

Standardization of X-Ray Radiography Methodology for the Detection of Hidden Insect Infestation in Different Varieties of Groundnut

A. Nagaraju, T. Ramesh Babu, B. Sarath Babu

Received 14 December 2016 ; Accepted 16 January 2017 ; Published online 4 February 2017

Abstract Investigations were carried out on standardization of X-ray radiography methodology for the detection of hidden insect infestation of groundnut bruchid, *Caryedon serratus* olivier in groundnut. Studies revealed that the different voltages are required for the detection of hidden insect infestation in different varieties of groundnut due to their seed size and thickness of seed coat, which allows the passage of X-rays through seeds. Among the two hundred combinations the exposure of groundnut seeds to X-ray radiation ranges between 22–25 Kilovoltage and 6-7 milliampere for 10 seconds of exposure period was standardized as the best combinations for different groundnut varieties. Whereas for the same varieties the range of parameters below and above the standardized values results in lighter and darker images respectively.

Keywords X-ray radiography, Hidden infestation, Groundnut bruchid.

Introduction

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. Variety of detection methods is employed in locating infestation for early diagnosis of low level infestations and to ascertain the control measures. It is well known that X-rays can penetrate most materials. The 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 the extent of insect damage in individual seed or grain.

The X-ray test is used to manually separate the infested rice and wheat kernels [1]. The X-ray test used in seed quality programs to assist morphological and physiological evaluation [2]. This X-ray test is quick and precise evaluation of seed quality of castor seeds [3]. The Granary weevil infestation in Torca variety of wheat by using X-ray radiography [4]. Standardized X-ray radiography methodology is used for the detection of hidden insect infestation in cereals and pulse and quarantine workers in India traditionally used only a range of values from 10 KV to 30 KV and a current of 4 mA to 12 mA for an exposure period

A. Nagaraju*

Department of Entomology, National Bureau of Plant Genetic Resources—Regional Station, Rajendra Nagar, Hyderabad, Andhra Pradesh 500030, India

T. R. Babu, B. S. Babu

College of Agriculture, Acharya NG Ranga Agricultural University, Rajendra Nagar, Hyderabad, Andhra Pradesh 500030, India

e-mail: nagagrigo34@gmail.com

*Correspondence

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
1	5	5	6	21	10	5	6	41	15	5	6
2	5	5	8	22	10	5	8	42	15	5	8
3	5	5	10	23	10	5	10	43	15	5	10
4	5	5	12	24	10	5	12	44	15	5	12
5	5	6	6	25	10	6	6	45	15	6	6
6	5	6	8	26	10	6	8	46	15	6	8
7	5	6	10	27	10	6	10	47	15	6	10
8	5	6	12	28	10	6	12	48	15	6	12
9	5	7	6	29	10	7	6	49	15	7	6
10	5	7	8	30	10	7	8	50	15	7	8
11	5	7	10	31	10	7	10	51	15	7	10
12	5	7	12	32	10	7	12	52	15	7	12
13	5	8	6	33	10	8	6	53	15	8	6
14	5	8	8	34	10	8	8	54	15	8	8
15	5	8	10	35	10	8	10	55	15	8	10
16	5	8	12	36	10	8	12	56	15	8	12
17	5	9	6	37	10	9	6	57	15	9	6
18	5	9	8	38	10	9	8	58	15	9	8
19	5	9	10	39	10	9	10	59	15	9	10
20	5	9	12	40	10	9	12	60	15	9	12

Table 1. Continued.

Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec
61	20	5	6	81	22	5	6
62	20	5	8	82	22	5	8
63	20	5	10	83	22	5	10
64	20	5	12	84	22	5	12
65	20	6	6	85	22	6	6
66	20	6	8	86	22	6	8
67	20	6	10	87	22	6	10
68	20	6	12	88	22	6	12
69	20	7	6	89	22	7	6
70	20	7	8	90	22	7	8
71	20	7	10	91	22	7	10
72	20	7	12	92	22	7	12
73	20	8	6	93	22	8	6
74	20	8	8	94	22	8	8
75	20	8	10	95	22	8	10
76	20	8	12	96	22	8	12
77	20	9	6	97	22	9	6
78	20	9	8	98	22	9	8
79	20	9	10	99	22	9	10
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
101	25	5	6	121	26	5	6	141	28	5	6
102	25	5	8	122	26	5	8	142	28	5	8
103	25	5	10	123	26	5	10	143	28	5	10
104	25	5	12	124	26	5	12	144	28	5	12

Table 1. Continued.

Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec
105	25	6	6	125	26	6	6	145	28	6	6
106	25	6	8	126	26	6	8	146	28	6	8
107	25	6	10	127	26	6	10	147	28	6	10
108	25	6	12	128	26	6	12	148	28	6	12
109	25	7	6	129	26	7	6	149	28	7	6
110	25	7	8	130	26	7	8	150	28	7	8
111	25	7	10	131	26	7	10	151	28	7	10
112	25	7	12	132	26	7	12	152	28	7	12
113	25	8	6	133	26	8	6	153	28	8	6
114	25	8	8	134	26	8	8	154	28	8	8
115	25	8	10	135	26	8	10	155	28	8	10
116	25	8	12	136	26	8	12	156	28	8	12
117	25	9	6	137	26	9	6	157	28	9	6
118	25	9	8	138	26	9	8	158	28	9	8
119	25	9	10	139	26	9	10	159	28	9	10
120	25	9	12	140	26	9	12	160	28	9	12

Table 1. Continued.

Sl. No.	KV	mA	Sec	Sl. No.	KV	mA	Sec
161	30	5	6	181	32	5	6
162	30	5	8	182	32	5	8
163	30	5	10	183	32	5	10
164	30	5	12	184	32	5	12
165	30	6	6	185	32	6	6
166	30	6	8	186	32	6	8
167	30	6	10	187	32	6	10
168	30	6	12	188	32	6	12
169	30	7	6	189	32	7	6
170	30	7	8	190	32	7	8
171	30	7	10	191	32	7	10
172	30	7	12	192	32	7	12
173	30	8	6	193	32	8	6
174	30	8	8	194	32	8	8
175	30	8	10	195	32	8	10
176	30	8	12	196	32	8	12
177	30	9	6	197	32	9	6
178	30	9	8	198	32	9	8
179	30	9	10	199	32	9	10
180	30	9	12	200	32	9	12

of 10–25 seconds for cereals and leguminous seed materials [5]. The stone weevil infestation was detected by standardizing a range of X-ray radiography values of about 20–34 KV, 12–30 mA current [6].

Although the technology is known and the suit-

able X-ray machinery available, the input factors viz., the voltage (KV), current (mA) and the exposure period (s) have not been standardized for the groundnut. Literature search did not reveal any tangible work in the name of standardization of the X-ray radiography in terms of quantification of voltage, current and period of exposure in groundnut. Therefore consid-

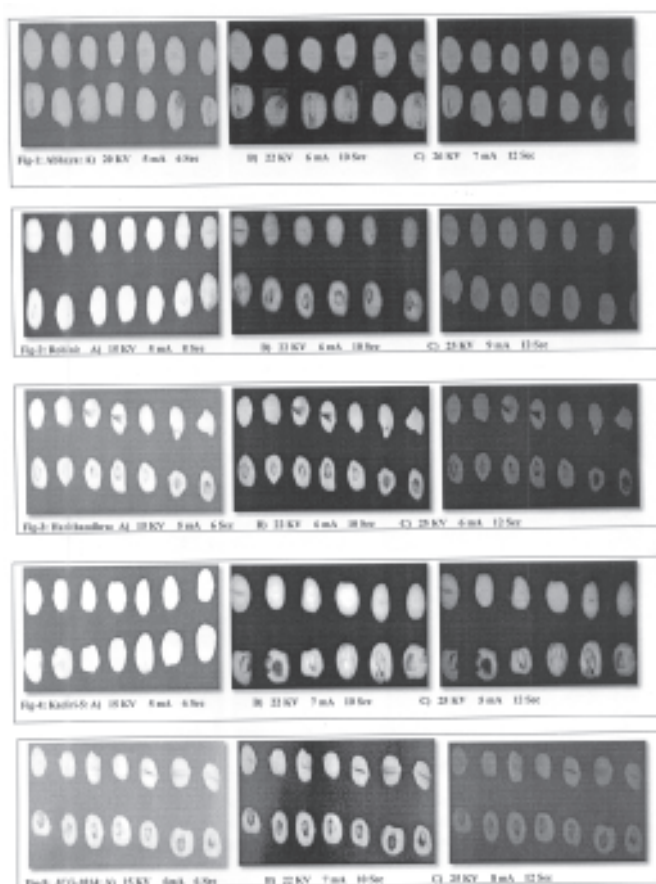


Fig. 1.

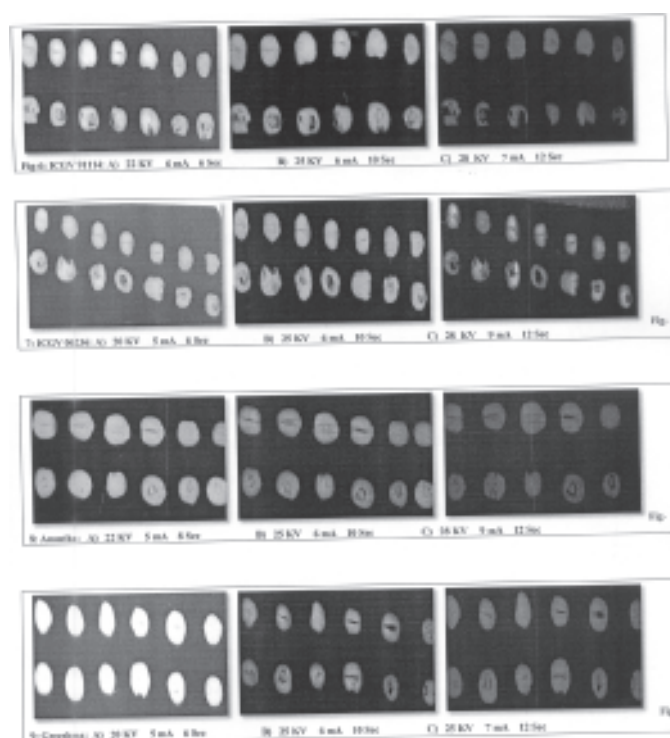
ering the importance and usefulness of this non-destructive method of detecting insect damage levels in the seed, the current studies were undertaken for the present investigation.

Materials and Methods

Experiments were proposed to be undertaken on different groundnut varieties which were collected from different research stations in Andhra Pradesh and necessary steps were taken to maintain both healthy and infested material separately. 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 obtaining 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 seeds were placed over the adhesive tape, which is highly convenient to pick out and separate the seeds with internal (hidden) infestation. The seeds were arranged in such a manner to easily differentiate the infested and healthy seeds, where there were one row of infested seeds and one row with healthy seeds. Steps were taken to select the infested seeds through



X-ray radiography images of Abhaya, Rohini, Harithandhra, Kadiri-5, JCG-1014, ICGV 91114, ICGV 06236, Anantha and Greeshma with three different combinations, where 'a' & 'c' are lighter and darker images respectively. The image 'b' is standardized image with top and bottom row shows the healthy seed material and hidden infested images clearly.

Fig. 1 and **Fig. 2.** X-ray radiography images of Abhaya, Rohini, Harithandhra, Kadiri-5, JCG-1014, ICGV 91114, ICGV 06236, Anantha and Greeshma with three different combinations, where 'a' and 'c' are lighter and darker images respectively. The image 'b' is standardized image with top and bottom row shows the healthy seed material and hidden infested images clearly.

the presence of pin size holes on grain material 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 different groundnut varieties to find out a standard voltage, current and exposure period. The combination of treatments for groundnut was 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 different groundnut varieties (Plate 1-9 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 different groundnut varieties severely infested with bruchid,

Caryedon serratus Olivier. Among these two hundred combinations the exposure of these varieties to X-ray radiation of 22 KV and 6 mA for 10 s was selected as the best combination for Abhaya, Rohini and Harithandhra, 22 KV and 7 mA for 10 s was selected as the best combination for Kadiri-5 and JCG-1014, 25 KV and 6 mA for 10 s was selected as the best combination for ICGV 91114, ICGV 06236, Anantha, Greeshma. The other combinations like 15–22 KV and 5–6 mA for 6–8 s and 25–28 KV and 5–9 mA for 12 s manifested into lighter and darker images respectively for different varieties of groundnut.

These values clearly demonstrated the variations in the requirements of input factors of X-ray radiography are attributed to variation in the shape and thickness of seed material. For medium seeded varieties the voltage, current and exposure periods are usually range between 22 to 25 KV, 6–7 milliamperes and 10 seconds respectively. The literature on different groundnut varieties was scanty and did not show up comparable work done in standardization of X-ray radiography technique for the detection of hidden insect infestation.

References

1. Brabec DL, Pearson TC, Schwartz CR (2012) Detection of lesser grain borer larvae in internally infested kernels of brown rice and wheat using an electrically conductive rolling mill. *Appl Engg in Agric* 19 : 727–733.
2. Melo PRB, De Oliveria JA, Carvalho MLM, De Guimaraes RM, Carvalho B (2009) Application of the X-ray test to study the internal morphology and physiological quality of arnica seeds (*Lychnophora-pinaster* Mart.). *Revista Brasileira De Sementes* 31 : 146–154.
3. Carvalho MLM, De Alves RA, Oliveira LM (2010) Radiographic analysis in castor bean seeds (*Ricinus-communis* L.). *Revista Brasileira De Sementes* 32 : 170–175.
4. Grundas A, Nawrocka S, Grodek J (2010) Losses caused by granary weevil larva in wheat grain using digital analysis of X-ray images. *Int Agrophysics* 24 : 63–68.
5. Ramakrishnan N, Sarath Babu B, Ramesh Babu T (2012) Standardization of X-ray radiography methodology for the detection of hidden infestation in pulses. *Ind J Pl Prot* 40 : 12–18.
6. Maharajan A, Latha S, Sathyanarayana N, Reddy OR (2005) X-ray analysis: A non-destructive detection of stone weevil, *Sternochetusmangiferae* in mango fruits. *Ind J Pl Prot* 33 : 164–166.