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Effect of planting time and spacing on maturity, quality and seed yield of bell pepper, *Capsicum annuum* L

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ABSTRACT

The present investigation was carried out at vegetable research farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan during Kharif 2011 to investigate the effect on seed yield and its attributes in bell pepper cv Solan Bharpur as influenced by planting time and spacing. The experiment was laid out in randomized block design factorial comprising of 24 treatment combinations of different planting time viz P_1 (4 April), P_2 (11 April), P_3 (18 April), P_4 (25 April), P_5 (02 May), P_6 (09 May), P_7 (16 May) and P_8 (23 May) and spacing viz S_1 (60 x 45 cm), S_2 (45 x 45 cm) and S_3 (45 x 30 cm). The results of the experiment showed that maturity, quality, seed yield and its components significantly varied with variation of planting time and spacing. Among all the treatment combinations P_7 x S_1 (16 May, 60 x 45 cm) was found the best for days to maturity for fully ripe fruits whereas P_2 x S_1 (11 April, 60 x 45 cm) revealed the best results for number of seeds and weight per fruit (g), seed recovery (%), seed yield per plant (g), fruit rot incidence (%), seed germination (%), seed vigor index I and II and 1000-seed weight (g). In overall P_2 x S_3 (11 April 11, 45 x 30 cm) resulted in the highest seed yield per plot (kg) and per ha (q).

Keywords: Planting time; spacing; maturity; quality; seed yield; yield attributes; fruit rot bell pepper

INTRODUCTION

Bell pepper, *Capsicum annuum* L is a high value solanaceous vegetable crop grown extensively in central and south America, Peru, Bolivia, Costa Rica, Mexico, in almost all the European countries, Honkong and India. It originated in New World tropics and subtropics and was introduced in India by the British in 19th century in Shimla, Himachal Pradesh and Nilgiri hills of Tamil Nadu (Greenleaf 1986). It is used either raw as salad, cooked as vegetable, pickled or processed and is appreciated worldwide for its flavour, aroma and colour. The productivity of capsicum in Indian conditions is very low as compared to world production as well as productivity. Production of any crop can be increased by supplying quality input and seed is the most important input in any crop production. Among the various cultural practices followed for capsicum production planting time and plant geometry are of prime importance. There is a wide range of planting time for capsicum which may affect the seed yield due to varying climatic conditions at different stages of crop growth. The variation in planting time may also affect the plant vigour and spread which further affect the seed yield and quality thus variable spacing is required. Optimum plant spacing ensures proper growth and development of plant resulting in good size fruit. Considering the above facts the present experiment was undertaken to find out the suitable planting time and optimum plant spacing for obtaining maximum seed yield of bell pepper with good quality.

MATERIAL and METHODS

The experiment was carried out at vegetable research farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan during Kharif 2011 to investigate the effect on seed yield and its attributes in bell pepper cv Solan Bharpur as influenced by planting time and spacing. The experiment was laid out in randomized block design factorial comprising of 24 treatment combinations of different planting time viz P_1 (4 April), P_2 (11 April), P_3 (18 April), P_4 (25 April), P_5 (02 May), P_6 (09 May), P_7 (16 May) and P_8 (23 May) and spacing viz S_1 (60 x 45 cm), S_2 (45 x 45 cm) and S_3 (45 x 30 cm). Observations were recorded on days to maturity for fully ripe fruit, number of seeds and weight per fruit (g), seed recovery (%), seed yield per plant (g), per plot (kg) and per hectare (q), fruit rot incidence (%), seed germination (%), seed vigor index I and II and 1000-seed weight (g). The recommended doses of manures and fertilizers as well as all agronomic practices were applied timely for raising a healthy and normal crop. Data on different seed yield and quality characters were recorded and analyzed statistically as described by Panse and Sukhatme (1987) for randomized block design factorial.

RESULTS and DISCUSSION

Effect of planting time: Significant differences were observed for the effect of planting time on days to maturity for fully ripe fruits. Among the different planting times P_7 took the minimum number of days to maturity for fully ripe fruits (100.56) whereas maximum days to maturity for fully ripe fruit (107.00) were found in P_1 (Table 1). Maximum number of seeds per fruit (177.76) was observed in the planting time P_2 which may be due to the prevalence of favourable climate during the cropping season while planting time P_8 gave the minimum number of seeds per fruit (141.59) which may be due to very high temperature at seed set time in the late growing season. Influence of planting time on seed weight was found significant where the planting time P_2 gave the maximum seed weight per fruit (0.81 g) which may be due to the optimum temperature for fruit and seed set during the early season and as a result of which more number of seeds were developed thereby increasing the seed weight. Planting time P_8 resulted in minimum seed weight per fruit (0.51 g) which may be due to the desiccation of pollen grains under high temperature leading to poor seed set. Maximum seed recovery (1.59%) was observed in the planting time P_2 and minimum in P_8 (1.26%). Considerable diversity was visible on seed yield per plant where planting time P_2 resulted in maximum seed yield per plant (15.37 g) which may be due to the favourable climatic conditions for increased fruit set thereby producing more number of fruits with better size per plant and hence resulting in more seed yield per plant. Duczmal and Kaczmarkiewicz (1984) and Sharma and Peshin (1996) also reported that early planting resulted in higher seed yield per plant.

Planting time P_8 resulted in minimum seed yield per plant (4.31 g). Maximum seed yield per plot and per hectare (0.311 kg and 6.15 q respectively) was obtained in P_2. Duczmal and Kaczmarkiewicz (1984) and Sharma and Peshin (1996) also reported that early planting resulted in higher seed yield per hectare. Planting time P_8 resulted in minimum seed yield per plot and per hectare (0.087 kg and 1.72 q respectively). Later planting in general recorded higher incidence of fruit rot than early plantings. Minimum fruit rot incidence (6.54%) was observed in P_2 while P_8 recorded maximum fruit rot incidence (16.88 %) which may be due to coinciding with the period of heavy rainfall, high humidity and temperature especially during fruit development stage leading to severe attack of fruit rot resulting in high reduction in the number of marketable fruits and seed yield. Seed germination, seed vigour index-I and seed vigour index-II (88.82%, 388.48 and 1100.12 respectively) were observed maximum in P_2 which may be due to favorable temperature and other climatic conditions for seed setting and development of healthy seed. P_8 recorded minimum seed germination and seed vigour index-I and II (71.32%, 268.46 and 706.97 respectively). P_2 gave the maximum 1000-seed weight (4.55 g) while planting time P_8 gave the minimum 1000-seed weight (3.59 g). The results are in line with the findings of Sharma and Peshin (1996) who reported that early planting of capsicum resulted in maximum 1000-seed weight.

Effect of plant spacing: The plant spacing significantly influenced the days to maturity for fully ripe fruits. Minimum number of days to maturity for fully ripe fruit (101.08) was recorded in the spacing S_1 which may be because of availability of sufficient nutrients and light to the plant due to wider spacing and thus enhancing better growth and development of the fruit whereas maximum number of days to maturity for fully ripe fruit (106.08) was observed with the S_3 (Table 1). Among the different spacings maximum

Table 1. Effect of planting time and spacing on maturity, quality and seed yield of bell pepper, *Capsicum annuum* L

Treatment	Days to maturity for fully ripe fruit	# seeds/ fruit	Seed weight/ fruit (g)	Seed recovery (%)	Seed yield /plant (g)	Seed yield /plot (kg)	Seed yield /ha (q)	Fruit rot incidence (%)	Seed germination (%)	Seed vigour index-I	Seed vigour index-II	1000-seed weight (g)
Planting time												
P_1: Apr04	107.00	173.48	0.76	1.53 (1.23)*	13.56	0.27	5.41	7.77 (2.77)*	85.68 (68.06)**	364.44	1022.34	4.36
P_2: Apr11	105.22	177.76	0.81	1.59 (1.26)	15.37	0.31	6.15	6.54 (2.53)	88.82 (71.58)	388.48	1100.12	4.55
P_3: Apr18	104.44	174.65	0.77	1.54 (1.24)	14.03	0.28	5.59	7.43 (2.71)	86.43 (68.68)	369.62	1040.32	4.40
P_4: Apr25	104.11	162.98	0.67	1.44 (1.20)	9.83	0.20	3.95	10.77 (3.27)	80.07 (63.58)	328.07	892.23	4.11
P_5: May02	103.11	159.09	0.63	1.39 (1.18)	8.60	0.17	3.43	11.88 (3.44)	77.95 (62.03)	311.72	844.95	3.96
P_6: May09	101.00	155.59	0.61	1.37 (1.17)	7.63	0.16	3.07	12.88 (3.58)	76.58 (61.09)	304.29	815.80	3.92
P_7: May16	100.56	152.48	0.58	1.33 (1.15)	6.81	0.14	2.69	13.77 (3.70)	75.14(60.11)	292.71	785.08	3.80
P_8: May23	101.33	141.59	0.51	1.26 (1.12)	4.31	0.09	1.72	16.88 (4.10)	71.32 (57.62)	268.46	706.97	3.59
Mean	103.35	162.21	0.67	1.43	10.02	0.20	4.00	10.99	80.25	328.47	900.98	4.09
$CD_{0.05}$	1.90	7.08	0.06	0.02	1.93	0.04	0.76	0.28	2.64	18.30	61.52	0.16
Spacing												
S_1: 60 x 45 cm	101.08	179.67	0.77	1.50 (1.22)*	12.44	0.18	3.62	9.87 (3.08)*	84.04 (67.34)**	354.45	988.91	4.28
S_2: 45 x 45 cm	102.88	160.74	0.66	1.42 (1.19)	9.64	0.19	3.75	11.18 (3.29)	79.68 (63.47)	324.63	886.93	4.06
S_3: 45 x 30 cm	106.08	146.21	0.58	1.37 (1.17)	7.97	0.24	4.64	11.93 (3.42)	77.02 (61.47)	306.34	827.09	3.92
Mean	103.35	162.21	0.67	1.43	10.02	0.20	4.00	10.99	80.25	328.47	900.98	4.09
$CD_{0.05}$	1.16	4.34	0.03	0.01	1.18	0.02	0.46	0.17	1.62	11.21	37.67	0.10

*Figures in the parentheses are square root transformed values
**Figures in the parentheses are arc sin transformed values

Table 2. Effect of interaction of planting time and spacing on maturity, quality and seed yield of bell pepper, *Capsicum annuum* L

Treatment	Days to maturity for fully ripe fruit	# seeds/ fruit	Seed weight/ fruit (g)	Seed recovery (%)	Seed yield /plant (g)	Seed yield /plot (kg)	Seed yield /ha (q)	Fruit rot incidence (%)	Seed germination (%)	Seed vigour index-I	Seed vigour index-II	1000-seed weight (g)
P1S1	105.00	190.75	0.86	1.584 (1.26)*	15.95	0.239	4.72	6.70 (2.56)*	90.01 (71.93)**	392.02	1127.51	4.52
P1S2	106.33	171.97	0.76	1.551 (1.25)	13.08	0.262	5.17	7.97 (2.81)	85.43 (67.65)	366.79	1014.41	4.43
P1S3	109.67	157.73	0.65	1.444 (1.20)	10.69	0.321	6.33	8.63 (2.93)	81.60 (64.60)	334.52	925.08	4.13
P2S1	103.00	196.58	0.96	1.709 (1.31)	19.30	0.289	5.72	5.03 (2.21)	95.38 (79.24)	436.80	1265.52	4.88
P2S2	104.67	176.63	0.78	1.545 (1.24)	14.37	0.287	5.68	6.63 (2.57)	87.50 (69.36)	374.69	1064.14	4.41
P2S3	108.00	160.07	0.70	1.519 (1.23)	11.92	0.358	7.06	7.97 (2.81)	83.57 (66.14)	353.95	970.70	4.34
P3S1	102.00	191.92	0.88	1.596 (1.26)	16.39	0.246	4.86	6.37 (2.51)	90.73 (72.50)	396.90	1144.44	4.56
P3S2	104.33	174.30	0.79	1.575 (1.25)	13.95	0.279	5.51	7.30 (2.69)	86.83 (68.79)	376.53	1047.75	4.50
P3S3	107.00	157.73	0.65	1.445 (1.20)	10.78	0.323	6.39	8.63 (2.92)	81.74 (64.76)	335.42	928.77	4.13
P4S1	102.00	181.42	0.80	1.536 (1.24)	12.52	0.188	3.71	9.37 (3.05)	84.54 (66.90)	360.67	993.41	4.39
P4S2	103.33	160.30	0.64	1.386 (1.18)	8.77	0.175	3.47	11.30 (3.35)	78.54 (62.41)	313.78	856.87	3.96
P4S3	107.00	147.23	0.59	1.398 (1.18)	7.89	0.237	4.68	11.63 (3.41)	77.13 (61.42)	309.77	826.40	3.99
P5S1	100.67	175.58	0.72	1.425 (1.19)	10.08	0.151	2.99	11.03 (3.31)	80.63 (63.92)	327.94	903.67	4.07
P5S2	103.00	157.97	0.64	1.413 (1.19)	8.39	0.168	3.32	11.97 (3.45)	77.93 (61.99)	315.19	843.83	4.04
P5S3	105.67	143.73	0.54	1.322 (1.15)	6.74	0.202	4.00	12.63 (3.55)	75.29 (60.18)	292.03	787.36	3.78
P6S1	98.67	173.25	0.72	1.452 (1.20)	9.69	0.145	2.87	11.70 (3.41)	80.00 (63.48)	329.39	889.92	4.15
P6S2	100.33	153.30	0.58	1.324 (1.15)	6.84	0.137	2.70	13.30 (3.64)	75.44 (60.28)	293.01	790.60	3.78
P6S3	104.00	140.23	0.54	1.339 (1.16)	6.13	0.184	3.63	13.63 (3.69)	74.30 (59.53)	290.48	766.87	3.82
P7S1	98.33	169.75	0.67	1.370 (1.17)	8.29	0.124	2.46	12.70 (3.55)	77.76 (61.88)	308.60	840.63	3.91
P7S2	100.00	150.97	0.58	1.351 (1.16)	6.50	0.130	2.57	13.97 (3.73)	74.90 (59.93)	294.52	779.43	3.86
P7S3	103.33	136.73	0.50	1.267 (1.13)	5.16	0.155	3.06	14.63 (3.82)	72.75 (58.52)	275.01	735.19	3.62
P8S1	99.00	158.08	0.59	1.313 (1.15)	5.47	0.082	1.62	16.03 (3.99)	73.26 (58.87)	283.26	746.19	3.75
P8S2	101.00	140.47	0.49	1.224 (1.11)	4.01	0.080	1.58	16.97 (4.11)	70.91 (57.34)	262.54	698.37	3.50
P8S3	104.00	126.23	0.45	1.233 (1.11)	3.30	0.099	1.96	17.63 (4.20)	69.78 (56.63)	259.57	676.35	3.52
Mean	103.35	162.21	0.67	1.43	10.02	0.20	4.00	10.99	80.25	328.47	900.98	4.09
$CD_{0.05}$	3.28	12.26	0.10	0.04	3.34	0.07	1.31	0.49	4.58	31.70	106.55	0.28

*Figures in the parentheses are square root transformed values
**Figures in the parentheses are arc sin transformed values

number of seeds per fruit (179.67) was obtained with the spacing S_1 which may be due to the bigger fruit size whereas minimum number of seeds per fruit (146.21) was observed in S_3 due to small sized fruits. Maximum seed weight per fruit (0.77 g) was recorded in S_1 whereas minimum seed weight per fruit (0.58 g) was obtained in spacing S_3. Khurana et al (2002) also observed a linear increase in seed weight per fruit with every increase in plant spacing. The highest seed recovery (1.50%) was obtained in S_1 whereas the lowest (1.37%) in spacing S_3. Diversity was observed due to different spacing on seed yield per plant. Among different spacings S_1 gave the maximum seed yield per plant (12.44 g) which may be due to more number of seeds per fruit. The results are in line with the findings of Sanchez et al (1993). Minimum seed yield per plant (7.97 g) was observed in S_3. Among the different spacings S_3 gave the maximum seed yield per plot and per hectare (0.235 kg and 4.64 q respectively). This may be due to more number of fruits per plot and per hectare in S_3 as compared to other spacings resulting in higher seed yield. Similar findings were reported by Khurana et al (2002). Minimum seed yield per plot and per hectare (0.183 kg and 3.62 q respectively) was observed in spacing S_1 due to lesser number of fruits per plot and per hectare. The lowest fruit rot incidence (9.87%) was observed in S_1 which may be due to the better air circulation in the widely spaced plants whereas the highest fruit rot incidence (11.93%) was recorded in the closest spacing S_3. The highest seed germination and seed vigour index-I and II (84.04%, 354.45 and 988.91 respectively) were obtained in S_1. The lowest seed germination and seed vigour index-I and II (77.02%, 306.34 and 827.09 respectively) were obtained in S_3. Maximum 1000-seed weight (4.98 g) was obtained in the spacing S_1 whereas minimum (3.92 g) was in S_3. These results are in conformity with the findings of Everett and Suramanya (1985), Kalappa (1982) and Dharmatti and Kulkarni (1988) who reported that wider spacing resulted in higher 1000-seed weight.

Effect of planting time and spacing interaction: Data on interaction between planting time and spacing for days to maturity for fully ripe fruit revealed that the combination P_7 x S_1 (16 May 16, 60 x 45 cm) took minimum days (98.33 days) (Table 2). The combination P_2 x S_1 produced the maximum number of seeds per fruit (196.58), highest seed weight per fruit (0.96 g), highest seed recovery (1.71%), highest seed yield per plant (19.30 g), minimum fruit rot incidence (5.03%), maximum seed germination (95.38%), highest seed vigour index-I (436.80), maximum seed vigour index-II (1265.52) and maximum 1000-seed weight (4.88 g). The seed yield per plot and per hectare (0.358 kg and 7.06 q respectively) were obtained in combination P_2 x S_3 (April 11, 45 x 30 cm). The combination P_8 x S_2 (May 23, 45 x 45 cm) gave the lowest seed yield per plot and per hectare (0.08 kg and 1.58 q respectively), minimum seed recovery (1.224%) and 1000-seed weight (3.50 g). The findings of current study are in line with those of earlier workers (Sharma and Peshin 1996).

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