - 87.7 F from field-setting until the day of first harvest.

Poor stigma receptivity because of dried out condition resulting from mean air temperature of 72 and 73 F was found to be a causal factor, by Cochran and Dempsey, in pimento peppers (9). This might be another possibility in the present experiment since the average daily temperature was 77 F during flowering and fruit setting.

Fruits with larger diameter were obtained from plants grown at 50 F night temperature. This result is contrary to Well's observations (55), where elongated and pointed fruits at the stylar end were noticed at 50 F night temperature. This difference may be attributed to different experimental conditions since the plants were in controlled environmental chambers maintained at 78 F day temperature throughout the experiment. Differential night temperature was suggested as indirectly affecting fruiting by influencing the quantities of carbohydrates and growth substances.

Pot size had no significant effect on yield of peppers. But significant age times pot size interaction occurred for total yield and total marketable yield per plant.

Angeli (1) reported higher yields from pepper seedlings grown in 4" x 4" peat-pots than 2.8" x 2.8" pots. Casseres (6) obtained similar significant higher early and total yield of tomatoes using wider spacing in flats.

Spacing in the field had a significant effect on early marketable yield and total yield. Significant spacing times age interaction occured for early marketable yields. The 36" x 18" spacing resulted in higher early marketable and total yield.

Spacing also had a significant effect on total marketable yield per plant. The 36" x 24" spacing increased total marketable yield per plant.

Increase in early marketable and total yield with 36" x 18" spacing may be attributed to more plants because per plant total marketable yield was significantly larger with 36" x 24" spacing for the Tasty Hybrid cultivar.

Results with 12" x 12", 24" x 24", and 36" x 36" spacing demonstrated that high density planting offers a promising method of increasing both total and marketable yield of the standard early cultivar, Vinedale (25).

Experimental results indicate that spacing for maximum yield depends on the variety, type of use, and other cultural operations (21, 36, 49, 50).

Reducing plant population was found to increase total seed weight in peppers but lowered seed production per plant and per fruit (12).

Age of the transplants had a significant effect on early marketable yield, total marketable yield, plant height, early marketable yield per plant, and total marketable yield per plant. The oldest transplants (55 days) were superior for all the above yields but increased plant height occurred with young transplants (48 days).

Significant age times spacing interaction occurred for early marketable yield.

Age times pot size interaction was significant for total marketable yield per plant. Similar transplants (55 days) were recommended for good yield of peppers (3, 51).

Nicklow (32) observed similar significant effect with pepper transplants on early yields but discouraged the use of transplants with open flowers. Better yields were also obtained with 60 day old transplants (1, 50). Age was found to affect early and total yields in tomatoes (6, 33).

Significant age times pot size times spacing times night temperature interaction was observed for early marketable yield, plant height, and early marketable yield per plant.

Early marketable yield showed a positive correlation with total marketable yield, total yield, season's average marketable fruit weight, and length of fruit. It showed a higher value of coefficient of correlation ($r = 0.583$) with total marketable yield (Appendix III).

Total marketable yield exhibited a positive correlation with total yield, and length of fruit. High value of coefficient of correlation ($r = 0.695$) shows that as the total marketable yield increases the total yield increases.

SUMMARY AND CONCLUSIONS

This study was initiated to determine the effect of night temperature, pot size, spacing and age of transplant on sweet pepper (Capsicum annum. L.) yield in a factorial design at two different levels of each factor.

During early stages of growth in the greenhouse, the low night temperature of 50 F caused a significant reduction in the number of leaves and plant height, when compared with plants from the 55 F night temperature.

The plants grown in pot of 2½" diameter were significantly taller with more leaves than plants grown in 3" pots. This might be attributed to shading due to overcrowding.

After transplanting to the field, the plants exposed to 55 F night temperature in the greenhouse were taller. This phenomenon no longer existed once the plants began to set fruits. All the plants appeared to have attained nearly the same height at the end of last harvest.

Night temperature, to which seedlings were exposed during the early growth period, did not affect the yield of peppers in this study. The transplants after field-setting experienced a daily average minimum-maximum temperature regime of 66 F -88 F from the first day of field-setting till the first harvest. These unfavorable daily temperatures prevailing during flowering and fruit-setting might have overcome the effects of night temperatures to which the seedlings were exposed in the greenhouse. Seedlings exposed to 50 F night temperature produced fruits with larger diameter.

Pot size had no significant effect on yield of peppers. But significant age times pot size interaction occurred for total yield and total marketable yield per plant.

Spacing had a significant effect on early marketable yield and total yield. A spacing of 36" x 18" was found to produce larger yields than the 36" x 24" spacing.

Significant spacing times age interaction occurred for early marketable yields. A spacing of 36" x 24" increased the total marketable yield per plant.

Age of transplants had a significant effect on early marketable yield, total marketable yield, early marketable yield per plant and total marketable yield per plant. The 55-day old transplants produced higher yields, but plant height was greater with 48-day old transplants.

Significant age times spacing interaction occurred for early marketable yields. Significant age times spacing and age times pot size interaction occured for total marketable yield per plant.

Significant age times pot size times spacing times night temperature interaction was observed for early marketable yield, plant height, and early marketable yield per plant.

Early marketable yield was positively correlated with total marketable yield, total yield, season's average marketable fruit weight, and length of fruit.

Total marketable yield exhibited a significant positive correlation with total yield and length of fruit.

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APPENDIX

APPENDIX I

Effect of age, pot-size, spacing, and night temperature on marketable early yield, total marketable yield, total yield, season's average marketable fruit weight, plant height in field, fruit length, and fruit diameter of pepper transplants.

Age	Pot size	Spacing	Night temp.	Early marketable yield per treatment	Total marketable yield per treatment	Total yield per treatment	Season's average marketable fruit weight per treatment	Plant height in field per treatment
(days)	(inches)	(inches)	(F)	(lb)	(lb)	(lb)	(lb)	(cms)
48	2½	36x18	50	2.93	10.40	22.75	0.23	32.01
48	2½	36x24	50	2.10	9.10	22.75	0.22	31.42
48	2½	36x18	55	3.30	10.25	25.00	0.24	33.10
48	2½	36x24	55	3.43	9.80	23.95	0.23	34.50
48	3	36x18	50	2.83	11.28	27.78	0.23	31.69
48	3	36x24	50	3.48	11.10	25.05	0.22	32.96
48	3	36x18	55	3.98	11.23	26.85	0.21	36.79
48	3	36x24	55	2.45	9.93	23.65	0.22	32.10
55	2½	36x18	50	4.70	13.74	27.39	0.23	31.25

APPENDIX I (cont.)

Age	Pot size	Spacing	Night temp.	Early marketable yield per treatment	Total marketable yield per treatment	Total yield per treatment	Season's average marketable fruit weight per treatment	Plant height in field per treatment
(days)	(inches)	(inches)	(F)	(lb)	(lb)	(lb)	(lb)	(cms)
55	2½	36x24	50	3.40	11.50	25.93	0.23	31.50
55	2½	36x18	55	5.38	14.05	28.25	0.23	34.23
55	2½	36x24	55	2.80	13.25	25.85	0.23	30.50
55	3	36x18	50	5.05	12.48	27.55	0.23	30.03
55	3	36x24	50	2.65	10.58	23.58	0.23	28.58
55	3	36x18	55	4.40	11.75	26.20	0.23	33.40
55	3	36x24	55	3.43	10.38	23.30	0.23	31.84
LSD 0.05								
Age				0.65	1.43	NS	NS	1.17
Pot-size				NS	NS	NS	NS	NS
Spacing				0.65	NS	1.652	NS	NS
Night temperature				NS	NS	NS	NS	1.166
Age x Pot size				NS	NS	2.34	NS	NS

APPENDIX I (cont.)

Age (days)	Pot size (inches)	Spacing (inches)	Night temp. (F)	Early marketable yield per treatment (lb)	Total marketable yield per treatment (lb)	Total yield per treatment (lb)	Season's average marketable fruit weight per treatment (lb)	Plant height in field per treatment (cms)
LSD 0.05								
Age x Spacing				0.91	NS	NS	NS	NS
Age x Night temperature				NS	NS	NS	NS	NS
Pot size x Spacing				NS	NS	NS	NS	NS
Pot size x Night temperature				NS	NS	NS	NS	NS
Spacing x Night temperature				NS	NS	NS	NS	NS
Age x Pot size x Spacing				NS	NS	NS	NS	NS
Age x Pot size x Night temperature				NS	NS	NS	NS	NS
Age x Spacing x Night temperature				NS	NS	NS	NS	NS
Pot size x Spacing x Night temperature				NS	NS	NS	NS	NS
Age x Pot size x Spacing x Night temperature				1.83	NS	NS	NS	3.30

APPENDIX II

Effect of age, pot size, spacing, and night temperature on early marketable yield per plant, total marketable yield per plant, total yield per plant, season's average marketable fruit weight per plant, fruit length per treatment, and fruit diameter per treatment of papper transplants.

Age	Pot-size	Spacing	Night temp.	Early marketable yield/ plant	Total marketable yield/ plant	Total yield /plant	Season's average marketable fruit weight /plant	Fruit length/ treatment	Fruit diameter/ treatment
(days)	(inches)	(inches)	(F)	(lb)	(lb)	(lb)	(lb)	(cms)	(cms)
48	2½	36x18	50	0.37	1.30	2.86	0.03	6.77	7.09
48	2½	36x24	50	0.35	1.52	3.79	0.04	6.73	7.44
48	2½	36x18	55	0.42	1.28	3.13	0.03	6.96	7.03
48	2½	36x24	55	0.57	1.63	3.99	0.04	7.04	6.92
48	3	36x18	50	0.35	1.41	3.47	0.03	6.88	7.49
48	3	36x24	50	0.58	1.85	4.17	0.04	6.67	7.14
48	3	36x18	55	0.50	1.41	3.36	0.03	7.16	7.18
48	3	36x24	55	0.41	1.66	3.94	0.04	7.16	7.13

APPENDIX II (cont.)

Age	Pot-size	Spacing	Night temp.	Early marketable yield/ plant	Total marketable yield/ plant	Total yield /plant	Season's average marketable fruit weight /plant	Fruit length/ treatment	Fruit diameter/ treatment
(days)	(inches)	(inches)	(F)	(lb)	(lb)	(lb)	(lb)	(cms)	(cms)
55	2½	36x18	50	0.59	1.72	3.43	0.03	7.47	7.32
55	2½	36x24	50	0.57	1.92	4.09	0.04	6.96	7.09
55	2½	36x18	55	0.67	1.76	3.53	0.03	7.14	6.80
55	2½	36x24	55	0.47	2.21	4.31	0.04	7.05	7.05
55	3	36x18	50	0.62	1.56	3.45	0.03	6.97	7.48
55	3	36x24	50	0.44	1.76	3.93	0.04	6.91	7.03
55	3	36x18	55	0.55	1.47	3.28	0.03	7.17	7.09
55	3	36x24	55	0.57	1.73	3.88	0.04	6.64	7.17
LSD 0.05									
Age				0.09	0.21	NS	NS	NS	NS
Pot size				NS	NS	NS	NS	NS	NS
Spacing				NS	0.21	0.26	0.001	NS	NS
Night temperature				NS	NS	NS	NS	NS	0.19

APPENDIX II (cont.)

Age (days)	Pot-size (inches)	Spacing (inches)	Night temp. (F)	Early marketable yield/ plant (lb)	Total marketable yield/ plant (lb)	Total yield /plant (lb)	Season's average marketable fruit weight /plant (lb)	Fruit length/ treatment (cms)	Fruit diameter/ treatment (cms)
LSD 0.05									
Age x Pot size				NS	0.29	NS	NS	NS	NS
Age x Spacing				NS	NS	NS	NS	NS	NS
Age x Night temperature				NS	NS	NS	NS	NS	NS
Pot size x Spacing				NS	NS	NS	NS	NS	NS
Pot size x Night temperature				NS	NS	NS	NS	NS	NS
Spacing x Night temperature				NS	NS	NS	NS	NS	NS
Age x Pot size x Spacing				NS	NS	NS	NS	NS	NS
Age x Pot size x Night temp.				NS	NS	NS	NS	NS	NS
Age x Spacing x Night temp.				NS	NS	NS	NS	NS	NS
Pot size x Spacing x Night temp.				NS	NS	NS	NS	NS	NS
Age x Pot size x Spacing x Night temperature				0.25	NS	NS	NS	NS	NS

APPENDIX III

Linear correlation co-efficients for the parameters under study

	Early marketable yield	Total marketable yield	Total yield	Season's average marketable fruit weight	Plant height	Fruit length	Fruit diameter
Early marketable yield	1.00000						
Total marketable yield	0.58307*	1.00000					
Total yield	0.39495*	0.69568*	1.00000				
Season's average marketable fruit weight	0.25249*	0.14355	0.10412	1.00000			
Plant height	-0.03341	-0.04445	0.12941	-0.10008	1.00000		
Fruit length	0.33212*	0.31699*	0.12127	0.15570	-0.00058	1.00000	
Fruit diameter	-0.04049	0.04011	0.07642	0.19586	-0.24228	0.05163	1.00000

*A value of plus or minus 0.2464 required for significance at the 0.05 test level.

APPENDIX IV

Manhattan daily temperatures (F)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
April	Max						69	56	47	36	48	68	61	66	59	63	56	72	77	70	79	74	70	76	72	66	53	59	73	79	82	
	Min						46	42	33	28	26	26	39	35	48	44	35	42	45	55	57	55	46	46	50	51	46	40	39	53	64	
May	Max	74	59	70	77	75	78	66	78	80	78	73	70	68	67	72	68	75	89	82	84	91	86	77	75	77	75	61	76	72	76	78
	Min	49	42	34	42	56	56	54	47	61	54	57	44	42	43	35	55	38	49	59	52	65	60	48	56	48	60	52	54	55	48	55
June	Max	85	82	81	71	80	83	79	92	89	87	89	87	83	83	97	95	89	86	80	85	85	86	96	104	98	95	89	90	89	91	
	Min	59	66	59	62	53	50	61	68	67	70	70	67	66	68	70	77	56	74	61	54	57	54	69	65	74	76	65	66	72	70	
July	Max	99	99	98	96	92	95	96	97	96	92	96	95	92	83	82	85	89	94	84	87	75	77	85	83	84	87	92	91	88	91	84
	Min	75	71	69	69	68	70	74	74	76	67	67	72	69	61	56	51	62	75	69	69	63	65	67	69	64	63	65	69	65	69	63
August	Max	81	82	86	88	88	94	94	90	88	90	94	88	86	87	83	89	90	91	94	93	95	97	90	84	99	97	93	92	90	87	88
	Min	59	55	58	63	66	71	76	67	71	71	71	68	67	63	66	64	69	69	70	69	73	76	74	69	71	76	73	74	71	72	70
Sept.	Max	84	87	81	82	80	82	71	78	84	79	82	72	65	74	75	71	54	66	74	72	90	81	84	76	73	77	65	71	66	66	
	Min	74	70	66	58	61	53	60	66	69	60	58	57	60	56	55	47	45	38	54	64	66	61	66	62	58	63	63	60	51	57	
Oct.	Max	71	82	79																												
	Min	56	55	61																												

SOME EFFECTS OF CULTURAL PRACTICES ON GROWTH AND YIELD OF PEPPERS (*CAPSICUM ANNUM* L.)

by

RAMCHANDRA N. NADMICHETTU

B. S., Andhra Pradesch Agricultural University, 1971

AN ABSTRACT OF A MASTER'S THESIS

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The pepper is a frost sensitive plant and it requires a long growing season to produce profitable yields. In order to lengthen the growing season, the seed is usually sown in greenhouses or other forcing structures during late winter or very early spring. It is also desirable to grow large, thrifty plants to transplant in the field because early peppers command the highest prices. One of the common phenomena observed in garden or field grown pepper transplants in Kansas is lack of early fruit-set resulting in lower yields and reduced prices.

A study was initiated to determine the effect of greenhouse night temperature, pot-size, spacing and age of transplant on sweet pepper (Capsicum annum L.) yield in a factorial design at two different levels of each factor.

During early stages of growth in the greenhouse the pepper seedlings cv. Tasty Hybrid exposed to low night temperature of 50 F showed a significant reduction in the number of leaves and plant height, when compared with plants exposed to 55 F night temperature. The plants grown in pots of 2½" diameter were significantly taller with more leaves than plants grown in 3" pots. This might be attributed to shading due to overcrowding.

Greenhouse night temperature, to which seedlings were exposed during the early growth period, did not affect the yield of peppers in this study after transplanting to the field. The transplants after field-setting experienced a daily average minimum-maximum temperature regime of 66 F -88 F from the first day of field setting until the first harvest. These unfavorable daily temperatures prevailing during flowering and fruit-setting might have overcome the effects of night temperatures to which seedlings were exposed in the greenhouse. Seedlings exposed to 50 F night temperature produced fruits with larger diameter.

Pot-size had no significant effect on yield of peppers. A significant age times pot-size interaction occurred for total yield and total marketable yield per plant.

Field spacing had a significant effect on early marketable yield and total yield. A spacing of 36" x 18" was found to produce larger yields than the 36" x 24" spacing. Significant spacing times age interaction occurred for early marketable yields. A spacing of 36" x 24" increased the total marketable yield per plant.

Age of transplants had a significant effect on early marketable yield, total marketable yield, early marketable yield per plant and total marketable yield per plant. The 55-day old transplants produced higher yields, but plant height was greater with 48-day old transplants. Significant age times spacing interaction occurred for early marketable yields. Significant age times spacing and age times pot-size interaction occurred for total marketable yield per plant.

Significant age times pot size times spacing times night temperature interaction was observed for early marketable yield, plant height, and early marketable yield per plant.

Early marketable yield was positively correlated with total marketable yield, total yield, season's average marketable fruit-weight, and length of fruit.

Total marketable yield exhibited a significant positive correlation with total yield and length of fruit.