AN EFFICIENT AND ECONOMIC WAY OF KILLING PINK BOLLWORMS IN COMMERCIAL COTTON

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Introduction

Because several countries have forbidden the importation of the pink bollworm, Pectinophora gossypiella (Saunders) (Lepidoptera, Gelechiidae), it is essential that exported cotton bales are free from infestation. We have studied the technical details of the machinery used at each stage of processing raw cotton. The effect of the processing and storing of cotton on the pink bollworms was discovered, and an efficient and economic method of killing pink bollworms in commercial cotton was developed.

Materials and Methods

Several standard saw-cylinder ginning mills, found to be free of pink bollworm and in good working order, were tested. The machines were "washed" by passing 200 kg of unginned cotton that is free of pink bollworm through them. The tests were then carried out by passing unginned and raw cotton, artificially infested with pink bollworm, through the machines.

A flow diagram can explain cotton processing (fig. 1); arrows represent the direction of flow of processing, numbers represent the name of each stage in process. The area enclosed at the top represents the vulnerable initial storage stage; the area enclosed at the lower left represents the relatively safe baling and bale-stacking stage. Three machines were tested: multiroller machines for removing impurities; saw-cylinder machines with brush rollers for ginning; and machines for baling.

Results and Discussion

The impurity-removing machine (fig. 2) consists of 5 rollers, each with 12 rows of staggered spikes, to remove impurities which then drop through a net. The rollers rotate at 400-500 rpm, giving a line speed of 10.5 ms. The larvae are killed or wounded by cotton seed and impurities moving at this speed. A few living larvae also drop through the impurity net. By passing infested cotton through the machine 95.4% of the larvae were killed (table 1).

The ginning machine (fig. 3) consists of 3 parts: the first part, for feeding and cleaning, has a 610 mm spiked roller that rotates at 280-300 rpm to give a line speed of 9.6 ms; the second part, for ginning, has a high speed rotary saw-cylinder with teeth (fig. 5) that hook fibers from the cotton seed and send them to the rear box; the third part, for collecting the cotton, consists of a box. If larvae are to enter the rear box, they must avoid the sharp teeth of the saw and pass through one of three narrow gaps (fig. 4):

G1, the 0.9-1.05 mm gap between the saw and ginning grid;
G2, the 2.8-3.0 mm gap in the ginning grid above the working point, where the fibers are hooked and pass into the rear box;
G3, the 4.5 mm gap above the working point of the ginning grid.

Because the pink bollworm larvae are 13-15 mm long and 2.5-3.0 mm diameter, they are unlikely to survive the narrow gaps, but, if they do pass into the rear box, they are then killed by a 480 mm brush-roller that rotates at 1400-1600 rpm.

The efficiency of the whole machine is more than 99% (table 2). As can be seen, the initial cleaning was responsible for removing over 95% of the larvae. To test the efficiency of the ginning apparatus itself, infested cotton was passed through alone. Of 400 larvae introduced only 1 live larva was found in ginned cotton, a first instar which could not have survived the winter. Overall, the killing efficiencly of the ginning machine was found to be at least 99.76% (table 3).

Finally, the baling press develops a pressure of up to 90 tons, giving a bale density of 300-400 kg/m^3, enough to kill any remaining larvae. The killing efficiency of the baling process is 99.79% (table 4). There are a few survivors because the cotton does not compress uniformly and may have gaps large enough for a pink bollworm larva.

To test the efficiency of the whole process, 40 duplicate tests were made in 5 plants. Of more than 120,000 introduced individuals, none survived (table 5).

The Hupei Tianmen County Ginning Plant uses a smaller ginning machine without a cleaning device and with a non-standard saw-cylinder. The overall efficiency of this plant is well over 99% (table 6). However, this is not good enough; therefore, cotton produced by this plant should not be exported.

Environmental Factors

Only part of China is infested with the pink bollworm. In ginning mills the stacks of unginned cotton and the cleaning workshops are particularly susceptible. The baling workshops and the stacks of bales are relatively safe. In high-risk areas of the plants sparrows are common and feed on pink bollworms as they climb in search of hiding places to overwinter. Because pink bollworms are less active during winter and because the productive season for cotton is October to February, the dangerous area and the relatively safe area of the plant can remain fairly stable. The baling workshop and stacks of bales should be as far removed from susceptible parts of the plant as possible to reduce the risk of infestation.

To prevent the accidental introduction of pink bollworm, bales must not be covered with a cover previously used on unginned cotton and bales must not be loaded on anything previously used for unginned cotton.

Storage

It is much better to store bales in a separate storage depot than at the ginning plant. Insect-free bales transferred to such a depot can be assumed to remain free of pink bollworm and can then be passed for export. Bales kept at the ginning plant cannot be passed until effectively treated.

Table 1. Effect of Killing and Removing Pink Bollworms in Process of Removing Unginned Cotton Impurities.

	Tests		
	I	II	Average
1. Unginned cotton, kg.	175	175	175
2. Larvae introduced into unginned cotton	452	541	
3. Larvae sifted out by machine for removing petrified unginned cotton Percent removed	356 78.76	409 75.60	77.18
4. Larvae sifted out by machine with 8 rollers for removing impurities Percent removed	77 17.04	105 19.41	18.23
5. Percent removed in No. 3 + 4	95.80	95.01	95.41
6. Proportion of dead to living larvae	1:4.77	1:7.71	

Table 2. Efficiency of Killing and Sifting out Pink Bollworms by Saw-Cylinder Ginning Machine

	Tests			
	I	II	III	Average
1. Unginned cotton, kg	200	175	175	
2. Larvae introduced into unginned cotton	472	421	545	
3. Larvae sifted out by top cleaning part Percent removed	459 97.25	408 96.91	507 93.03	95.73
4. Larvae sifted out by bottom part for removing impurities Percent removed	13 2.75	12 2.85	38 6.97	4.19
5. Larvae remaining in unginned cotton	0	1	0	
6. Larvae remaining in cottonseed	0	0	0	
7. Percent removed in No. 3 + 4	100.00	99.76	100.00	99.92
8. Dead to living larvae in No. 3 Ratio	14:445	63:345	33:474	36.67:421.33 1.0:11.5
9. Dead to living larvae in No. 4 Ratio	9:4	10:2	34:4	17.67:3.33 5.3:1.0
10. Percent of larvae killed by top cleaning part	2.97	14.96	6.24	8.06
11. Percent of larvae killed by bottom impurity-removing part	1.91	2.38	6.24	3.51
12. Percent in No. 10 + 11	4.88	17.34	12.29	11.50
13. Total efficiency of whole ginning process, in percent	100.00	99.76	100.00	99.92

Table 3. Results of Killing and Sifting Pink Bollworms by Ginning Machine alone, without Top Cleaning Part

	number	dead to alive	efficiency
1. Larvae introduced in unginned cotton	400		
2. Larvae sifted out by bottom impurity-removing part	220	215:5 =43:1	
3. Remaining in work box	178		
4. Remaining in ginned cotton	2	1:1	
5. Percent of larvae killed and sifted out by ginnning machine alone (398 of 400)			99.50
6. Percent of larvae killed by saw-cylinder machine (215+1)/(220+2)			97.30
7. Percent of total efficiency (399/400)			99.75

Table 4. Death Resulting from Baling Press

	Huining Mill	Nanshiman Mill	Total
1. Number of tests	7	23	30
2. Density of bale (Kg/m^3)	292-322.5	309-379	
3. Larvae introduced into each bale	500 or 300	300 or 100	
4. Number of times bale was press to kill 100% of larvae	5	17	22
5. Number of times bale was pressed to kill 99.6% of larvae	2	0	2
6. Number of times bale was pressed to kill 99.0% of larvae	0	5	5
7. Number of times bale was pressed to kill 98.0% of larvae	0	1	1
8. Number of times bale was pressed to kill less than 100% of larvae	2	6	8
9. Larvae introduced			5,300
10. Larvae surviving	2	9	11
11. Percent efficiency			99.79

Table 5. Results of Total Process
(Cleaning, Ginning, and Baling Workshops)

	County					
	Shen	Hengshui	Zaoqiang	Gucheng	Haimen	Total
1. Tests	12	7	11	7	3	40
2. Density of bale Kg/m^3	342.5	299	308	254	300+	
3. Larvae introduced	24,000	16,436	26,719	9,800	45,000	121,955
4. Larvae surviving	0	0	0	0	0	0
5. Efficiencey, percent	100	100	100	100	100	100

Table 6. Efficiency of non-standard total process
(Ginning and Baling Workshops)

	Bale weight (Kg.)	Bale density (Kg/m^3)	Number of larvae introduced in a bale	Larvae found alive	Efficiency	Inspection time (hours)
Tests						
I	72	300	4,666	6	99.87	5
II	73.5	306	4,666	12	99.74	5
III	82.5	344	4,666	2	99.96	5

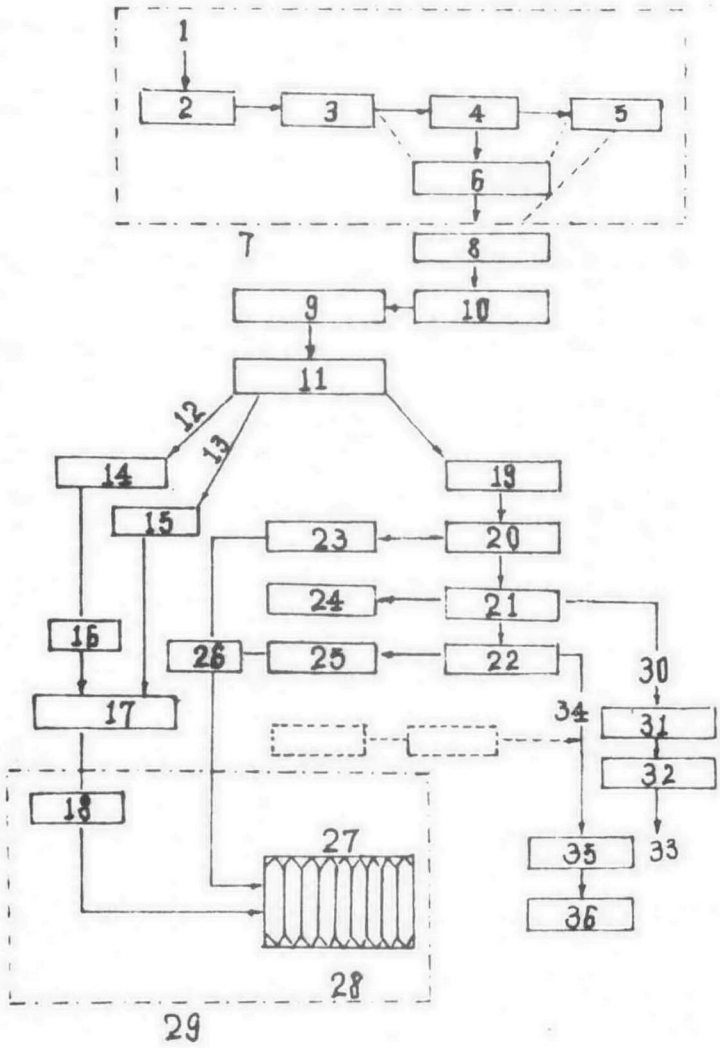

Figure 1. Technological process of ginning by saw-cylinder machine. (30-36 not used in production of normal cotton bales)
1. Unginned cotton. 2. Weighing scales. 3. Delivery duct for unginned cotton. 4. Storage. 5. Dryer. 6. Unginned cotton stack in field. 7. High-risk area. 8. Unginned cotton air-flow separator. 9. Distributor. 10. Multiroller impurity-removing machine. 11. Saw-cylinder with brush roller. 12. Ginned cotton. 13. Sterile seed and falling fibers. 14. Raw cotton delivery duct. 15. Sterile seed cleaner. 16. Raw cotton collection box. 17. Condenser. 18. Baling press. 27. Bale. 28. Ready for storage. 29. Relatively safe area.

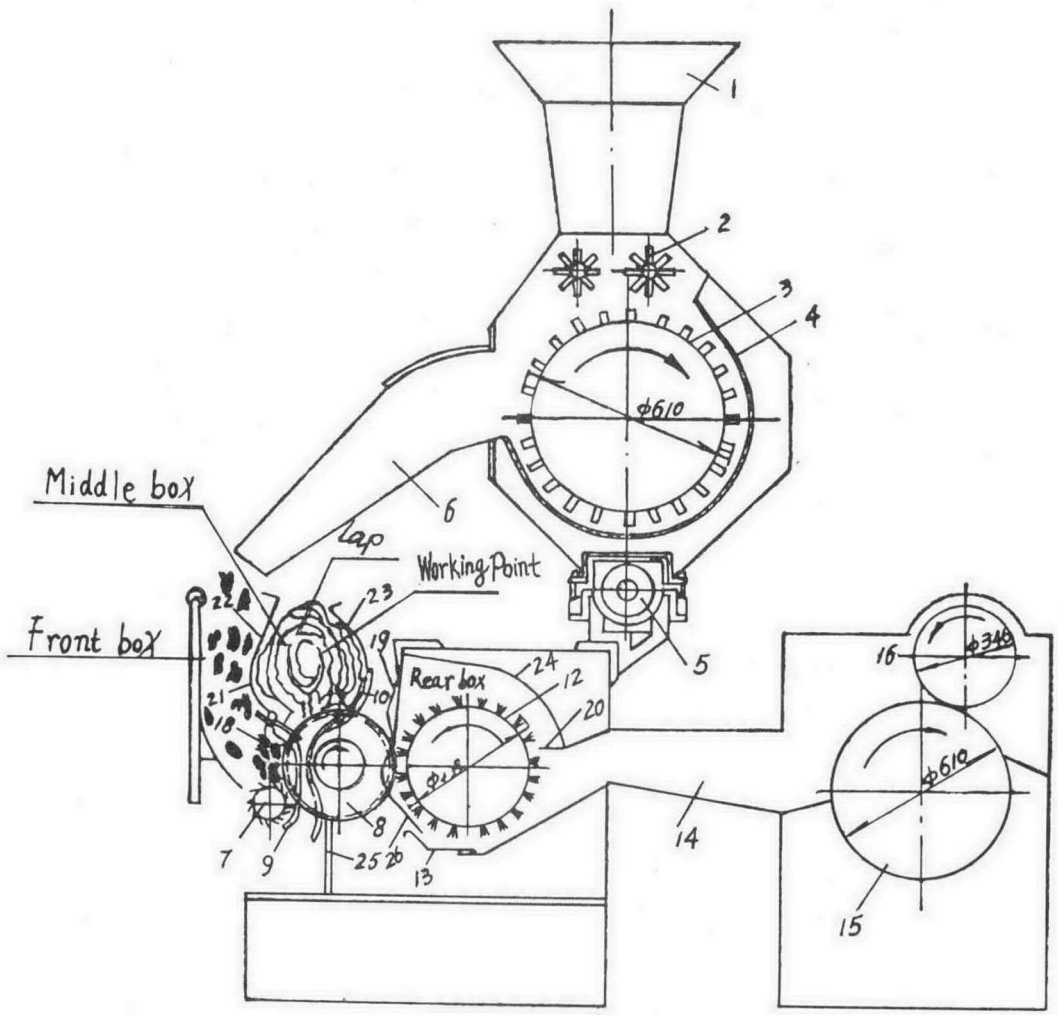

Figure 3. Saw-cylinder with brush roller.
1. Hopper. 2. Feeding roller. 3. Roller. 4. Impurity-removing net. 5. Impurity-removing screw. 6. Cotton flow plate. 7. Even roller. 8. Saw-cylinder. 9. Shell prevention grid. 10. Ginning grid. 11. Cottonseed card. 12. Brush-roller. 13. Adjustment plate for removing impurities. 14. Delivery tube. 15. Dust cage. 16. Consolidating roller. 17. Ginning cell. 18. Feed roller with blades. 19. Front windshield. 21. Embracing plate. 22. Movable cover. 23. Post embracing plate. 24. Covering plate. 25. Plate for preventing impurities. 26. Lateral windshield.

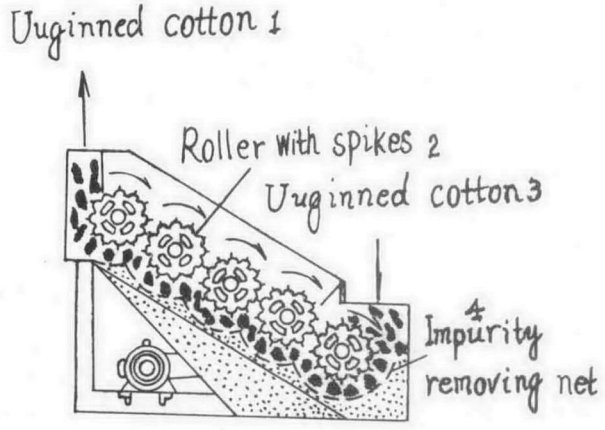

Figure 2. Impurity-removing machine with five rollers.

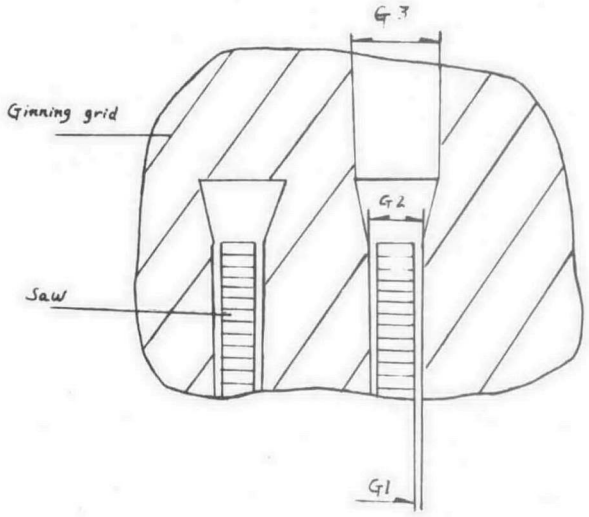

Figure 4. The narrow gaps. (Proportions not exact.)

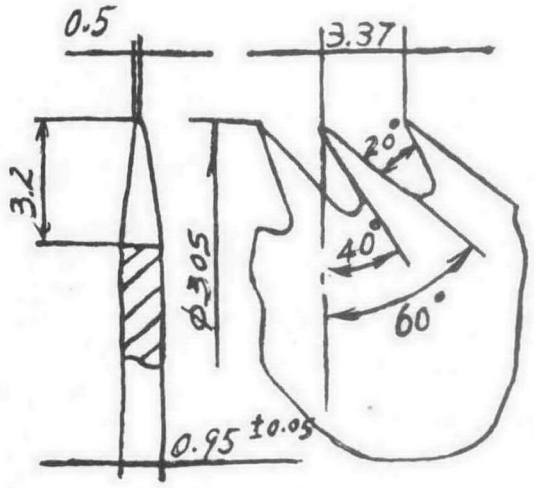

Figure 5. Form of sawtooth.

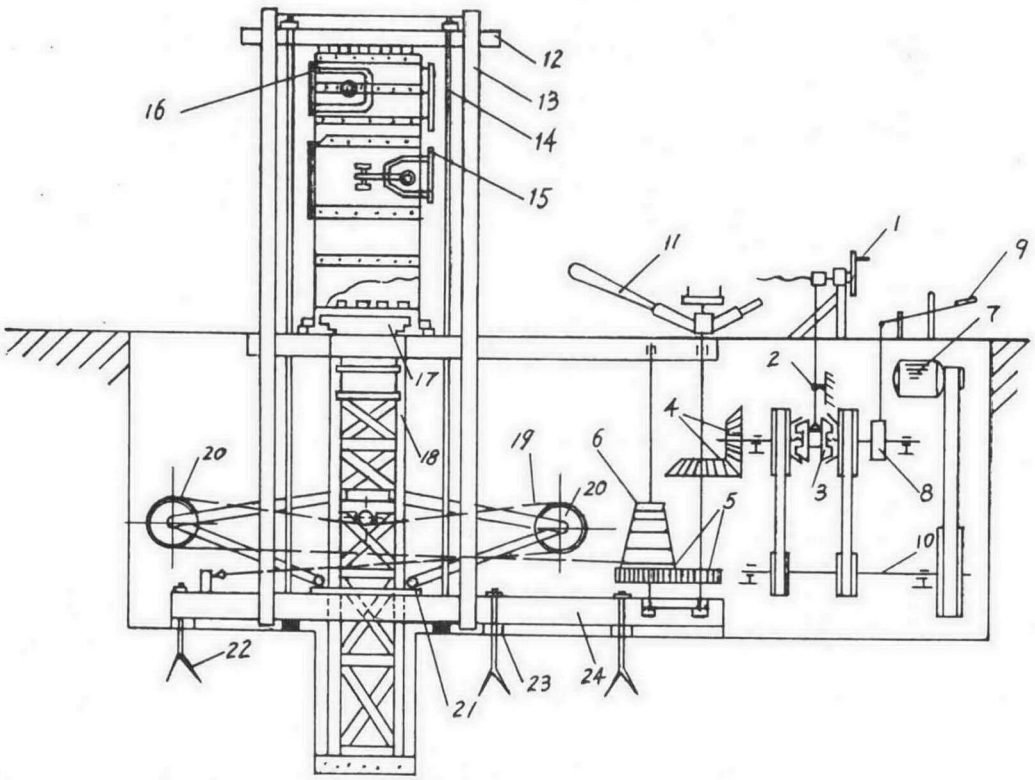

Figure 6. Double-box baling press.
1. Power operating plate. 2. Brace. 3. Clutch. 4. Bevel gear. 5. Large and small gears. 6. Cone pulley. 7. Motor. 8. Brake wheel. 9. Brake handle. 10. Drive beltwheel. 11. Manual handle. 12. Cover. 13. Angle-iron pillar. 14. Supporting pillar. 15. Bottom box door handle. 16. Top box door handle. 17. Elevating pillar. 18. Angle-iron frame. 19. Cable. 20. Pulley. 21. Base pin. 22. Screw shaft. 23. Square wooden pad. 24. Machine support.