



Effect of seed treatment, soil application and foliar spray of some insecticides on seed quality of bell pepper (*Capsicum annuum* L.)

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Abstract: Studies were carried out to evaluate the efficacy of some insecticides as seed treatment, soil application and foliar sprays on seed quality characters of bell pepper (*Capsicum annuum* L.) cultivar Solan Bharpur during *Kharif* season 2013. The treatments comprised of seed application of imidacloprid (Gaucho 600FS) and thiamethoxam (Cruiser 70WS), soil application of neem cake @ 2 q/acre and carbofuran @ 6 kg/acre and foliar sprays of imidacloprid (Confidor 200 SL), thiamethoxam (Actara 25 WS), indoxacarb 14.5 SC @ 0.5ml/l, NSKE (neem seed kernel extract) @ 5%, Neem Raj 500ppm @ 2.5ml/l and control. The observations regarding quality parameters recorded were germination percentage, seedling length, seedling dry weight, seed vigour index-I, seed vigour index-II and electrical conductivity. The results revealed that treatment combination viz., seed treatment and foliar spray with thiamethoxam (S₂F₂) recorded significantly higher germination percentage (96.33%), seed vigour index-I (934.10), seed vigour index-II (245.02) and minimum electrical conductivity (216.67dSm⁻¹) at 0.05 level of significance. Therefore, seed treatment and foliar spray of thiamethoxam may be recommended for quality seed production of bell pepper.

Keywords: Capsicum, Cultivar, Electrical conductivity, Germination, Seed vigour

INTRODUCTION

Bell pepper (*Capsicum annuum* L.) is an important solanaceous vegetable crop grown almost all over the world. It holds a significant place among vegetables because of its high nutritional value; rich source of ascorbic acid as only 50 g of green fruit can meet the daily requirement of an individual (McGillivray, 1953) and also rich in minerals such as iron, potassium, calcium, magnesium, phosphorus, sodium and selenium (Agarwal *et al.*, 2007). Bell pepper is originated in Mexico with secondary centre in Guatemala (Bukasov, 1930; Smith and Heiser, 1957) and was introduced in India by the Britishers in the 19th century in Shimla hills. In India, bell pepper is grown in Himachal Pradesh, Jammu and Kashmir, Uttrakhand, Arunachal Pradesh and Darjeeling district of West Bengal during summer months and as autumn crop in Maharashtra, Karnataka, Tamil Nadu and Bihar. The mild climate with humid environmental condition of Himachal Pradesh during the summer season is best suited for off season cultivation of bell pepper for fresh fruit and seed production.

Seed is the most important input in agricultural

production. India has diverse climate and agro-climatic conditions of the plains are not congenial for seed production of bell pepper due to various biotic (pests and diseases), abiotic (rainfall, temperature etc.) and crop factors like flower and fruit drop (Lal *et al.*, 2014). Like other vegetables, the seed yield and quality attributes (germination, vigour) of bell pepper are greatly influenced by these factors. Among the biotic factors insect pests are important which cause heavy loss to the crop of which sucking pests and fruit borers which not only affect the seed yield but the seed quality is greatly hampered. Plant protection measures when taken up through seed treatment, soil application and foliar spray are known to manage these pests effectively and in turn enhance the seed yield and quality. Although chemical control of various insect pests of bell pepper for vegetable production is well documented yet very few studies on seed treatment, soil application with synthetic insecticides and botanicals for the management of insect pests and their effect on seed yield and quality are carried out in Himachal Pradesh and elsewhere in India. Keeping all this in view, the present studies have been undertaken to evaluate the effect of some commonly used insecticides and bo-

tanicals on seed quality of bell pepper (*Capsicum annuum* L.).

MATERIALS AND METHODS

The experiment was carried out at Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP during *Kharif*, 2013. The seedlings were transplanted in a plot having size of 5.4 m² (2.40 m × 2.25 m) in Randomized Complete Block Design with three replicates. FYM and fertilizers were applied as per recommendations of package of practices, Directorate of Extension Education of the university (FYM @ 200 quintal/ha, CAN @ 400 Kg/ha, SSP @ 475 Kg/ha and MOP @ 90 Kg/ha). The treatments comprised 24 different combinations of two seed treatments viz. S₁ (Imidacloprid-Gaucho 600FS @12ml/kg) and S₂ (Thiamethoxam-Cruiser 70WS@ 10g/kg) three days prior to sowing; two soil treatments viz. Neem cake (S₃) and Carbofuran (S₄)@ 270 g/plot (13.5 g/plant) and 8.1 g/plot (0.405 g/plant) at the time of seedling transplantation; and six foliar sprays viz., F₁ (Imidacloprid) @ 0.5ml/l, F₂ (Thiamethoxam - Actara 25 WS) @ 0.40 g/l, F₃ (Indoxacarb14.5 SC) @ 0.5ml/l, F₄ (NSKE) @ 5 per cent and F₅ (Neem Raj 500ppm) @ 2.5ml/l first at 30 days after transplanting and second at 15 days after the first spray and F₆ i.e. control (without any spray).

The samples were collected from five plants randomly selected from every plot of each treatment (4S×6F=24 treatments × 3 replications =72plots). Red ripe fruits were harvested from selected plants, seeds extracted and dried to eight per cent moisture content. The germination test was conducted with 100 seeds from each plot in five replications by using petri plate method as per ISTA Rules (Anonymous, 1985). The root length and shoot length of ten normal seedlings were measured on the 7th day. The seed vigour index-length (SVI-I) was calculated by adopting the method suggested by Abdul-Baki and Anderson (1973) as Seed vigour index-I (SVI-I) = Germination (%) × seedling length (cm). Dry weight of seedlings was measured by taking the ten normal seedlings used for root and shoot length. The seedlings were kept in blotting paper and dried in hot air oven maintained at 75° C for 24hours. The dried seedlings were cooled in a desiccator for 60 minutes, then seedlings were weighed in an electronic balance and the weight was expressed in mg as dry weight of ten seedlings. Seed vigour index-II (SVI-II) was calculated as SVI-II = Germination (%) × seedling dry weight (mg).

Electrical conductivity variations were observed using 25 seeds per replication of each treatment combination. Seeds were soaked in 25 ml of distilled water for 24 hours. After the expiry of the said period electrical conductivity was measured using the digital conductivity meter (EUTECH Instruments: CON 700

Conductivity / °C / °F meters) and the results were expressed as dSm⁻¹. The statistical analysis of the data recorded was done as per design of the experiments as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The quality of the seed is the ultimate attribute that determines the seedling performance in the field under various biotic and abiotic stresses. Seed vigour is one of the factor that determines the seed quality. Bold and vigorous seeds give better plant stand and further growth of plants and fruits. Data on different seed quality characters of capsicum has been recorded and presented in Table 1 & 2. The germination percentage of capsicum seeds differed significantly due to seed and soil treatments at 0.05 level of significance. Significantly higher germination (86.61%) was recorded in seeds treated with thiamethoxam (S₂) followed by seeds treated with imidacloprid (S₁) (83.22 %), soil application of neem cake (S₃) (81.28%) and soil application of carbofuran (S₄) (78.72 %). Irrespective of seed and soil treatments, the foliar spray of thiamethoxam (F₂) recorded significantly higher germination (91.25 %) at p<0.05 followed by imidacloprid (F₁) which recorded 87.25 per cent seed germination. All the treatment combinations of seed or soil application with foliar sprays resulted in improved seed germination over control i.e. crop raised with seed or soil application but without foliar sprays. However, treatment combination seed treatment and foliar spray of thiamethoxam (S₂F₂) recorded significantly higher seed germination (96.33 %) followed by seed treatment with imidacloprid and foliar spray of thiamethoxam (S₁F₂, 92.33 %), seed treatment with thiamethoxam and foliar spray of imidacloprid (S₂F₁, 91.00 %) whereas the minimum germination (65.33 %) was observed in soil application with carbofuran without any foliar spray (S₄F₆). It is evident from the present study that physically and physiologically sound seeds produced from the treated seeds and sprayed plants for insect's control lead to high and uniform germination. These results are in conformity with Almeida *et al.* (2009) who reported an increased expression of seed germination with thiamethoxam and imidacloprid in carrot seeds. In soyabean, pea and some other crops Horii *et al.* (2007) and Cataneo *et al.* (2010) also reported similar results with thiamethoxam (Cruiser).

Seedling length and dry weight indicates the strength of seed and are the important attributes of the seed vigour. Seed treatment with thiamethoxam (S₂) resulted in significantly higher seedling length 8.21 cm at p<0.05 followed by seed treatment with imidacloprid (S₁) 8.05 cm, soil application of neem cake (S₃) 7.87 cm and soil application of carbofuran

Table 1. Effect of seed treatment, soil application and foliar spray of some insecticides on seed quality of bell pepper

Foliar application*	Dose	Germination percentage				Seedling length (cm)				Seedling dry weight (mg)				Seed vigour index (SVI-I)				Seed vigour index (SVI-II)								
		Seed** treatment		Soil*** application		Seed treatment		Soil application		Seed treatment		Soil application		Seed treatment		Soil application		Seed treatment		Soil application						
		S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄	S ₁	S ₂	S ₃	S ₄					
F ₁ - Imidacloprid (confidors)	0.5ml/l	88.33 (70.03)*	91.00 (72.53)	86.00 (68.01)	83.67 (66.14)	87.25	8.83	8.31	8.20	8.46	2.46	2.49	2.42	2.39	2.44	751.04	803.85	714.97	686.07	738.98	217.01	226.59	208.12	200.24	212.99	
F ₂ -Thiamethoxam (Actara)	0.40g/l	92.33 (73.90)	96.33 (78.95)	89.33 (70.91)	87.00 (68.85)	91.25	9.50	8.97	8.80	9.24	2.49	2.54	2.46	2.44	2.48	877.15	934.10	801.33	765.32	844.47	229.60	245.02	220.06	212.29	226.74	
F ₃ - Indoxacarb (Avaunt)	0.5ml/l	81.33 (64.38)	83.67 (66.14)	79.67 (63.17)	77.33 (61.55)	80.50	7.39	7.43	7.34	7.27	7.36	2.32	2.36	2.29	2.27	2.31	600.78	621.65	585.01	562.48	188.42	197.73	182.70	175.29	186.04	
F ₄ -NSKE (neem seed kernel extract)	5%	86.00 (68.01)	88.67 (70.30)	84.00 (66.40)	81.00 (64.14)	84.92	8.04	8.17	7.82	7.76	7.95	2.45	2.47	2.42	2.3	2.43	691.13	724.41	657.17	628.31	210.41	219.01	203.56	193.31	206.57	
F ₅ -NeemRaj (Neem formulation)	2.5ml/l	83.33 (65.89)	85.33 (67.46)	82.00 (64.87)	78.00 (62.01)	82.17	7.55	7.73	7.46	7.40	7.53	2.38	2.42	2.37	2.34	2.38	628.88	659.34	611.72	577.21	619.29	198.61	206.22	194.07	182.26	195.29
F ₆ - Control		68.00 (55.53)	74.67 (59.76)	66.67 (54.71)	65.33 (53.91)	68.67	7.33	7.38	7.28	7.24	7.31	2.28	2.31	2.24	2.21	2.26	498.20	551.29	485.55	473.01	502.02	154.82	172.73	149.55	144.39	155.37
Mean		83.22 (66.29)	86.61 (69.19)	81.28 (64.68)	78.72 (62.76)	82.46	8.05	8.21	7.87	7.78	7.98	2.39	2.43	2.37	2.34	2.38	674.53	715.77	642.63	615.40	662.08	199.81	211.22	193.01	184.63	197.17
CD P=0.05																										
F						0.57				0.03					0.01						5.69				1.88	
S						0.46				0.02					0.01						4.64				1.53	
F*S						1.14				0.05					0.02						11.47				3.79	

Values in parentheses are transformed values; *Foliar spray (F); ** Seed Treatment(S₁) Imidacloprid (Gaucho 600 FS), (S₂) Thiamethoxam (Cruiser 70WS); *** Soil Application (S₃) Neem Cake, (S₄) Carbofuran (Furadon 3G)

Table 2. Effect of seed treatment, soil application and foliar spray of some insecticides on electrical conductivity (dSm^{-1}) of the bell.

Foliar application	Dose	Electrical conductivity (dSm^{-1}) in the indicated treatment				Mean
		Seed treatment		Soil application		
		Imidacloprid (Gaucho) ^{**} (S ₁)	Thiamethoxam (Cruiser) (S ₂)	Neem cake (S ₃)	Carbofuran (Furadan) (S ₄)	
*F ₁ – Imidacloprid (Confidor)	0.5ml/l	231.49	221.85	239.39	244.56	234.32
F ₂ -Thiamethoxam(Actara)	0.40g/l	223.67	216.67	235.63	240.57	229.14
F ₃ - Indoxacarb(Avaunt)	0.5ml/l	251.85	234.13	257.70	260.73	251.10
F ₄ - NSKE (Neem Seed Kernel Extract)	2.5ml/l	240.70	226.43	246.03	248.00	240.29
F ₅ -Neem formulation(Neem Raj)	5%	247.78	229.43	252.12	255.88	246.30
F ₆ – Control		323.39	312.50	328.71	333.44	324.51
Mean		253.15	240.17	259.93	263.86	254.28

*F- Foliar Spray, **S₁, S₂-Seed treatment, S₃, S₄- Soil application; CD_{p=0.05}, F = 0.48; S = 0.39; F*S = 0.96

(S₄) 7.78 cm. Irrespective of seed and soil treatments, foliar spray of thiamethoxam (F₂) lead to significantly higher seedling length (9.24 cm) followed by imidacloprid (F₁) which recorded 8.46 cm seedling length. The interaction of seed treatment and foliar spray (S₂F₂) resulted in significantly higher seedling length (9.70 cm). Similar results were obtained for seedling dry weight which showed that seed treatment and foliar spray of thiamethoxam (S₂F₂) recorded significantly higher seedling dry weight (2.54 mg) (table.1). The healthy seeds produced from treated plants lead to vigorous seedling having more length and dry weight. These results are in close conformity with Cataneo *et al.* (2006) who observed that thiamethoxam accelerated germination, induced more growth of the embryonic axis and minimized the negative effects in presence of aluminium, salinity and water deficiency in soyabean seeds.

Seed vigour is the sum total of all those properties of seeds which determine the potential level of performance and activity of a non- dormant seed during germination and seedling emergence (Perry, 1978). It was observed that seed vigour index-I (SVI-I) was significantly influenced by all treatment combinations of these insecticides (Table 1). Seed treatment with thiamethoxam (S₂) recorded significantly higher SVI-I (715.77) followed by seed treatment with imidacloprid (674.53), soil application of neem cake (642.63) and soil application of carbofuran (615.40). Irrespective of seed or soil treatments, foliar spray of thiamethoxam (F₂) recorded significantly higher SVI-I (844.47). Next best treatment was imidacloprid (F₁) which recorded 738.98 SVI-I. Among all treatment combinations, seed treatment and foliar spray of thiamethoxam (S₂F₂) recorded significantly higher SVI-I (934.10) at $p < 0.05$ whereas the least seed vigour (473.01) was recorded in soil application of carbofuran without any spray. Data pertaining to seed vigour index- II (SVI-II) showed similar results. The seed treatment with thiamethoxam (S₂), foliar spray of thiamethoxam (F₂) and treatment combination viz., seed treatment and foliar spray of thiamethoxam (S₂F₂) gave significantly higher 211.22, 226.74 and 245.02 SVI-II, respectively. These results are in conformity with Horii *et al.* (2007) and Cataneo *et al.* (2010) who reported that seed treatment and subsequent foliar spray of thiamethoxam and imidacloprid significantly increased the seed germination and vigour in soyabean, pea and some other crops. Almeida *et al.* (2009) recorded increased vigour of carrot seeds and reported that thiamethoxam and imidacloprid act as bio-activators and stimulates the physiological performance of seeds. These results are also in agreement with Stevens *et al.* (2008) and Moser and Obrycki (2009) who reported that seed treatment and subsequent foliar spray of thiamethoxam and imidacloprid resulted in higher germination and

vigour in soyabean, wheat and corn seeds.

Electrical conductivity is a major factor that indicates the vigour of the seed. Electrical conductivity is characterized by the total leachates or reserves from the seed. Sound seeds having intact integuments resulted in least leachates when soaked in water and weaker seeds having ruptured or degraded seed coat resulted in more leachates. The seeds having more leachates are less vigorous than those having less leachates. In the present studies, the electrical conductivity differed significantly due to seed, soil and foliar treatments. The mean electrical conductivity was recorded significantly lowest in seed treatment with thiamethoxam (S_2 , 240.17 dSm^{-1}) and the foliar spray of thiamethoxam (F_2 , 229.14 dSm^{-1}) as compared to other treatments. The treatment combination viz., seed treatment and foliar spray of thiamethoxam (S_2F_2) recorded significantly minimum electrical conductivity (216.67 dSm^{-1}) and maximum electrical conductivity 333.44 dSm^{-1} was observed in soil application with carbofuran without any foliar spray (S_4F_6). This indicated that plant protection through seed treatment and foliar sprays at appropriate time lead to healthy growth of plants and resulted in sound, intact and vigorous seeds. These findings concur with those of Pataky *et al.* (2000) who reported that maize seeds treated with the insecticide thiamethoxam decreased the incidence of Stewart's wilt. The results are also in close agreement with Kandolo (2008) who reported improved or maintained vigour in maize seeds treated with Apron® Star 42 WS (thiamethoxam, metalaxy-m and difenoconazole), which was indicated by a reduced or equivalent solute leakage following fast imbibition. The reduced number of diseased plants in the Apron® Star 42 WS treatment may be due to its broad spectrum activity against many pests and diseases.

Conclusion

Seed treatment with thiamethoxam (Cruiser) @10 g per kg seed and two foliar sprays of thiamethoxam (Actara) @ 0.40g /l, first spray after thirty days of transplanting and second after fifteen days of first spray, were found effective in managing insect pests and resulted in production of high quality seeds in bell pepper. Therefore, seed treatment with thiamethoxam (Cruiser) and two foliar sprays of thiamethoxam (Actara) may be recommended after multiyear and multi location trials for quality seed production in capsicum.

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