Environment & Ecology 35 (4) : 2776—2780, October—December 2017
Website : environmentandecology.com ISSN 0970-0420

Standardization of X-ray Radiography Methodology for the Detection of Hidden Insect Infestation in Ber

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Received 17 December 2016; Accepted 19 January 2017; Published online 7 February 2017

Abstract Investigations were carried out on standardization of X-ray radiography methodology for the detection of hidden insect infestation of berfruit borer, *Meridarchisscyrodes* Meyrick. Studies revealed that high voltages are required for the deterction of hidden insect infestation in ber fruits due to their high amounts of water, which restricts the passage of X-rays through fruits. Among the two hundred combinations the exposure of ber fruits to X-ray radiation of 32 kilovoltage and 9 milliampere for 12 seconds was selected as the best combination for ber. Whereas the other combinations 22 kilovoltage and 5 milliampere for 8 seconds, 28 kilovoltage and 6 milliampere for 10 seconds and 30 kilovoltage 8 milliampere for 10 seconds manifested into lighter images.

Keywords X-ray radiography, Compact X-ray machine, Hidden infestation, Tube voltage, Tube current.

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Introduction

World Trade Organization (WTO) enhanced international business, while it has also reduced trading boundaries among countries. The regulations under Sanitary and Phytosanitary measures (SPS) of the WTO were put in place to deal with the exchange of exotic seed or planting material, either in bulkor as small samples meant for various crop improvement programs. Quarantine is the last defence against an unwanted imported non- invasive alien pest. The germplasm or seed samples imported from other countries meant for crop improvements programs are generally very small in quantities necessitating to go for non-destructive method for detecting the pests associated with seed material especially the hidden insect infestation in the present context. The heavy load of inspection and the limited duration

restricts the quality of inspection and forfeits the chance of an accurate and effective quarantine program. It is well known that X-rays can penetrate most materials X-ray radiography provides a permanent, visible film record of the internal condition of a product. It is especially useful for the rapid examination of relatively large samples to determine extent of insect-damage in individual seed or grain or fruits.

Similarly this methodology was also supported to detect stone weevil in mango fruits (1), apple (2), cherries and apple (3) and on various fruits (4). Although the technology is known and the suitable X-ray machinery available, the input factors viz., the voltage, current and the exposure period have not been standardized for the ber. The stone weevil infestation was detected by standardizing a range of X-ray radiography values of about 20-34 KV, 12-30mA current [1] and for the seed quality in horticulture crops (5).

In the absence of standardiized values of these input factors, users resort to standardization every time. Standardizing the methodology for a variety of fruit material is quite an important task to further the use of X-ray radiography. Therefore considering the importance and usefulness of this non-destructive method of detecting insect damage levels in the eduible fruit of ber, the current studies were undertaken for the present investigation.

Materials and Methods

Experiments were proposed to be undertaken on ber which were collected from different fruit markets in Hyderabad and necessary steps were taken to maintain both healthy and infested material sepa-

Table 1. Treatment combinations of voltage, current and exposure period.

Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec
1	5	5	6	21	10	5	6	41	15	5	6	61	20	5	6	81	22	5	6
2	5	5	8	22	10	5	8	42	15	5	8	62	20	5	8	82	22	5	8
3	5	5	10	23	10	5	10	43	15	5	10	63	20	5	10	83	22	5	10
4	5	5	12	24	10	5	12	44	15	5	12	64	20	5	12	84	22	5	12
5	5	6	6	25	10	6	6	45	15	6	6	65	20	6	6	85	22	6	6
6	5	6	8	26	10	6	8	46	15	6	8	66	20	6	8	86	22	6	8
7	5	6	10	27	10	6	10	47	15	6	10	67	20	6	10	87	22	6	10
8	5	6	12	28	10	6	12	48	15	6	12	68	20	6	12	88	22	6	12
9	5	7	6	29	10	7	6	49	15	7	6	69	20	7	6	89	22	7	6
10	5	7	8	30	10	7	8	50	15	7	8	70	20	7	8	90	22	7	8
11	5	7	10	31	10	7	10	51	15	7	10	71	20	7	10	91	22	7	10
12	5	7	12	32	10	7	12	52	15	7	12	72	20	7	12	92	22	7	12
13	5	8	6	33	10	8	6	53	15	8	6	73	20	8	6	93	22	8	6
14	5	8	8	34	10	8	8	54	15	8	8	74	20	8	8	94	22	8	8
15	5	8	10	35	10	8	10	55	15	8	10	75	20	8	10	95	22	8	10
16	5	8	12	36	10	8	12	56	15	8	12	76	20	8	12	96	22	8	12
17	5	9	6	37	10	9	6	57	15	9	6	77	20	9	6	97	22	9	6
18	5	9	8	38	10	9	8	58	15	9	8	78	20	9	8	98	22	9	8
19	5	9	10	39	10	9	10	59	15	9	10	79	20	9	10	99	22	9	10
20	5	9	12	40	10	9	12	60	15	9	12	80	20	9	12	100	22	9	12

Table 1. Continued.

Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	MA	Sec
101	25	5	6	121	26	5	6	141	28	5	6	161	30	5	6	181	32	5	6
102	25	5	8	122	26	5	8	142	28	5	8	162	30	5	8	182	32	5	8
103	25	5	10	123	26	5	10	143	28	5	10	163	30	5	10	183	32	5	10
104	25	5	12	124	26	5	12	144	28	5	12	164	30	5	12	184	32	5	12
105	25	6	6	125	26	6	6	145	28	6	6	165	30	6	6	185	32	6	6
106	25	6	8	126	26	6	8	146	28	6	8	166	30	6	8	186	32	6	8

Table 1. Continued.

Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl No	KV	mA	Sec
107	25	6	10	127	26	6	10	147	28	6	10	167	30	6	10	187	32	6	10
108	25	6	12	128	26	6	12	148	28	6	12	168	30	6	12	188	32	6	12
109	25	7	6	129	26	7	6	149	28	7	6	169	30	7	6	189	32	7	6
110	25	7	8	130	26	7	8	150	28	7	8	170	30	7	8	190	32	7	8
111	25	7	10	131	26	7	10	151	28	7	10	171	30	7	10	191	32	7	10
112	25	7	12	132	26	7	12	152	28	7	12	172	30	7	12	192	32	7	12
113	25	8	6	133	26	8	6	153	28	8	6	173	30	8	6	193	32	8	6
114	25	8	8	134	26	8	8	154	28	8	8	174	30	8	8	194	32	8	8
115	25	8	10	135	26	8	10	155	28	8	10	175	30	8	10	195	32	8	10
116	25	8	12	136	26	8	12	156	28	8	12	176	30	8	12	196	32	8	12
117	25	9	6	137	26	9	6	157	28	9	6	177	30	9	6	197	32	9	6
118	25	9	8	138	26	9	8	158	28	9	8	178	30	9	8	198	32	9	8
119	25	9	10	139	26	9	10	159	28	9	10	179	30	9	10	199	32	9	10
120	25	9	12	140	26	9	12	160	28	9	12	180	30	9	12	200	32	9	12

rately. A Faxitron X-ray machine available at National Bureau of Plant Genetic Resources (NBPGR) gives soft X-ray radiation enough for studying experimental material in smaller quantities. X-ray film for ob-

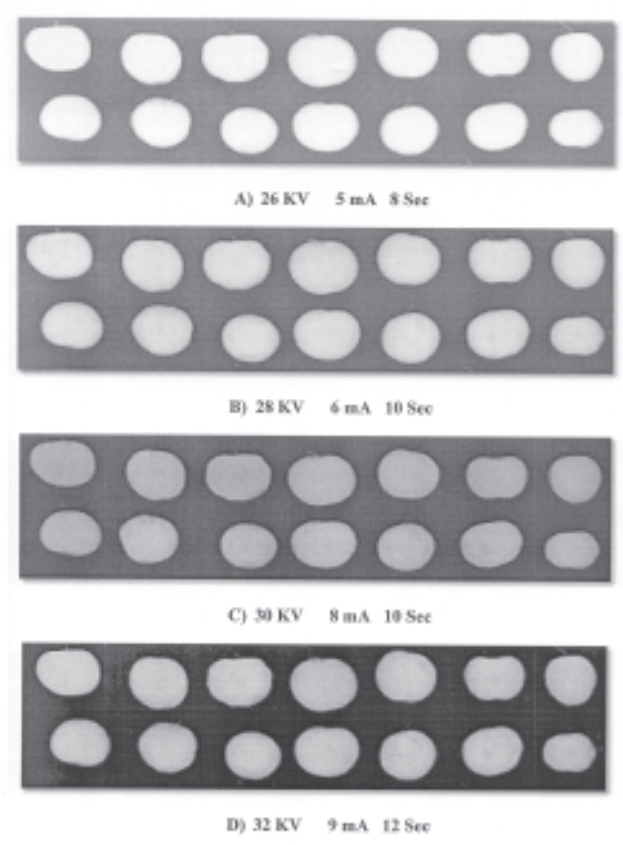

Fig. 1. X-ray radiography images of ber with four different combinations, where A, B and C images are lighter and the image D is darker image of healthy ber fruits.

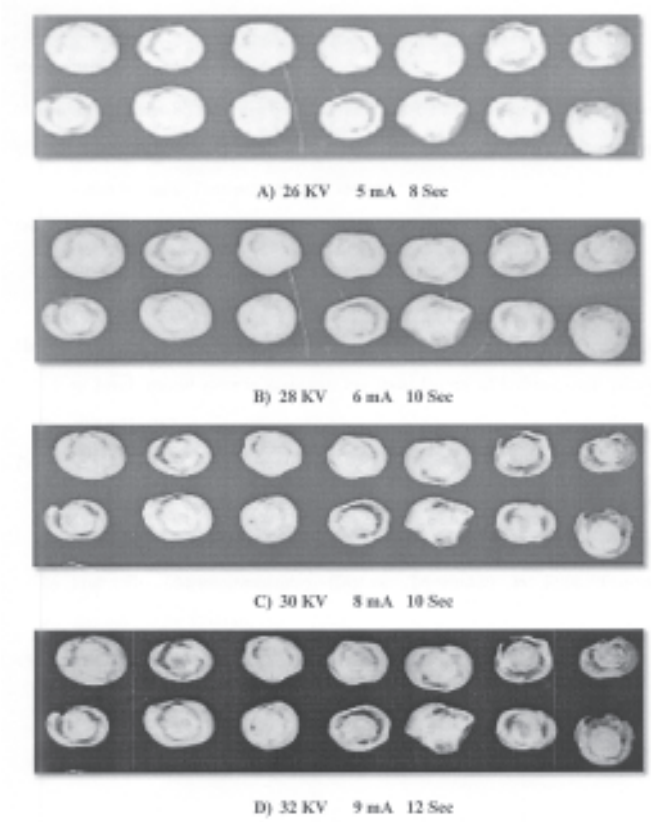

Fig. 2. X-ray radiography images of ber with four different combinations, where A, B and C images are lighter and the image D is standardized image with fruits of ber shows hidden infested images clearly.

taining standard images and the chemicals for developing and fixing the image in the dark room were procured from Care Stream Health India Pvt Ltd for the study.

During X-ray exposure the small samples of 10 to 20 fruits were placed over the adhesive tape, which is highly convenient to pick out and separate the fruits with internal (hidden) infestation. The fruits were arranged in such a manner to easily differentiate the infested and healthy fruits, where there were one row of infested fruits and one row with healthy fruits. Steps were taken to select the infested fruits through the presence of pin size holes on fruits to facilitate the standardization of the X-ray radiography values viz., voltage(KV), current (mA) and exposure period (s). Then the required adjustments in voltage (KV), Current (mA) and exposure period (s) in the X-ray machine were made for the exposure. After the exposure to radiation the X-ray film was processed with the help of chemicals for image development (Developer) and fixing (Fixer).

Treatments and experiment procedures

The experiments were planned for berto find out a standard voltage, current and exposure period. The combination of treatments for berwas worked out as detailed below. At a given voltage level there would

be 200 treatment combinations of current and exposure periods as given in the Table 1. Likewise image analysis in terms of its quality so as to reveal its gross internal contents which include hidden infestation were intended to be studied for ber (Plate 1-2 respectively). Adjustments in combinations of current and exposure periods were made based on the preliminary image results while working in the laboratory.

Results and Discussion

Radiography tests for determining the best treatment combinations were undertaken with the ber fruits severely infested with fruit borer, *Meridarchisscyrodes* Meyrick. Among these two hundred combinations the exposure of ber fruits to X-ray radiation of 32 kilovoltage and 9 milliampere for 12 seconds was selected as the best combination for ber.Whereas the other combinations like 22 kilovoltage and 5 milliampere for 8 seconds, 28 kilovoltage and 6 milliampere for 10 seconds and 30 kilovoltage 8 milliampere for 10 seconds manifested into lighter images.

For the detection of hidden insect infestation in ber, the amount of voltage , current and period of exposure to radiation is high in case of ber because of their high amounts of water content in the fruits which restricts the penetration of X-rays in accordance with the fruit containing high amounts of water resulted in the poor penetration of X-rays and requires high amounts of voltage and current to detect hidden insect infestation (4). The literature on this fruit was scanty and did not show up comparable work done in standardization of X-ray radiography technique in ber for the detection of hidden insect infestation.

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