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晋南果园2种介壳虫发生规律与药剂防治研究

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摘 要:【目的】明确晋南果园草履蚧和朝鲜球坚蚧生长发育的薄弱环节,筛选出高效防治药剂。【方法】田间调查研究核桃园草履蚧和苹果园朝鲜球坚蚧的发生规律,测定4种杀虫剂对2种介壳虫的防治效果。【结果】晋南果园中草履蚧和朝鲜球坚蚧1 a(年)均发生1代;2月中旬至3月上旬是草履蚧若虫的发生高峰期;5月下旬至6月上旬是朝鲜球坚蚧初孵若虫爬出母介壳分散到枝条上危害的时期。4种杀虫剂对2种介壳虫的防治试验表明,40%杀扑磷乳油800倍液综合防效最好,而22%氟啶虫胺腈悬浮剂4 000倍液和22.4%螺虫乙酯悬浮剂4 000倍液的持效性优于10%吡虫啉可湿性粉剂2 000倍液。【结论】分别在2月中旬至3月上旬、5月下旬至6月上旬草履蚧和朝鲜球坚蚧初孵若虫发生高峰期,选用22%氟啶虫胺腈悬浮剂4 000倍液或22.4%螺虫乙酯悬浮剂4 000倍液喷雾防治,能有效控制2种介壳虫的发生危害。

关键词:果园;介壳虫;草履蚧;朝鲜球坚蚧;发生规律;化学防治
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Occurrence dynamics and chemical controls of two scale species occurred in orchards in the south of Shanxi province

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Abstract:【Objective】Scales are important pests that occurre on forest and fruit trees. Both *Drosicha corpulenta* (Kuwana) and *Didesmococcus koreanus* Borchs wre the dominant specie that occurre in orchards in the south of Shanxi province. Their nymphs and female adults feed on the juices of plants and weaken the plant growing and influence the quality of fruit. In recent years, the occurrence areas and population densities of *D. corpulenta* and *D. koreanus* increased year by year because of the increase of fruit species, changes of cultivation patterns, transportation of nursery stocks, climate change, etc. Comprehensive control techniques had been vastly investigated for *D. corpulenta* and *D. koreanus*, including agricultural control, biological control and chemical control. However, chemical control was still the main technique against these two scale insects. Moreover, the control effects of ordinary pesticides were significantly affected by the biological characteristics of scale insects and the time of control Therefore, exploring the population dynamics, identifying the optimum control time, and finding out the high efficient control insecticides are necessary for the control of *D. corpulenta* and *D. koreanus*.【Methods】Field observations and experiments were carried out in the year of 2015 and 2016 to investigate the occurrence period of egg, nymph, male

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adult, and female adult and to find out the weak period of growth and development of *D. corpulenta* and *D. koreanus*in occurred in walnut orchard and apple orchard, respectively. Furthermore, 4 000 fold diluents of 22% Sulfoxaflor SC, 2 000 fold diluents of 10% Imidacloprid WP, 4 000 fold diluents of 22.4% Spirotetramat SC, and 800 fold diluents of 40% Methidathion EC were sprayed seperately by manual sprayer on walnut trees and apple trees in the field to determine their effects on these two scale insects when they were in stage.【Results】*D. corpulenta* occurred one generation per year and overwintered in egg stage in the soil at the base of trunk in southern Shanxi. In the following year, the over-wintering eggs hatched from February to April, and the nymphae climbed up the tree to feed on the buds. The peak period of newly moulted nymphae appeared from middle February to early March. The female nymphae emerged as adults molted twice. On the contrary, male nymphae pupated in late March and adults emerged in early May. After mating with the male adults in early and middle May, the female adults started to go down from the walnut trees from the late May to the early and middle June. After entering the ground, female adults laid eggs in white waxiness oocysts. These eggs then over-summered and overwintered till the February or March of the next year. *D. koreanus* also occurred one generation per year and overwintered as second instar nymphae in the bark cracks and rough skins of the apple tree. In the following year, the over-wintering nymphae crawled out from molting crust to feed on the new branches. Female nymphs emerged as adults molted in early April when apple trees started growing, while the male ones pupated and emerged as adults in the middle April. After mating, male adults later died, while the female ones died after laying eggs under their scales. Eggs of *D. koreanus* hatched from the mid to the late May. The newly moulted nymphae spread outward from mother shells and then fed on branches, leaves, and fruits.They were gradually covered by the white waxiness. The peak period of newly moulted nymphae was the late May to the early June. And they overwintered after developing as the second instar nymphae in September or October. Chemical experiments showed that the field control efficacy of 800 fold diluents of 40% Methidathion EC was 93.13% 3 days after spraying, which was significantly efficient than other three insecticides. 7 days after spraying, the field control efficacies of all these four insecticides increased. And the control effects of 800 fold diluents of 40% Methidathion EC was still the best, which was 94.12%. However, there was no significant difference among the tested insecticides. 14 days after spraying, the field control efficacies of these four insecticides were all above 90%. The control effects of 4 000 fold diluents of 22% Sulfoxaflor SC and 4 000 fold diluents of 22.4% Spirotetramat SC still increased, which were higher than those of 800 fold diluents of 40% Methidathion EC and 2 000 fold diluents of 10% Imidacloprid WP. The control effects of these four insecticides showed the same tendency for *D. koreanus*.【Conclusion】During the period of the middle February to the early March and the late May to the early June, both 4 000 fold diluents of 22% Sulfoxaflor SC and 4 000 fold diluents of 22.4% Spirotetramat SC could be used to effectively control the newly moulted nymphae of *D. corpulenta* and *D. koreanus*, respectively.

Key words: Orchard; Scale insect; *Drosicha corpulenta* (Kuwana); *Didesmococcus koreanus* Borchs; Occurrence dynamics; Chemical control

介壳虫种类繁多,是危害多种林木和果树的一类重要害虫[1]。其中,草履蚧 *Drosicha corpulenta*(Kuwana)和朝鲜球坚蚧 *Didesmococcus koreanus* Borchs分别属于蚧总科的绵蚧科 Margarodidae 和蜡蚧科 Coccidae,广泛分布于我国北京[2]、山东[3]、陕西[4-5]、山西[6-8]、河北[9-10]、河南[11]、宁夏[12]等地的苹果、梨、柿、杏等果树和杨、柳等林木上。其若虫和雌成虫以刺吸式口器刺吸枝干和嫩芽,造成汁液流失和树势衰弱,并影响果品产量与品质,严重时枝条枯萎以致整株枯死[13]。近年来,由于果树栽培种类增多、

种植模式改变、苗木调运、气候变化以及介壳虫抗药性增强等原因[14],许多地区草履蚧和朝鲜球坚蚧的发生面积和发生量呈逐年上升的趋势[6,10],给果农造成了一定的经济损失。

为了有效控制草履蚧和朝鲜球坚蚧的危害,已有专家对2种介壳虫的生物学习性、发生规律[5,15]、人工清除[16]、胶环或塑料裙物理阻隔[17]、红环瓢虫和黑缘红瓢虫等天敌昆虫生物防治[18-19]、休眠期和生长期化学药剂防治[6,20]等技术进行了深入研究。但各种非化学防治技术均存在一定的缺陷,如农业物理防治技术比较费工;生物防治中红环瓢虫虽在草履蚧发生后期可以控制其数量,但草履蚧已经造成危害等[10]。因此,在果树生长期对其枝干进行化学农药喷雾仍然是生产实践中防治草履蚧和朝鲜球坚蚧的主要技术手段[8,20]。所选用的药剂主要包括吡虫啉、高效氯氟氰菊酯、毒死蜱等广谱传统性杀虫剂[6,21],而一些对刺吸式害虫具有优异毒杀活性的新型杀虫剂应用则较少,如氟啶虫胺腈[22]、螺虫乙酯[23]等。同时,由于介壳虫虫体表面具有蜡粉、蜡质及介壳等保护层,药剂难以穿透,加之初孵若虫扩散速度快,果农难以把握防治适期等诸多原因,导致介壳虫防治效果并不理想[24-25]。作为晋南果园中介壳虫的优势种类[26],在对草履蚧和朝鲜球坚蚧的防治过程中面临着同样的问题。因此,为了厘清草履蚧和朝鲜球坚蚧在晋南果园的发生规律,明确其生长发育的薄弱环节,并筛选出高效防治药剂,笔者于2015—2016年对2种介壳虫进行了调查研究,并分别测定了4种药剂的田间防效,以期为生产上提高对草履蚧和朝鲜球坚蚧的控制效果提供理论依据。

1　材料和方法

1.1　试验地点

草履蚧和朝鲜球坚蚧发生规律调查和药剂防治试验地点分别设置在山西省临汾市襄汾县贾村乡核桃园和尧都区魏村镇苹果园内。其中,核桃园面积1 334 m^2,树龄5 a,株行距3 m×4 m,管理水平一般,草履蚧发生严重。苹果园面积2 668 m^2,树龄20 a,株行距3 m×4 m,管理水平中等,朝鲜球坚蚧发生较重。

1.2　供试药剂及处理

(1)22%氟啶虫胺腈悬浮剂4 000倍液(美国陶氏益农公司);(2)10%吡虫啉可湿性粉剂2 000倍液(江苏克胜集团股份有限公司);(3)22.4%螺虫乙酯悬浮剂4 000倍液[拜耳作物科学(中国)有限公司];(4)40%杀扑磷乳油800倍液(陕西先农生物科技有限公司);(5)清水作为空白对照。上述5个处理,每个处理4次重复,共20个小区,每小区为1株有虫树株,随机区组排列。

1.3　方法

1.3.1　*草履蚧发生规律调查*　(1)出土调查。在试验地随机选择10株核桃树株,于2月份上旬在树干距地面10~20 cm处涂抹宽约10 cm的粘虫胶环(北京中捷四方生物科技股份有限公司),每隔5~7 d调查1次胶环上粘附的草履蚧若虫数量,记录草履蚧若虫出土起止时间。每次调查完成后,及时清除草履蚧若虫虫体,并根据实际情况补充粘虫胶。

(2)各虫态发生调查。草履蚧若虫出土后,另随机选择10株核桃树株,并在各树株东、南、西、北、中5个方位的上、中、下部位各选取1段20 cm长的嫩枝,调查记录草履蚧若虫、蛹(雄虫)和成虫发生数量。雌成虫出现后,采用涂胶环法调查记录其下树起止时间。每隔5~7 d调查1次,直至雌成虫下树完成。

(3)越冬卵调查。草履蚧雌成虫下树以后,每隔5~7 d随机选择树冠下土壤无破坏的核桃树3株,挖取距主干50 cm范围内的0~5 cm土层土样,采用崔美香等[10]的方法分离检测土壤中草履蚧越冬卵及其发育情况。

1.3.2　*朝鲜球坚蚧发生规律调查*　3月上旬开始,每隔5~7 d随机选取10株苹果树,并在每株东、南、西、北、中5个方位分上、中、下部位各随机选取20 cm长的枝条,检查记录朝鲜球坚蚧若虫出蛰时间、成虫发生期、产卵期和卵孵化期,直至若虫越冬开始。

1.3.3　*药剂防治试验*　在2种介壳虫初孵若虫发生期,采用新加坡利农背负式手动喷雾器将试验药剂按浓度均匀喷雾到供试树上,药液量为每株2 L。每株分别在东、南、西、北、中5个方位各选取1段20 cm长的嫩枝做好标记,调查喷药前活虫数和喷药后第3、7和14天的活虫数,按公式计算各药剂的防治效果。

虫口减退率/%=(喷药前活虫数-喷药后活虫数)/喷药前活虫数×100

校正防治效果/%=(处理区虫口减退率-空白对照区虫口减退率)/(1-空白对照区虫口减退率)×100

1.4 数据统计与分析

各药剂处理数据经单因素方差分析(one-way ANOVA)统计差异显著后,平均值采用邓肯氏新复极差法(DMRT法)进行多重比较。统计分析软件为SAS 8.1。

2 结果与分析

2.1 草履蚧的生活史及生活习性

晋南核桃园草履蚧年生活史见表1。结果显示,草履蚧1 a(年)发生1代,以卵在树干基部土壤下越冬;翌年2月至4月上旬越冬卵孵化,孵化期不整齐,初孵若虫暂居于卵囊内,待温度回升后,出土上树并聚集在嫩芽处危害,高峰期在2月中旬至3月上旬;雌性个体经过2次蜕皮后,变为成虫,雄性个体则于4月下旬在树皮裂缝下化蛹,5月初羽化后和雌成虫交配,5月中旬为交配盛期;雌成虫于5月中下旬开始下树,直至6月上中旬完毕;入土后,雌成虫先分泌白色蜡质卵囊,后产卵于囊内。卵在土中越夏并越冬,直至翌年2、3月。2月中旬至3月上旬是若虫发生高峰期。

表1 晋南核桃园草履蚧年生活史

Table 1 The life cycles of *D. corpulenta* occurred in walnut orchard in the south of Shanxi province

世代 Generation	6月下旬至翌年2月上旬 Late July to early February of the next year	2月中下旬、3月 Mid-to-late February, March	4月 April			5月 May			6月 June	
			上旬 Early	中旬 Middle	下旬 Late	上旬 Early	中旬 Middle	下旬 Late	上旬 Early	中旬 Middle
1年1代 One generation per year	⊙	⊙	⊙							
		–	–	–						
					◎	◎	◎			
						♂	♂	♂		
					♀	♀	♀	♀	♀	♀

注:⊙. 卵;–. 若虫;◎. 蛹(雄);♂. 雄成虫;♀. 雌成虫。下同。

Note: ⊙. Egg; –. Nymph; ◎. Pupae (Male); ♂. Male adult; ♀. Female adult. The same below.

2.2 朝鲜球坚蚧的生活史及生活习性

晋南苹果园朝鲜球坚蚧年生活史见表2。结果显示,朝鲜球坚蚧1 a发生1代,以2龄若虫在枝条裂缝、粗翘皮处越冬;翌年3月上中旬苹果树发芽时,越冬若虫从蜕皮壳下爬出并固着在枝条上吸食、危害,虫体不断膨大,并逐渐分化为雌、雄个体;4月上旬,雌性若虫蜕皮变为雌成虫,中下旬膨大为球形;雄性若虫则形成蜡壳,并在其中蜕皮化蛹,中旬羽化为雄成虫,完成交配后死亡;4月下旬,雌成虫虫体逐渐变硬形成球形,并开始产卵于体下,随后死去;5月中下旬卵开始孵化;初孵若虫从母体下爬出,分散固定在枝条、叶片、果实上危害,并逐渐被白色蜡质物包覆;9月至10月蜕皮变为2龄若虫,并在蜕皮壳下开始越冬。5月下旬至6月上旬是朝鲜球坚蚧初孵若虫从母体中爬出分散到枝条上危害的时期。

表2 晋南苹果园朝鲜球坚蚧年生活史

Table 2 The life cycles of *D. koreanus* occurred in apple orchard in the south of Shanxi province

世代 Generation	7月至翌年3月 July to March of the next year	4月 April			5月 May			6月 June		
		上旬 Early	中旬 Middle	下旬 Late	上旬 Early	中旬 Middle	下旬 Late	上旬 Early	中旬 Middle	下旬 Late
1年1代 One generation per year	–	–	–							
		◎	◎	◎						
			♂	♂	♂					
		♀	♀	♀	♀	♀				
				⊙	⊙	⊙	⊙			
						–	–	–	–	–

2.3　不同药剂对草履蚧的防治效果

4种杀虫剂对草履蚧的防治效果见表3。由表3可以看出,药后3 d,处理4的防效最高,为93.13%,显著高于其他3个药剂处理;其次为处理2,为88.31%,显著高于处理1和处理3。药后7 d,各药剂处理的防效均有所上升;其中,处理4的防效仍然最高,为94.12%,其余依次为处理3、处理1和处理2,防效分别为93.73%、93.30%和90.58%,4个处理之间差异不显著。药后14 d,各药剂处理的防效均超过90%,其中处理1和处理3防效仍在上升,且高于处理4,而处理2的防效则显著低于上述3个处理。

表3　不同药剂对草履蚧的防治效果

Table 3　Control efficacy of different insecticide against *D. corpulenta*

编号 No.	处理 Treatment	稀释倍数 Dilution factor	虫口基数/头 Pest number before treatment	药后3 d 3 d after treatment		药后7 d 7 d after treatment		药后14 d 14 d after treatment	
				减退率 Decreased rate/%	校正防效 Control efficacy/%	减退率 Decreased rate/%	校正防效 Control efficacy/%	减退率 Decreased rate/%	校正防效 Control efficacy/%
1	22%氟啶虫胺腈悬浮剂 22% Sulfoxaflor SC	4 000	440	83.52	80.42 Cc	94.31	93.30 Aa	94.29	93.71 Aa
2	10%吡虫啉可湿性粉剂 10% Imidacloprid WP	2 000	395	90.20	88.31 ABb	92.01	90.58 Aa	90.95	90.01 Ab
3	22.4%螺虫乙酯悬浮剂 22.4% Spirotetramat SC	4 000	394	86.48	83.91 BCc	94.77	93.73 Aa	95.27	94.59 Aa
4	40%杀扑磷乳油 40% Methidathion EC	800	441	94.24	93.13 Aa	95.07	94.12 Aa	94.71	93.94 Aa
5	对照 Control		456	16.01		15.43		14.48	

注: 表中的防效为各重复的平均值;同列数据不同小写字母表示在 $P<0.05$ 差异显著(DMRT 法),不同大写字母表示在 $P<0.01$ 差异显著。下同。

Note: The control efficacy control in the table is the average of the replications; different small letters indicate significant difference at $P<0.05$ (DMRT method), different capital letters indicate significant difference at $P<0.01$. The same below.

2.4　不同药剂对朝鲜球坚蚧的防治效果

4种杀虫剂对朝鲜球坚蚧的防治效果见表4。由表4可以看出,药后3 d,处理4的防效最高,其次是处理2,2者之间差异不显著,防效分别为91.73%和90.28%,都显著高于处理1(80.72%)和处理3(82.22%)。药后7 d,处理1和处理3防效分别上升至92.22%和91.12%,与处理4差异不显著,而处理2防效下降至88.56%。药后14 d,处理1和处理3防效仍在上升,处理2和处理4防效下降,处理2的防效极显著低于上述3个处理。

表4　不同药剂对朝鲜球坚蚧的防治效果

Table 4　Control efficacy of different insecticide against *D. koreanus*

编号 No.	处理 Treatment	稀释倍数 Dilution factor	虫口基数/头 Pest number before treatment	药后3 d 3 d after treatment		药后7 d 7 d after treatment		药后14 d 14 d after treatment	
				减退率 Decreased rate/%	校正防效 Control efficacy/%	减退率 Decreased rate/%	校正防效 Control efficacy/%	减退率 Decreased rate/%	校正防效 Control efficacy/%
1	22%氟啶虫胺腈悬浮剂 22% Sulfoxaflor SC	4 000	154	81.29	80.72 Bb	92.29	92.22 Aab	94.27	94.30 Aa
2	10%吡虫啉可湿性粉剂 10% Imidacloprid WP	2 000	168	90.63	90.28 ABa	88.77	88.56 Ab	86.84	86.95 Bb
3	22.4%螺虫乙酯悬浮剂 22.4% Spirotetramat SC	4 000	170	82.32	82.22 ABb	91.15	91.12 Aab	93.50	93.78 Aa
4	40%杀扑磷乳油 40% Methidathion EC	800	180	92.10	91.73 Aa	93.78	93.63 Aa	92.81	93.14 Aa
5	对照 Control		166	1.40		−0.40		−3.23	

3　讨　论

草履蚧雌成虫虫体表面被有白色蜡质分泌物[15],朝鲜球坚蚧则是于若虫后期即开始分泌蜡质,至成虫期已形成蜡质介壳(雌)和蜡层(雄)[4],导致化学药剂难以穿透并作用于虫体,防治效果多不理想,

而若虫孵化初期固定前，表皮裸露，对药剂较为敏感。本研究表明，晋南果园中草履蚧1 a发生1代，越冬卵孵化极不整齐并导致初孵若虫发生期较长。其中，2月中旬至3月上旬是草履蚧初孵若虫发生高峰期，这与李润临等[27]的报道一致。对朝鲜球坚蚧而言，5月中下旬至6月上中旬为若虫孵化盛期，并快速分散到枝条、叶片和果实等部位危害，这与张乃芹等[3]、郭小侠等[4]报道的山东和陕西种群的发生规律基本一致。因此，抓住2月中旬至3月上旬、5月下旬至6月上旬草履蚧和朝鲜球坚蚧初孵若虫发生期，并选择有效药剂防治，对控制2种介壳虫在晋南果园的危害能够起到事半功倍的作用。

田间药效试验结果显示，传统的介壳虫化学防治药剂杀扑磷对防治草履蚧和朝鲜球坚蚧具有较强的速效性和持效性。但由于杀扑磷毒性高、残留大，已于2015年在柑橘树及其他蔬菜瓜果上全面禁用。本研究结果显示，22%氟啶虫胺腈悬浮剂和22.4%螺虫乙酯悬浮剂对防治2种介壳虫具有较好的效果，且都具有低毒、低残留、对非靶标生物安全等诸多优点[28-30]，因而可用于控制晋南果园草履蚧和朝鲜球坚蚧的危害。同时，为弥补这2种药剂速效性不足的特点，生产中可适当加入对草履蚧和朝鲜球坚蚧速效性较好的药剂，如吡虫啉，效果会更加显著。除化学防治以外，结合草履蚧和朝鲜球坚蚧的生活习性和发生规律，还可协调利用农业防治、物理防治、生物防治等措施，如秋冬季深翻灌水、2月份树干绑缚诱虫带或草袋、保护利用天敌等，从而全面预防和降低2种介壳虫的发生和危害。此外，笔者仅研究了药剂在推荐浓度下对2种介壳虫的防治效果，梯度浓度下各药剂的防治效果还需进一步研究。

4 结 论

在2月中旬至3月上旬、5月下旬至6月上旬晋南草履蚧和朝鲜球坚蚧初孵若虫发生高峰期，选用22%氟啶虫胺腈悬浮剂4 000倍液或22.4%螺虫乙酯悬浮剂4 000倍液喷雾防治，可有效控制2种介壳虫的发生危害。

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