Original Research Article

Effect of thermophysical seed treatments on plant growth, yield and diseases incidence in bell pepper

ABSTRACT

The experiment was conducted to extrapolate the effect of different thermophysical seed treatments on plant growth, yield and disease incidence in bell pepper cv. Solan Bharpur. Ten treatments based on temperature-duration combinations of different thermophysical seed treatments viz., hot water seed treatment (49°C/45 min, 49°C/60 min and 50°C/60 min), hot air seed treatment (72°C/24 h, 72°C/36 h and 74°C/48 h) and microwave seed treatment (5 s, 10 s and 15 s at 900 Micro power level) along with untreated (control) were used for raising nursery and field transplantation. Under field conditions, the maximum values *w.r.t.* plant height, avg. fruit weight, no. of fruit per plant, fruit yield per plant, fruit yield per plot, fruit yield per ha, harvest duration and minimum values *w.r.t.* days to first marketable picking, incidence of diseases like Anthracnose, Cercospora leaf spot and Phytophthora rot were recorded in hot water seed treatment at 50°C/60 min. The incidence of virus diseases was recorded lowest in hot air seed treatment at 74°C/48 h in bell pepper cv. Solan Bharpur.

Keywords: Bell pepper, Seed treatment,Hot water treatment, Hot air treatment, Microwave treatment

INTRODUCTION

Bell pepper (*Capsicum annuum* L.), also known as sweet pepper, capsicum, green pepper or *Shimla mirch* is an important vegetable crop grown worldwide. Fruits of bell pepper are appreciated worldwide for their flavor, aroma and colour. It is a source of vitamins A, C & E, capsaicin, carotenoids, flavonoids and other secondary metabolites with antioxidant properties (Sun *et al*., 2007). The major constraints in bell pepper production are occurrence of diseases caused by fungi, bacteria and viruses. Most of these diseases are considered to be seed borne in nature and thus can be effectively managed using various seed treatment methods. In modern days, the use of thermophysical methods for plant growth stimulation and disease management are becoming more popular among the growers due to their least deleterious effect on environment and human health as compared to chemicals. Thermophysical seed treatments are based on temperature-time combinations in which pathogen is killed in or on the seeds without affecting the seed germination and viability. Most important thermophysical methods used for seed treatments are hot water, hot air and microwave seed treatment. Hot water treatment has been successfully applied to manage

seed borne diseases in vegetable crops. This treatment can penetrate the plant tissues, causes thermal changes and internally seed borne pathogens get affected (Grondeau *et al*., 1994). Hot air treatment is another common physical method used for the treatment of various types of seeds (Bang *et al.,* 2011). It is also considered as useful and effective disinfection method of seeds for controlling seed borne diseases in vegetables although the treatment should be carefully performed to maintain the germinability of seeds (Nakamura, 1982).Microwave radiation treatment is a new physical method used for stimulation of seeds (Olchowik*et al.,* 2002).Microwave seed treatment can control seedborne pathogens and thereby increase plant health and growth (Kanwal *et al*., 2018).Hence, keeping in view all above mentioned facts, the present investigation was carried out to determine the effect of hot water, hot air and microwave seed treatments on plant growth, yield and disease incidence in bell pepper.

MATERIALS AND METHODS

The present experiment was carried out at the Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan during 2019-2020. The different levels of temperature and duration of hot water, hot air and microwave seed treatments using thermostatic hot water bath, hot air oven and microwave oven were used. The seed of bell pepper cv. Solan Bharpur were subjected to 10 thermophysical treatments viz., hot water seed treatment (49°C/45 min, 49°C/60 min and 50°C/60 min), hot air seed treatment (72°C/24 h, 72°C/36 h and 74°C/48 h) and microwave seed treatment (5 s, 10 s and 15 s) along with untreated (control) before sowing in the nursery. After 30-40 days, the healthy and uniform seedlings under each treatments in nursery were uprooted carefully and transplanted in the field at a spacing of 60 $\times$ 45 cm in a plot size of 1.2 $\times$ 1.35 m. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications taking six plants per replications in the total of 30 plots. All the cultural practices were followed as mentioned in the Package of Practices for Vegetable Crops of Dr YS Parmar University of Horticulture and Forestry, Nauni (HP) from time to time to ensure a good crop stand (Anonymous, 2014).

Hot water bath works thermostatically controlling temperature with time. The seeds were pre-soaked in sterilized distilled water at room temperature for 15 min wrapped in muslin cloth in glass jar. Water bath was filled with 3 L water and device was connected with electricity. Temperature was set through digital PID (proportional integral derivative) controller. The pre-soaked seeds in muslin cloth were dipped in the hot water for a fixed period of time as per the treatment detail. The seed bags were frequently stirred for uniform exposure of seeds to hot water. At the end of the treatment, seeds were taken out of the hot

water bath and spread on blotter paper and were placed in shade for drying. The seeds were thereafter used for further test.

Hot air electric oven with forced air circulation system was used which ensured even distribution of heat. Temperature was set through digital PID controller. The seeds were kept in craft paper bags and subjected for heating to different treatment combinations. At the end of the treatments, seeds were taken out, cooled down to normal temperature and used for further tests.

A household type IFB microwave of 900 W with energy at high power supplied by magnetron operating at 2450 MHz frequency in the continuous mode, was used to carry out the experiment. Seeds were placed in a sterilized open Petri plates and subjected to different periods of exposure of 5, 10 and 15 s at micro power level 900 W. After the treatment, seeds were taken out and used for further tests.

In the field, data were recorded on plant height (cm), days to first marketable picking, average fruit weight (g), no. of fruits per plant, no. of fruits yield per plant (g), no. of fruits yield per plot (kg), no. of fruits yield per hectare (q), harvest duration days and disease incidence (%).

Average plant height was measured from base of the plant to the top of the main axis of the plant at monthly intervals in centimeters. Number of days from transplanting to first marketable harvesting were recorded. All plants were selected and total numbers of fruits of all the harvests from each plant were counted and average was taken to obtain number of fruits per plant. Total weight of the fruits was divided by the total number of fruits harvested in each replication and average fruit weight was calculated. Total fruit yield per plant was worked out by recording the yield at every picking in grams and sum of all the pickings was taken. Yield of each plot was converted to yield in kilograms per hectare. Harvest duration was calculated by counting the number of days from first fruit harvesting to final fruit harvesting and average value was taken. Incidence of various diseases like anthracnose,wilt and virus attack was recorded in experimental field by using the following formula:

$$\text{Disease Incidence (\%)} = \frac{\text{Number of diseased plant per plot}}{\text{Total number of plant per plot}} \times 100$$

Cercospora leaf spot severity (%): The assessment of severity of Cercospora leaf spot in the bell pepper crop was done and categorized into four grades according to Mckinney (1923) scale:

List 1 :The assessment of severity of Cercospora leaf spot in the bell pepper crop

Scale	Symptoms
0	No visible disease damage
1	0-25% leaf area is damaged
2	25-50% leaf area is damaged
3	50-75% leaf area is damaged, few leaves wilted
4	75-100% Severe defoliation, only new leaves remaining

The severity of cercospora leaf spot was recorded by using the following formula:

$$\text{Disease Severity (\%)} = \frac{\text{Sum total of all ratings}}{\text{Maximum disease grade} \times \text{Number of leaf observed}} \times 100$$

RESULTS AND DISCUSSION

The analyzed data recorded from the present investigation is presented in Table 1, 2, 3 and 4 as per various parameters. The data on plant height (Table 1) revealed that plants in plot receiving T_3 treatment(Hotwater seed treatment at 50°C for 60 min) showed significantly higher plant height of 26.80 cm, 45.48 cm and 60.33 cm after 30, 60 and 90 days of transplanting followed by T_7 (Microwave seed treatment at 5 s) with 26.62 cm, 43.35 cm and 58.52 cm height recorded on 30, 60 and 90 days after transplanting, respectively. However, the values of both the treatment were statistically at par on 30 days after transplanting. The lowest height among treatments were recorded in T_7 treatment (Hot air seed treatment at 74°C for 48 h). In control, the plants achieved height of 21.18 cm at day 30, 40.53 cm at day 60 and 51.46 cm at day 90 after transplanting. Our results are partly in line with the findings of Singh *et al.* (2019) and Singh *et al.* (2020). They also observed that hot water seed treatment at 50-52°C for 30 min increased plant growth characters in bell pepper cv. Solan Bharpur. The reasons behind the increased plant growth characters after treating seeds with hot water at 50°C for 60 min might be due to the reason that at this temperature and duration of seed treatment have resulted in increased imbibition process which triggered germination related activities such as GA synthesis, RNA synthesis and DNA replication and finally lead to the weakening of the endosperm and hence increased germination (Black and Bewley, 2000).

The data in Table 2 depicted that inT_3 treatment (Hot water seed treatment at 50°C for 60 min.) the fruits were ready to harvest early i.e. days to first marketable picking was recorded lowest (60 days). Plants in control plots revealed first marketable picking in 65 days and it was highest (68 days) in T_9 treatment (Microwave seed treatment at 15 s). The

difference among days to first marketable picking of fruits might be due to the reason that this parameter is directly related to increased plant growth after seed treatment and under hot water treatment with 50°C for 60 min the growth parameters were increased as discussed earlier. Average fruit weight varied significantly among the treatments and was recorded highest (53.01 g) in T_3 treatment (Hot water seed treatment at 50°C for 60 min.) followed by 51.98 g in T_2 treatment (Hot water seed treatment at 49°C for 60 min). However, the value of these treatments differed significantly with each other, whereas fruit weight was lowest (46.67 g) in T_9 treatment (Microwave seed treatment at 15 s) followed by 49.33 in T_8 treatment (Microwave seed treatment at 10 s). The value under these treatments differed significantly with each other. Control plants revealed a fruit weight of 51.55 g. Begum and Lokesh (2012) have reported that hot water seed treatment at 52°C for 30 minutes resulted in the enhancement of crop *w.r.t.* fruit characters, both in polyhouse and open conditions in okra (*Abelmoschus esculentus*). The reason behind in increase in fruit characters might be similar as discussed earlier related to the plant growth characters.

The data in Table 3 revealed that the number of fruits per plant were highest (19.48) inT_3 treatment (Hot water seed treatment at 50°C for 60 min.) followed by 19.14 inT_2 treatment (Hot water seed treatment at 49°C for 60 min). These treatments were however, significantly differed from each other. Number of fruits per plant (16.32) was recorded lowest in T_9 treatment (Microwave seed treatment at 15 s). Similarly, the fruit yield per plant (g), fruit yield per plot (kg) and fruit yield per ha (q) were highest inT_3 treatment (Hot water seed treatment at 50°C for 60 min) with 1032.71 g, 6.19 kg and 305.99 q respectively followed by T_2 treatment (Hot water seed treatment at 49°C for 60 min) with 995.32 g, 5.97 kg and 294.91 q, respectively. However, the value of these treatment differed significantly from each other and the lowest fruit yield per plant (g), fruit yield per plot (kg) and fruit yield per ha (q) were recorded in T_9 treatment (Microwave seed treatment at 15 s) with 761.75 g, 4.57 kg and 225.70 q, respectively. Furthermore, the harvest duration was highest (31.67 days) in T_3 treatment (Hot water seed treatment at 50°C for 60 min.)followed byT_2 treatment (Hot water seed treatment at 49°C for 60 min) with 28.67 daysand lowest values recorded in 21.67 days inT_5 treatment (Hot air seed treatment at 72°C for 36 h). In bell pepper, no report existed on the effect of hot water, hot air and microwave seed treatment on fruit yield characters. The present is, therefore, new attempt in this regard. Begum and Lokesh (2012) indicated that hot water seed treatment at 52°C for 30 minutes enhanced number of fruits, size of fruit in okra. The hot water seed treatment also reduced the incidence of mycoflora in the seeds and thereby enhanced the seed germination percentage and seed vigour index of the seedlings. All these factors were found to increase the plant growth and fruit yield characters. All of these factors related to hot water seed treatment might have played a positive role for improvement in fruit yield under present study also as discussed earlier

under plant growth characters. Singh *et al.* (2019) have also reported that hot water seed treatment at 50-52°C for 30 min increased plant growth, fruit and yield characters in bell pepper cv. Solan Bharpur.

The data (Table 4) recorded on the incidence/severity (%) of anthracnose, cercospora leaf spot, phytophthora rot and viruses indicated lowest incidence/ severity of anthracnose, cercospora leaf spot and phytophthora rot in T_3 treatment (Hot water seed treatment at 50°C for 60 min.)i.e. 1.85%, 3.73% and 3.69%, respectively and was highest in control plots i.e. 18.51, 28.03, 20.37 and 22.22, respectively. The effect of seed treatment on wilt disease was found non-significant. Hot air seed treatment at 74°C for 48 h reduced incidence of viruses significantly. Under the present experiment, we found that hot water seed treatment is more effective than hot air and microwave seed treatment in controlling major diseases of bell pepper. The reasons behind the reduced incidence of various diseases after hot water seed treatment were observed to be the killing of seed borne pathogens due to the increased temperature after treatment. The higher the temperature and duration of the seed treatment, more is the effect on the diseases. But higher temperature and exposure time may also be harmful to the seed as it is for the pathogens. Hence, an appropriate combination of temperature and duration is needed to be worked out for a crop (Nega *et al.*, 2003). We have found 50°C for 60 min the appropriate temperature and duration for thermophysical seed treatment in bell pepper. Seed treatment at this temperature and duration combination has resulted in improved plant growth, yield characters and reduced incidence of various diseases. Hot water treatments regarded as very effective method of controlling or destroying seed-borne pathogens both, outside the testa and inside the seed testa (Swiader *et al.*, 1992). Miller and Ivey (2005) recorded reduction in the seed-borne diseases of tomato and bell pepper, such as anthracnose, bacterial canker, bacterial spot, bacterial wilt and bacterial speck after treatment of seeds with hot water at 50 to 55°C for 25 to 30 min. Hot air treatment has not shown good resistance against fungal pathogens in seeds but has positive impact on controlling viruses in seeds (Couture and Sutton, 1980). There is no literature found on the effect of thermophysical seed treatment on cercospora leaf spot in case of bell pepper or other crop. Hence, present is the first attempt in this regard.

CONCLUSION

Studies concluded that in bell pepper cv. Solan Bharpur, hot water seed treatment at 50°C for 60 minutes or microwave seed treatment for 5 s enhanced germination and plant growth characters. Hot water seed treatment at 50°C for 60 minutes also increased fruit yield parameters and reduced the incidence/ severity of diseases like damping-off, anthracnose,

cercospora leaf spot, phytophthora rot. Hot air seed treatment at 74°C for 48 h was, however, found effective in reducing the incidence of viral diseases.

Table 1 Effect of thermophysical seed treatments on plant height in bell pepper under field condition

Treatments	Plant height (cm) after days of transplanting		
	30	60	90
T_1: Hot water 49°C/45min	23.51	42.48	56.81
T_2: Hot water 49°C/60min	24.03	45.09	57.03
T_3: Hot water 50°C/60min	26.80	45.48	60.33
T_4: Hot air 72°C/24 h	24.43	43.33	56.70
T_5: Hot air 72°C/36 h	24.64	41.00	55.54
T_6: Hot air 74°C/48 h	25.04	40.70	54.66
T_7: Microwave 5 s	26.62	43.35	58.52
T_8: Microwave 10 s	26.73	42.00	57.15
T_9: Microwave 15 s	25.36	41.83	56.00
T_0: Control	21.18	40.53	51.46
$CD_{(0.05)}$	**0.71**	**0.82**	**1.68**

Table 2 Effect of thermophysical seed treatments on first marketable picking and average fruit weight in bell pepper under field condition

Treatments	Days to first marketable picking	Average fruit weight (g)
T_1: Hot water 49°C/45min	63.67	51.15
T_2: Hot water 49°C/60min	62.33	51.98
T_3: Hot water 50°C/60min	60.00	53.01
T_4: Hot air 72°C/24 h	63.00	51.06
T_5: Hot air 72°C/36 h	64.33	50.33
T_6: Hot air 74°C/48 h	65.00	47.66
T_7: Microwave 5 s	65.00	51.46
T_8: Microwave10 s	67.00	49.33
T_9: Microwave15 s	68.00	46.66
T_0: Control	65.00	51.55
$CD_{(0.05)}$	**1.08**	**0.83**

Table 3 Effect of thermophysical seed treatments on fruit yield characters and harvest duration in bell pepper under field condition.

Treatments	Fruit yield characters				Harvest Duration days
	No. of fruits/plant	Fruit yield/plant (g)	Fruit yield/plot (kg)	Fruit yield/hectare (q)	
T_1: Hot water 49°C/45min	18.78	960.77	5.76	284.67	26.33
T_2: Hot water 49°C/60min	19.14	995.32	5.97	294.91	28.67
T_3: Hot water 50°C/60min	19.48	1032.71	6.19	305.99	31.67
T_4: Hot air 72°C/24 h	17.62	899.78	5.39	266.60	24.67
T_5: Hot air 72°C/36 h	16.51	831.02	4.98	246.23	21.67
T_6: Hot air 74°C/48 h	15.54	741.02	4.44	219.56	23.33
T_7: Microwave 5 s	18.22	938.06	5.62	277.94	24.33

$T_{8:}$ Microwave 10 s	17.38	857.50	5.14	254.07	23.33
T_9: Microwave 15 s	16.32	761.75	4.57	225.70	22.33
T_0: Control	15.24	785.79	4.71	232.83	21.67
$CD_{(0.05)}$	**0.20**	**20.76**	**0.12**	**6.15**	**1.36**

Table 4 Effect of different thermophysical seed treatments on disease incidence/ severity (%) in bell pepper under field condition

Treatments	Disease incidence (%)				
	Anthracnose*	**Cercospora leaf spot***	**Phytophthora rot***	**Wilt***	**Viruses***
T_1: Hot water 49°C/45min	5.55 (2.55)	7.20 (2.86)	5.55 (2.55)	0.00 (1.00)	5.55 (2.55)
T_2: Hot water 49°C/60min	3.70 (2.04)	5.33 (2.51)	4.62 (2.35)	0.00 (1.00)	3.70 (2.04)
T_3: Hot water 50°C/60min	1.85 (1.52)	3.73 (2.16)	3.69 (2.14)	0.00 (1.00)	2.77 (1.83)
T_4: Hot air 72°C/ 24 h	5.54 (2.51)	12.80 (3.71)	7.40 (2.86)	0.00 (1.00)	3.69 (2.14)
T_5: Hot air 72°C/36 h	5.08 (2.38)	11.73 (3.56)	7.40 (2.86)	0.00 (1.00)	2.77 (1.94)
T_6: Hot air 74oC/48 h	5.55 (2.55)	9.06 (3.17)	6.47 (2.72)	0.00 (1.00)	1.84 (1.62)
T_7: Microwave 5 s	12.96 (3.72)	18.93 (4.46)	12.96 (3.72)	0.00 (1.00)	11.11 (3.48)
$T_{8:}$ Microwave 10 s	11.11 (3.48)	16.80 (4.21)	11.11 (3.48)	0.00 (1.00)	9.25 (3.17)
T_9: Microwave 15 s	9.25 (3.17)	14.40 (3.92)	9.25 (3.17)	0.00 (1.00)	7.40 (2.86)
T_0: Control	18.51 (4.40)	28.03 (5.38)	20.37 (4.61)	0.00 (1.00)	22.22(4.81)
$CD_{(0.05)}$	**0.90**	**0.21**	**0.63**	**N.S.**	**0.73**

*The values in parentheses are square root transformed values

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