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Effect of Cold Plasma Treatment and Priming in Bell Pepper (*Capsicum annuum* L.)

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Abstract

The present investigation was conducted at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during *kharif* 2014 to study the "Effect of cold plasma treatment and priming on bell pepper (*Capsicum annuum* L. cultivar California Wonder). The experiment was laid out in Randomized Block Design (Factorial) in the field. The seeds were exposed to various durations of oxygen cold plasma treatment using glow discharge technique at FCIPT, Institute for Plasma Research, Gandhinagar, Gujarat, India. Seeds were pre-treated with power of 100 W oxygen gas was used at base pressure of 0.05m bar, operating pressure of 0.2 m bar, voltage of 500 V and current of 0.2A for treatment durations of 0, 3, 6, 9, 12, 15 minutes, The changes in surface morphology of plasma treated seeds were studied by Scanning Electron Microscopy (SEM) and Contact Angle Goniometer. Treatments comprised of primed and non-primed seeds and seven seed plasma treatments. Along with plasma treatment, seeds were also treated with standard osmopriming method for comparison. The plasma treatment alone as well as in combination with osmopriming up to 6 minutes plasma treatment was found superior over all treatments in terms of growth characters, fruit yield characters and seed yield characters. Osmoprimed seeds exposed with 6 minutes plasma were also found to be best treatment for most of the traits recording days to 50% flowering (45.33 days), fruit yield plant^{-1} (1.00 kg), ripe fruit yield plant^{-1} (830.35 g) and seed yield per plant (10.74 g).

Keywords: Bell pepper, cold plasma, seed, osmopriming , SEM

1. Introduction

Bell pepper (*Capsicum annuum* L.) has attained a status of high value crop in India in recent years and occupied a place of pride among vegetables in Indian cuisine because of its delicacy and pleasant flavour coupled with rich content of ascorbic acid, other vitamins and minerals (Agarwal et al., 2007). Bell pepper is a warm-season crop and performs well under an extended frost-free season with the potential of producing high yields of outstanding quality. Mid-hills of Himachal Pradesh are the leading suppliers of bell pepper during off-season (Chaudhary et al., 2009). The consumption of high quality bell peppers has been increasing drastically to satisfy consumers demand (Jovicich et al., 2015). The seeds of bell pepper possess problem in germination owing to hard seed coat. The problem is aggravated as the sowing is done in comparatively unfavourable climatic conditions in the month of January-February in the mid-hill conditions of Himachal Pradesh. Low seed germination and rapid deterioration during storage of bell pepper seeds are the major problems that affect the seed quality (McDonald, 1999). Different seed enhancement technologies like priming, coating, pelleting etc increases the moisture content of seed during treatment. In recent times, a new technique namely plasma treatment is evolved for this purpose. It has been shown in a number of previous studies that plasma pre-treatment of seeds stimulates their germination and leads to suppression of fungal and bacterial plant pathogens (Filatova et al., 2011). Cold plasma seed treatment is a modern eco-agricultural technology that has been suggested to stimulate plant growth. It is based on non-ionizing low-level radiation (so called cold plasma), which can activate the vitality of seeds but without causing gene mutations (Jiafeng et al., 2014). Crop yields are improved by treating the seeds in a low temperature plasma discharge generated between spaced electrodes connected to a source of high frequency electrical power (Krapivina et al., 1994).

Here, a dry seed treatment i.e. plasma treatment is employed to increase the seed coat permeability without increasing the moisture content of seed unlikely priming and other such treatments. Seed priming is one of the commonly used pre-sowing techniques for enhancing the seed quality and improving the overall germination under adverse environmental conditions (Peyvast et al., 2006). Among different strategies it is an easy, low cost and low risk technique (Tavili et al., 2011) . The problem of poor or slow germination can be solved seed priming. In the present studies, plasma treatment was combined with priming to investigate and study their individual as well as combined effects on the seed quality of bell pepper.

2. Materials and Methods

2.1. Plant Material

Seeds of bell pepper (*Capsicum annuum* L.) and (cultivar California Wonder) were obtained from Dr Y. S. Parmar university of Horticulture and Forestry Himachal Pradesh, India.

2.2. Treatment conditions

Bell pepper (*Capsicum annuum* L.) seeds were exposed to Glow Discharge plasma of oxygen gas was used at a base pressure of 0.05 m bar, operating pressure 0f 0.2 m bar, voltage of 500 V, current of 0.2 A and power of 100 W for treatment durations of 0, 3, 6, 9, 12 and 15 minutes. The plasma treatment was done at FCIPT (Facilitation Centre for Industrial Plasma Technologies), Institute for Plasma Research, Gandhinagar, Gujarat, India (An institute under Ministry of Atomic Energy, GOI). Along, with the plasma treatment seeds were also treated with osmopriming for comparison. In osmopriming the seeds are soaked in osmoticum i.e. PEG for about 72 hours at 15 ^{o}C and 90% relative humidity and after that wash it with tap water 3-4 times. After exposure to plasma the seeds were imaged by high resolution Scanning Electron Microscopy and Contact Angle Goniometer. Seed Surface Topography of plasma treated and untreated seeds were studied by Scanning Electron Microscopy (SEM) at 50 X and 100K X magnifications. And Seed Surface Morphology was studied by Contact Angle Goniometer. Water contact angle quantifies the wettability of a solid surface by a liquid. Control seeds were not exposed to any treatment.

2.3. Experimental design

The experiment was carried out at the Department of Seed Science and Technology, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan from March 2014 to September 2014. The experiment was planned as a randomized block design with four replications.

3. Results and Discussion

3.1. Days to 50% flowering

The minimum mean days to 50% flowering (49.71 days) was observed in the osmopriming treatment and on the other hand highest days to 50% flowering (51.10 days) were recorded with non-priming treatment. A significant improvement in days to 50% flowering was observed due to plasma treatment over control. Seeds exposed to plasma for 6 minutes recorded minimum days to 50% flowering (46.50 days) and the maximum days to 50% flowering (53.67 days) was recorded in control seed where no vacuum and no plasma treatment were given. This positive effect is probably due to the activation of synthesis of proteins, RNA, free amino acids and soluble sugars in the first phase of germination (Narayanareddy and Biradarpatil, 2012). Plasma induces biochemical changes in the seed that are required to start the germination process like internal physiological change connected with seed hormonal activities and enzymes activation (Zivkovic et al., 2004; Sera et al., 2008). Thus, upon seeding, plasma treated seeds can rapidly imbibe water and revive the seed metabolism, resulting in a higher germination rate and a reduction in the inherent physiological heterogeneity in germination (Sera et al., 2008) (Table 1).

Table 1: Effect of plasma treatment, seed priming and their interactions on days to 50% flowering

Plasma treatment durations	Days to 50% flowering		
	Osmoprimed	Non-primed	Mean (Plasma)
Vacuum	52.00	53.67	52.83
3minutes	48.00	48.67	48.33
6 minutes	45.33	47.67	46.50
9 minutes	48.67	49.67	49.17
12 minutes	50.00	51.00	50.50
15 minutes	51.33	52.33	51.83
Control	52.67	54.67	53.67
Mean (Priming)	49.71	51.10	

3.2. Ripe fruit yield plant^{-1} (gram)

Osmopriming treatment resulted in maximum ripe fruit yield per plant (718.68 g) whereas; non-priming resulted in minimum ripe fruit yield plant^{-1} (685.88 g). Significant variations for fruit yield plant^{-1} were observed among all the plasma treatments. Seed exposed to plasma for 6 minutes recorded maximum ripe fruit yield plant^{-1} (806.32 g). Whereas, the untreated control resulted in minimum ripe fruit yield plant^{-1} (603.08 g). Sera et al. (2012) was also of the view that increase in number of pods plant^{-1} were observed in priming. Increase in number of ripe fruits per plant with osmopriming may be due to early appearance of flowers and more plant height (Table 2).

3.3. Percent seed recovery

Significantly higher percent seed recovery after harvesting (1.19%) was recorded with osmopriming as compared with non-priming (1.17%) treatment. The percent seed recovery after harvesting differed significantly due to different plasma exposure time on seed. The seeds exposed to plasma for 6

Table 2: Effect of plasma treatment, seed priming and their interactions on number of ripe fruit fruit^{-1} in bell pepper (gm) and percent seed recovery

Plasma treatment durations	Ripe fruit yield plant^{-1} (g)			Percent seed recovery		
	Osmoprimed	Non-primed	Mean (Plasma)	Osmoprimed	Non-primed	Mean (Plasma)
Vacuum	656.21	664.61	660.41	1.10 (1.45)	1.03 (1.42)	1.06 (1.44)
3 minutes	763.12	723.63	743.37	1.27 (1.51)	1.28 (1.51)	1.28 (1.51)
6 minutes	830.35	782.28	806.32	1.29 (1.52)	1.32 (1.52)	1.31 (1.52)
9 minutes	722.19	679.79	700.99	1.28 (1.51)	1.26 (1.51)	1.27 (1.52)
12 minutes	738.17	691.33	714.67	1.16 (1.47)	1.15 (1.47)	1.15 (1.47)
15 minutes	704.91	669.33	687.12	1.11 (1.45)	1.07 (1.44)	1.09 (1.45)
Control	615.81	590.34	603.08	1.07 (1.44)	1.08 (1.44)	1.08 (1.44)
Mean (Priming)	718.68	685.88				

minutes recorded highest percent seed recovery (1.28%). The seed kept under vacuum and not exposed to plasma showed significantly lower percent seed recovery (1.06%) compared to plasma treated seeds. Whereas, the untreated control resulted in lowest percent seed recovery (1.08%).The percent seed recovery is the prime factor that decides the final seed yield of the crops. It may be due to, more number of seeds per fruit and high thousand seed weight.

3.4. Seed yield plant^{-1} (g)

It revealed significant variations for the character under study. The maximum seed yield plant^{-1} (8.56 g) was observed in osmopriming treatment. While, the non-primed seeds gave the minimum seed yield plant^{-1} (8.06 g). These results were in agreement with the findings of (Mehri, 2015) who reported increase in seed yield in soybean due to improved stand establishment, seedling vigor and the yield in the field. While comparing the exposure time of plasma to the seed, it significantly influenced seed yield plant^{-1}. Seed exposed to plasma for 6 minutes recorded maximum seed yield plant^{-1} (10.52 g). The minimum seed yield plant^{-1} (6.49 g) was recorded in control seed where no treatments were given (Table 3).

Table 3: Effect of plasma treatment, seed priming and their interactions on seed yield plant^{-1} (g) and seed yield ha^{-1} (kg) bell pepper

Plasma treatment durations	Seed yield plant^{-1} (gm)			Seed yield ha^{-1} (kg)		
	Osmoprimed	Non-primed	Mean (Plasma)	Osmoprimed	Non-primed	Mean (Plasma)
Vacuum	7.23	6.83	7.03	142.72	131.92	137.32
3 minutes	9.69	9.25	9.47	223.19	205.30	214.25
6 minutes	10.74	10.30	10.52	260.83	241.58	251.20
9 minutes	9.25	8.58	8.92	205.65	187.46	196.55
12 minutes	8.57	7.91	8.24	183.33	162.84	173.08
15 minutes	7.84	7.18	7.51	161.35	141.48	151.41
Control	6.61	6.37	6.49	122.36	112.54	117.45
Mean (Priming)	8.56	8.06		185.63	169.01	

3.5. Seed yield ha^{-1} (kg)

The maximum seed yield per hectare (185.63 kg) was observed in osmopriming treatment and the minimum seed yield ha^{-1} (169.01 kg) was recorded in non-priming treatment.

Seed exposed to plasma for 6 minutes recorded maximum seed yield per hectare (251.20 kg). Whereas, the untreated control resulted in minimum seed yield per hectare (117.45 kg). The increase in yield may be due to early emergence, earliness in flowering, more number of fruits plant^{-1} and increase in fruit weight. The results are in conformity with Odell et al. (1992); Dabrowska et al. (2000); Harris et al., (2001); Rashid et al., (2002). They reported increase in yield due to seed priming in tomato, hot pepper, maize and wheat respectively.

The results are in conformity with Jiafeng et al. (2014). They reported increase in the photosynthetic activity, more number of branches, accumulation of photosynthates, more number of fruits and increased fruit weight in plasma treated in seeds treated seeds which ultimately resulted in increased yield.

4. Conclusion

Plasma treatment with 6 minutes duration can be used as a beneficial pre-sowing treatment to enhance the physiological, growth and yield characteristics. This may be due to due to removal of thin lipid layer due to exposure to the plasma. This makes seeds water repellant and improves germination (Sera et al., 2010). Plasma treatment resulted in drastic decrease in apparent contact angle as a result wettability of the surface was increased due to oxidation by plasma treatment (Bormashenko et al., 2012).

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