Probe trapping technology for monitoring stored-product insects without impurity in stored grain

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Abstract

Based on the principle of separating stored-product insects from probe trap samples, the GJ94 type probe trap was developed for monitoring stored-product insects without impurities in stored grain The new type probe trap is comprised of the GJ89 type probe trap and a separator for stored-product insects and impurities, which is set between upper and lower probe body sections The factors, which influence grain impurities in probe traps in the bulk wheat, maize and paddy, were detected. The results showed that the grain impurities in traps were linearly related to the depth that a probe trap is inserted in the grain mass The effectiveness of the separator for separating five insect species at three population densities was tested in the laboratory. The rate of separation depended upon the insect species and population density. The detection of stored-product insects in wheat, maize and paddy with probe traps was done at 18℃, 20℃, 22℃, 24℃ and 26℃ in the laboratory for 48h. Results showed that the GJ94 type probe trap was very sensitive in detecting many insect species. Field tests of the devices by stratified designs in paddy and maize were reported. GJ96-type impurity detector designed for grain and seed, and its effect of monitoring impurity for grain and seed was also tested.

Introduction

In recent years, the research and application of trapping technology for stored-product insects has developed rapidly The discovery and commercialization of insect sex pheromones of some major stored product insects and the development of various traps contribute to the unprecedented development. Trapping technology for stored product insects has many advantages over the standard sampling procedures, and hence serves as an ideal tool for research purposes, and for control of stored product insects (Barak, and Harein, 1982, Burkholder, 1984, Subramanyam and Harein 1989, White et al , 1990, Yao 1992)

In the early 1950s, Chinese peasants and managers of small granaries used to insert bamboo poles with holes into grain mass for ventilation and pest trapping, This method is quite similar to the use of probe traps. In the last ten years, China also attached great importance to the research on probe trapping technology for monitoring stored product insects. One successful example is the research and development of the GJ89 type probe trap. According to the practical needs of China, we designed this device which can be used both for the stratified monitoring of bulk-stored grain and for bagged stored grain The GJ89 type probe trap is composed of traps and inner case, which has double uses. First, when the inner case inserts into the trap body, the trap may be horizontally inserted into bagged grain through an opening in the mouth of gunny bags to detect stored-grain insects. Secondly, when the inner case is removed, stratified monitoring of insect pests in bulk-stored grain can be done by connecting many traps end-to-end. A GJ89 A type or B probe trap is 50 cm long with 3 mm wall evenly covered with (downward) sloping holes of 2.8 mm diameter. The GJ89 A type trap body is 2.5 cm in diameter and can monitor insects in the grain mass of 3 m deep by stratification

The GJ89 B type trap body has 1.9 cm diameter and can monitor insects in grain mass of 6 m deep The two type traps, made of aluminum alloy, have transfer heads designed specially for probe traps which allow a single trap to be inserted into certain area in grain mass to detect insects. With these devices the scientific research cooperative group organized by Shaanxi Institute of Zoology carried several research projects of the ecology, biology, behavior and control of stored-product insects as well as automatic monitoring of population dynamics of the stored-product insects (Yao et al. 1992, 1992a, 1992b, 1993, 1993a, 1993b, 1995). GJ89 type probe traps are the same as other similar traps in that impurities (broken grain particles, debris and dusts, grass seeds, seed skins, and so on) will occur in its probe trap samples during insertion , while retrieving if from the grain mass or remaining at rest in the grain mass. Subramanyam et al. (1989a) modified the plastic traps so that the holes were sloping upwards. They determined that the traps with upward sloping holes can

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reduce the dockage and broken grain particle accumulation in trap samples, without affecting the sensitivity of insect trapping. The dockage accumulation in trap samples also makes it possible for insects to escape from the insect collection vial, and analysis of the species and number of insects from the samples with impurities influence affects counting (White et al 1990)

In the research of sensor-based probe traps for monitoring stored-product insects, Yao (1990) started with the idea of eliminating research of impurities, he developed the separator of insects and impurities successfully, and applied it to the development of new type probe trap The GJ94 type probe traps for monitoring stored-product insects without impurity consists of the GJ89 type probe trap and the FⅡ type separator of insect and impurities. This device can achieve the purpose of detecting insects without impurity in grain mass. As this device can separate the impurities and insects in trap samples in the course of insect detection, from the point of improving the qualities of stored grain and seed commodity, we inquired into the possibility of detecting the impurities in grain mass with the probe trap and designed ZJ96 type impurity detector which is specially suited to the detection of impurities in grain and seeds.

The main purposes of this research were as follows: (a) To investigate the effectiveness of the GJ89 type probe traps for impurity and insect monitoring and compares it with the standard grain trier. (b) To explain reasons for the presence of impurities in the samples of probe traps. (c) To test the effect of the FII type separator of insects and impurities on separating insects from the trap samples under the laboratory conditions. (d) To design the GJ94 type probe trap for monitoring stored-product insects without impurity according to the above mentioned principle of separating impurities from the probe trap samples and test the device at different temperatures in the laboratory. (e) To design the ZJ96 type impurity detector for grain and seeds on the basis of the research on the impurity monitoring technology, test the effect of the device on the impurity detecting for grain and seeds, and analyze the feasibility of this method. This paper reported these research results.

Materials and Methods

Test on the impurity and insect detection with the GJ89 type probe traps as a function of trapping duration

The experimental grains types, which were wheat, maize, paddy and barley were containerized in cement pools of one cubic meter respectively. We used 40 GJ89 type probe traps for monitoring stored product insects. The traps were manufactured by Shaanxi Institute of Zoology and Shaanxi Service Department of Optical Instrument For every grain type we set five sampling points at equal intervals, and of each point monitored two depths (surface − 50 cm and 50 − 100 cm). The trapping duration for each grain type was 1, 2, 3, 4, 5,6,7, 8, 9, 10, 11, 12 and 24 hours. For each probe trap sample, we measured the quantity of impurity and the number of each insect species We also took 0.5 kg samples with a grain trier at the probe trap sites to analyze the impurities and the number of insects, to compare these two monitoring methods. This experiment was carried out at a seed farm in Zhouzhi County in 1993. Determine impurities by probe trap sampling We designed a special experimental cylinder to monitor impurities in the grain. The box was cylinder of 40 cm diameter, and 50 cm height. In the center at the bottom was a round hole of 2.5 cm diameter. Such cylinders were used for holding wheat, maize and paddy. The GJ89 type probe traps were used for testing. Each time a probe trap was inserted into the grain mass through the hole at the bottom of the box, the depth of its friction against the grains is 50 cm. The weight of impurities produced when inserting the probe traps 50, 100, 150, 200, 250, 300 and 350 cm downward was counted respectively. With x standing for the distance of insertion into each grain type and y standing for the impurity quantity of each trap sample, we made the simple linear regression analysis and clarified the mutual relationship between the depth of insertion into the grain mass with probe traps and the forming of impurities in the probe trap samples. Maize was taken for experimental grain. When the probe traps were inserted into grain mass, their lower body of probe trap were made to stretch out of the holes at the bottom of the boxes. Then the traps were placed statically in grain mass and samples were taken out of the bases of the traps per 24 hours The detection lasted for 12 days We counted the number of insect species catches of each probe trap sample, made the multivariate linear regression analysis on the relationship between impurity quantity of samples (y) and insect larvae (x_1), maize weevil (x_2), saw-toothed grain beetle (x_3), red flour beetle (x_4) and lesser grain borer (x_5), and analyzed relationship between the impurities and number of each insects species. This test was carried out in Shaanxi Institute of Zoology in 1995.

Separating stored product insects and impurities with the FII type separator

In order to minimize the impurities in probe trap samples, we designed a separator to separate stored-product insects and impurities. This device is 14 mm in diameter with 2 mm walls evenly covered with 2 mm holes. The insects and impurities in probe traps fell through entered the separator. Impurities remained in the separators while insects got out of the separators and dropped into insect collection vessel The FⅡ type separator can be used with the GJ94 type probe trap for monitoring stored-product insects without impurities. There were 75 experimental FⅡ separators, and the maize weevil, *Sitophilus zeamais* red flour beetle *Tribolium castaneum*, saw-toothed grain beetle *Oryzaephilus surinamensis*, lesser grain borer *Rhyzopertha dominica* and rusty grain beetle *Cryptolestes ferrugineus* were used as experimental insect species The densities of each species used were 1, 5 and 10 adults, and were put into separator, respectively The separation was repeated 5 times. The experiment was performed at the room temperature of 32℃ in Shaanxi Institute of Zoology in August, 1994. Species at each density were put into separators at the same time. The insect population of each treatment was recorded once every five minutes The process lasted 120 minutes The percentage of separation for each treatment was counted. Duncan's multiple range tests was used for mean separation

Monitoring insects free of impurity with the GJ94 type probe traps at different temperatures in the laboratory

Twelve experimental detectors, the GJ94 type probe traps without impurity. Each trap consisted of the GJ89 type probe trap for monitoring stored-product insects and FII type separator of insects and impurities. The experimental grain types were wheat, maize and paddy. All of them were infested with insects. The percentage of impurities contained in each kilogram grain was 11.8%, 11.5% and 0.5% respectively. Each type of grain was contained in a special test box, whose volume was 10000 ml and at the bottom of that was a hole of 2.5 cm diameter that allowed probe traps to stretch out In investigation, rather than take out the traps, samples can be obtained directly to analyze the quantity of impurities and insect species captured Since April, 1997, at the room temperature of 18℃, 20℃, 22℃, 24℃, and 26℃, samples were monitored once every 48 hours. Impurities in separators and insect collection vessels were detected. Catches of saw-toothed grain beetle and lesser grain borer were measured

Effect of stratified monitoring with the GJ94 probe trap for monitoring stored product insects without impurity during different trapping duration

The experimental grain types were maize and paddy Both were grains infested by insects and stored in 1992 The experimental box was 40cm in diameter and 100 cm in height Each type of grain was contained in eight experimental boxes. Thirty-two GJ 94 type probe traps for monitoring stored product insects without impurity were used to detect two depths vertically in each experimental box. The distance between grain depths was the grain surface − 50 cm and 50 − 100 cm. The trapping duration of each grain type was 24, 48, 72 and 96 hours respectively For each grain type, detection was carried out in the eight experimental boxes during each trapping duration. The experiment was repeated once Each experiment was carried out in batches The average impurity quantity separated by separators and that in insect collection vessels of each monitoring treatment was calculated by stratum. The impurity among depths was quantified. A paired t-test was used to determine differences between upper and lowers. The total of insect catches and the effect of separating insects with the FⅡ type separator of insects and impurities during each trapping duration were counted.

Monitoring impurities in grain and seed with the GJ96 type impurity detector

The experimental equipment was: the GJ96 type impurity detector for grain and seeds, which was manufactured by Shaanxi Institute of Zoology and Shaanxi Service Department of Optical Instrument The device consists of A and B type detector. The A type detector is similar to the GJ89 and GJ94 type probe trap in being covered with 2.8 mm or 4 mm downward sloping holes. However, the sloping holes are located on the lower part of the detector. So it can be applied to monitor impurity of grain and seeds of medium particle size such as wheat, paddy, barley, sorghum. The B type detector is the same as the type in design except for its 4-mm holes. The experimental variety of wheat seed was Mianyang 26; the rice seed was Xianyou 63; the maize seed was Zhongdan2 Ten gunny-bags of each crop variety were detected respectively. The interval of vertical detection was 60 cm. The average impurity quantity monitored and impurity volume (ml) were calculated. Meanwhile, grain trier was used to sample 0.1 kg From each bag of grain respectively to analyze impurity quantity with a grain sieve and compare the percentage of seed purity of the two monitoring methods The experimental grain types were maize and paddy. Each type of grain was contained in six experimental boxes for impurity monitoring with a diameter of 40 cm and a height of 100 cm. For each box, we used the ZJ96 type impurity detector to monitor 70 cm vertically at three spots and calculated the average impurity quantity and volume monitored. In the meantime, the grain trier was adopted to draw samples of the grain type in each experimental box at the interval of 10 cm from the grain surface to the depth of 70 cm. We mixed the seven grain samples, separated impurities with grain sieves and calculated the impurity quantity of grain mass, the percentage of impurity quantity and impurity volume to obtain absolute content of impurities in the detecting area of grain mass. The experiment on impurity monitoring of wheat mass was carried out in experimental storehouse. There were five detecting spots and the monitoring design was the same as that of the above-mentioned grain type. Linear regression analysis was made for the results obtained by the two monitoring methods.

Results

Results of the detection of impurities and insects during different trapping duration with the GJ89 type probe trap Impurities existed commonly in the monitoring of samples of 1 – 24 h various treatments of the four-grain types. The impurity quantity had a tendency to increase with an increase in trapping duration. Comparison of the two monitoring methods showed that the impurities in probe trap samples were lower. In 24h, the average impurity quantity in samples of wheat, barley, paddy and maize contained in a single probe trap was 0.3, 0.6, 0.6 and 0.4g, respectively, which was about 1/9 of the impurity quantity of 0.5 kg samples taken with a grain trier; Also the number of species captured and quantity of species were higher than that of 0.5 kg samples taken in the same way (Table 1) 10 GJ89 type probe traps for monitoring stored product insects were used for each grain type and trapping duration were 24 hours.

Table 1. The detection of impurities, species and insect catches in four grain types during different trapping time with the GJ89 Type probe for monitoring product insects stored.

Trapping Duration h	wheat			barley			paddy			maize		
	dusts mg	No species	Trap catches	dusts mg	No. species	Trap catches	dusts mg	No. species	Trap catches	dusts mg	No. species	Trap catches
1	2.1	7	169	1.6	8	208	2.5	7	67	0.3	6	31
2	2.2	6	164	1.8	8	298	2.7	10	97	0.4	7	70
3	2.3	5	250	2.6	10	644	2.7	8	201	0.3	6	48
4	2.5	8	240	2.4	8	386	2.8	9	154	0.6	6	69
5	2.4	8	286	3.0	8	683	2.9	10	192	0.7	9	52
6	2.3	9	271	2 1	8	619	3.1	7	211	0.5	5	55
7	2.2	7	363	3.1	10	658	3.5	8	175	0.9	7	91
8	2.2	8	449	2.0	9	1268	3.5	8	385	1.1	7	154
9	2.7	9	346	2.7	9	836	3.8	7	276	1.5	7	134
10	2.2	9	393	2.6	9	881	3.7	8	334	1.6	7	139
11	2.7	7	451	2.7	9	583	3.8	6	236	1.8	7	125
12	2.8	10	543	3.0	9	1102	4.0	9	375	2.1	7	167
24	3.0	11	436	5.5	9	986	6.3	10	824	3.6	10	320
CK (500g)	26.9	9	318	51.5	9	835	54.3	7	328	31.2	8	152

Analysis on the factors, which affect formation of impurities in probe trap, samples

With x representing the distance of insertion into the grain mass and y the weight of impurity in probe traps, we made the linear regression analysis. The analysis results for wheat mass was $y = 271.2x - 96$, $r = 0.8911$, $F = 19.27 > F_{0\ 01} = 16.26$. This indicated that the relationship was very significant ($P < 0.01$). The analysis result for maize was $y = 89x + 63.9$, $r = 0.926$, $F = 18.096 > F_{0\ 01} = 16.26$, This showed that the relationship was very significant ($p < 0.01$). The analysis result for paddy mass was $y = 187.29x - 40.71$, $r = 0.9305$, $F = 19.32 > F_{0\ 01} = 16.26$. This also showed that the relationship was very significant, ($p < 0.01$) Results of the three tests indicated that there was a close relationship between the impurities of samples of the probe trap and the distance of inserting traps in grain mass, and it was significantly correlated to the distance of insertion (Fig. 1).

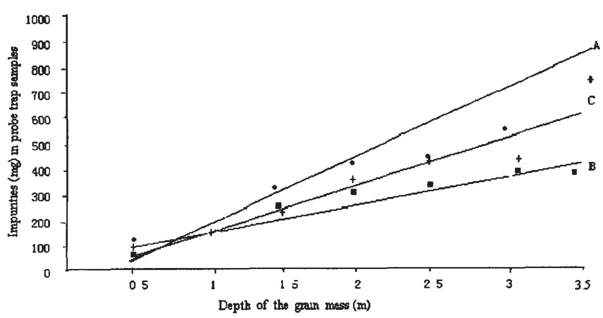

Fig. 1. Regression of the impurity quantity (y) of probe trap samples against the distance (x) inserting probe trap into the wheat (A), maize (B) and paddy (C) A: $y = 271.2x - 96$, $r = 0.8911$; B: $y = 89x + 63.94$, $r = 0.926$; C: $y = 187.29x - 40.71$, $r = 0.9305$

Multivariate linear regression analysis was made on the relationship between the monitoring sample (y) and various larvae captured in maize mass (x_1), maize weevil (x_2), saw-toothed grain beetle (x_3), red flour beetle (x_4), and lesser grain borer (x_5) The regression equation was $y = -0.5501 - 0.087\ x_1 + 0.267\ x_2 - 1.27x_3 - 0.082x_4 + 12.37x_5$, $r = 0.9682 > r_{0\ 01} = 0.882$. This showed the relationship was significant. F test was made to the regression equation $F = 11.98 > F_{0\ 05} = 6.26$. This indicated that the regression analysis was significant ($p < 0.05$). The research showed that if the probe trap for monitoring stored product insects was placed in grain mass for a long time, the formation of impurities in trap samples would be closely related to the number of insect species captured. Perhaps, dusts were carried into the probe traps by insects. At three population densities with the F II type separator for stored-product insects and impurities, effect of separating five species of stored product insects indicated that at the room temperature of 32℃, the separation of insects with the separator was different for difference of insect species and population densities. Under the condition of single insect, the five experimental species could be separated in 5 – 35 minutes. When insects were in group, the separation effect was affected, and had a tendency to decrease with the increase in density. The 10-minute test at 5 adults showed that the variation between maize weevil and the other insects was highly significant, the 20 and 30 minute tests showed that the separation percentage of the four insect species of maize weevil, red flour beetle, lesser grain borer and rusty grain beetle were not significant. This showed that there was not much difference between the activities of the four stored product insects in group. However, the performance of saw-toothed grain beetle's activity decreased obviously. At the density of 10 adults, although the separation percentage of each species was different, it was not significant

Application of the GJ94 type probe trap for monitoring stored product insects without impurity at different temperature of 18, 20, 22, 24 and 26℃

The GJ94 type probe trap for monitoring stored product insects without impurity was adopted to detect wheat, maize and paddy during 48h The results showed that a certain amount of impurities remained in the separator for insects and impurities, while no impurities remained in the collection bottle This indicated that the effect of separating impurities was ideal In each treatment, the separation effect of saw-toothed grain beetle with the separator for insects and impurities was 100%, and that of lesser grain borer was 60 – 100% (Table 2).

Table 2. The effect of monitoring stored product insects without impurity at different temperatures in the laboratory.

℃	grain type	Dusts in SII (mg)	OS		RD	
			Trap catches	Sep(%)	Trap catches	Sep(%)
	wheat	13.5	9	100	36	94.4
18	maize	25.5	9	100	37	81.1
	paddy	1.3	5	100	23	100
	wheat	32.5	4	100	29	89.7
20	maize	2	12	100	20	80
	paddy	5.5	4	100	5	60
	wheat	11	6	100	43	100
22	maize	26	8	100	32	84.3
	paddy	12	4	100	25	95.7
	wheat	34.5	4	100	96	100
24	maize	34	6	100	72	91.7
	paddy	2.5	5	100	27	92.6
	wheat	54	3	100	77	93.5
26	maize	52	7	100	79	75.9
	paddy	5.5	14	100	15	80

For each grain type, 4 probe traps for monitoring stored product insects without impurity were used to detect 48 h
SII: separator of insects and impurities; OS: *O surinamensis*; RD: *R dominica*

Effect of stratified monitoring in grain mass with the GJ94 type probe trap for monitoring stored-product insects without impurity at different trapping duration

The effect of separating impurities in maize and paddy at each trapping duration of 24, 48, 72 and 96 hours all reached 100%. The impurity quantities monitored in the interval of 50 – 100 cm were higher than that in the interval of the grain surface – 50 cm. The variation could be significant or very significant (Table 3). The effect of monitoring the five species of stored product insects showed that there existed certain differences between the effects of separating insects with the separator for insects and impurities. The separation effect of lesser grain borer was 64.7 – 100 %, saw-toothed grain beetle 77.3 – 100 %, red flour beetle 50 – 100%, long-headed flour beetle 95.1 – 100%, and the total of insects captured 79.4 – 99.4%.

Table 3. Test on the effect of separating impurities with the separator for insects and impurities in stratified monitoring During different trapping time in experimental laboratory.

Grain type	Trapping duration (h)	Depth in grain (cm)	Dusts collec. Vial (mg)	Mean ± SE of SII (mg)	t	p
	24	s – 50	0	66.9 ± 8.8	2.206	<0.05
		50 – 100	0	208.4 ± 37.2		
	48	s – 50	0	16.6 ± 5.9	3.476	<0.01
		50 – 100	0	155.8 ± 38.4		
paddy	72	s – 50	0	81.6 ± 28.1	2.586	<0.05
		50 – 100	0	193.9 ± 30.9		
	96	s – 50	0	31.2 ± 7.1	4.062	<0.01
		50 – 100	0	222 ± 44.9		
	24	s – 50	0	19.1 ± 4.1	5.594	<0.01
		50 – 100	0	265.8 ± 42.4		
	48	s – 50	0	13 ± 8.9	4.582	<0.01
		50 – 100	0	216.1 ± 42		
	72	s – 50	0	25.2 ± 9.3	3.7257	<0.01
		50 – 100	0	170.9 ± 36.8		
	96	s – 50	0	7.3 ± 4.2	5.5588	<0.01
		50 – 100	0	152.3 ± 24.9		

Average impurity quantity of sixteen GJ94 type probe traps for monitoring without impurity
SII: Separator of insects and impurities $n = 14$ $p = 0\ 05$ $t = 2.145$; $p = 0.01$, $t = 2.977$

Table 4. Effect of impurity detection of seeds by the ZJ96 type impurity detector and grain trier.

Species and Variety of crop	Methods	Impurity		t	P	Net rate(%)
		Volume (ml)	Mean ± Se(mg)			
Wheat:	ZJ 96 A type	0.1	27.4 ± 8.5	0.0630	> 0.05	99.9
Mianyang 26	100 g sample	0.1	28.7 ± 17.5			
Maize:	ZJ 96 A type	0.1	25 ± 6	0.2901	> 0.05	99.9
Zhongdan 2	100 g sample	0.1	21 ± 8.5			
Rice:	ZJ 96 A type	0.1	65.1 ± 12.8	3.8502	< 0.01	99.9
Xiangyou 63	100 g sample	0.1	14.7 ± 2.5			

Experiment on the effect of impurity monitoring for grain and seed with the ZJ96 type impurity detector for grain and seeds

The table 4 indicated that the effect of monitoring impurities in wheat and paddy seeds by the two methods were basically the same, and the distinction did not reach significant level ($p > 0.05$). However, the impurity monitoring of paddy seed was different. The impurity quantity detected with the ZJ96 type impurity detector for grain and seeds was obviously higher than that by sampling on the grain surface, and the variation was very significant ($p<0.01$) Each detection of impurities in grain and seeds with the ZJ96 type impurity detector took about 8 – 10 seconds, while that by the grain trier took about 1 minutes. So the latter was 4 – 5 times slower than the former. With x representing the average impurity quantity monitored in each grain type with the ZJ96 type impurity detector and y the impurity content separated with a grain sieve in samples of 100g grain taken with a grain trier from each experimental box of grain type, linear regression analysis was made on the results for two detecting methods. The result for wheat was: $y=0.0007x+0.28$, $r=0.9496$, $F=36.73>F_{0.01}=21.2$ ($p<0.01$). The result for paddy was: $y=0.002x-0.05$, $r=0.9071$, $F=18.5733>F_{0.05}=7.71$ ($p<0.05$). The result for maize was $y=0.002x+4.82$, $r=0.9819$, $F=107.13>F_{0.01}=21.2$ ($p<0.01$). Results of the three tests indicated that there was a close relationship between the two methods (Fig. 2).

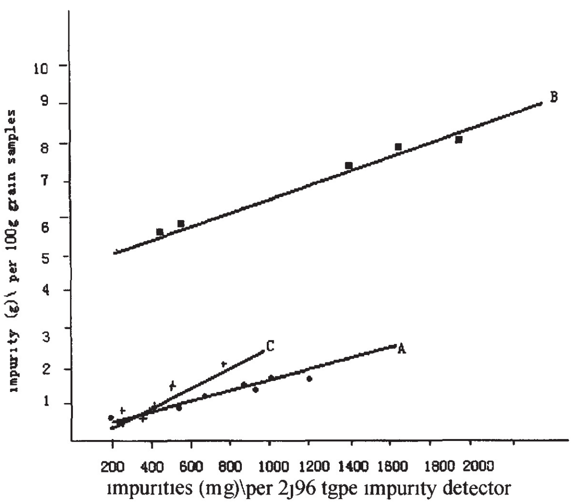

Fig.2. Regression of impurity content of grain (y) against the impurities detected with ZJ 96 type detector (x)
A: Wheat, $y = 0.0007x + 0.29$, $r = 0.8894$; B: Malze $y=0.002x+4.92$, $r=0.9641$; C: Paddy $y=0.002x-0.05$, $r=0.8228$

Discussion

The impurity in 0.5 kg samples taken with a grain trier was nine times as much as that found in sample with a probe trap during 24h, and more than ten times as much as the capture of probe trap during 1 – 12h, and the insect species and number of species captured were obviously smaller than the capture of probe trap during 12 – 24h and similar to the capture of probe traps during 6 – 11h. The results indicated that the probe trap had an ideal tool for trapping insects. Although the method of sampling 0.5 kg or 1 kg with a grain trier was one of absolute sampling, but there were many errors in the sampling for many times And there were artificial errors for counting number of insects or species from the large amount of impurities with a grain sieve The multi-errors affected the work efficiency and effect of detection with a grain trier. Low impurity quantity in samples of the probe trap for monitoring stored product insects was an advantage of probe trapping technology. But it would still take some time for counting insect species and quantities from probe trapping samples with impurities. In our research of various sensor-based probe traps, impurity was also a key factor, which influenced the sensitivity.

When the probe traps were inserted into grain mass, impurities in grain mass dropped into the traps because of the mechanical friction of the wall and grain. The correlatively between impurity of samples and insertion depth of the trap was very significant. The stationary placement of the probe trap in grain mass for a long time could also produce impurities. The impurity was mainly dusts carried by insects The result showed that there was always a problem of impurity either in the course of inserting the probe trap into the grain mass or in stationary placement of it in grain mass for a long time.

By putting a certain amount of experimental insects into the F2 type separator for separating insects and impurities, the experimental

Insects at the density of one adult could be separated from the separator in about 30 minutes. While in-group activity, because of the mutual influence between insects, the separating speed had a tendency to decrease with the increase of density. The separating speed differed according to insect species. It was faster for insects with a larger type of such as maize weevil and red flour beetle, and slower for saw-toothed grain beetle, and lesser grain borer. The separating speed of insects could be improved by the design of separators.

The separator for insects and impurities had many uses. It could be combined with the GJ89 probe trap for monitoring stored product insects to separate insects from impurities in probe trap samples The probe trap for monitoring stored product insects without impurities could be combined with various special sensors to develop various sensor-based probe traps. This device could also be applied to the tests about insect behaviors and habits and some other researches.

The effect for separating insects from impurities in samples of the GJ94 type probe was ideal. But there was the different impurity quantity of sample in each layer. This was related to insertion distance of the trap. As the process of trapping insects with the probe trap was in a discrete state, it was possible that a small number of insects had still remained in the separator So, insects remained in the separator should also be investigated.

The result showed that the GJ94 type probe trap had the function of separating insects and impurities in trapping samples According to this principle, we designed the ZJ96 type impurity detector for grain and seeds. The device could detect impurities smaller than grain and seeds rapidly. Under the condition of low impurity quantity, the impurity quantity detected when inserting 60 cm was about similar to the absolute content of impurities in grain and seeds; under the condition of high impurity quantity, though the impurity quantity was lower than the absolute content of impurities in grain and seeds, it had a clear correlation with the practical content. The research of the basic design of the ZJ96 type impurity detector for grain seeds and the GJ94 type probe trap for monitoring stored product insects was similar. Therefore, the impurity quantity in the impurity separator of the GJ94 type probe trap for monitoring stored product insects could reflect separator the impurity content in certain areas of the grain mass. Impurity not only affects the commercial quality of grain and seeds, also is an important factor of the occurrence and harm of some insects. In the storage and preservation of grain and seeds, importance should be attached to impurity monitoring and control.

Acknowledgement

This research was supported by funds from National Natural Science Foundation of China.

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