

# 中国的白背飞虱研究概况

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## Management of the Whitebacked Planthopper, *Sogatella furcifera* in China: A Mini-review

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**Abstract:** The progress of the research on the whitebacked planthopper, *Sogatella furcifera* and its management based on 214 papers published in China since 1949 was summarized. The contents included biology, migration, occurrence characteristics, and population dynamics of the whitebacked planthopper; yield losses, and varietal resistance of rice; and integrated management of the pest.

**Key words:** whitebacked planthopper; migration; population dynamics; yield loss; varietal resistance; integrated pest management; rice

**摘要:** 通过对 214 篇发表在中国省级以上刊物的相关研究论文分析, 概述了建国以来中国对白背飞虱研究与治理等方面的研究进展, 内容包括白背飞虱的生物学特性、迁飞规律、发生特点、种群动态、为害损失、水稻品种抗性及其种群综合治理等方面。

**关键词:** 白背飞虱; 迁飞; 种群动态; 为害损失; 品种抗性; 综合治理; 水稻

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白背飞虱 *Sogatella furcifera* (Horváth), 属同翅目(Homoptera)、飞虱科(Delphacidae), 是我国最重要的水稻害虫之一, 其成、若虫直接刺吸稻株的韧皮部汁液, 造成水稻生长缓慢, 分蘖延迟, 瘪粒增加; 为害严重时, 造成稻株枯死, 呈“虱烧”状(第 115 页彩色图片 1)。水稻品种在田间条件下对白背飞虱的抗性可分为感虫型(产卵多、孵化若虫多)、耐虫型(产卵多、孵化若虫少)和抗虫型(产卵少、孵化若虫少)(第 115 页彩色图片 2)。白背飞虱分布广泛, 几乎遍及我国所有的稻区, 包括华南、华中、华北、东北以及西南稻区, 西北稻区可达新疆自治区的米泉等地。因而, 白背飞虱引起了学术界的广泛关注。我国自 20 世纪 20 年代就开始了白背飞虱的研究。新中国成立后, 尤其是 1980 年以后, 对白背飞虱的研究日渐深入和系统。有关白背飞虱的研究论文与专题综述<sup>[11,29,72,73,104,166,185,189]</sup>, 数量大、涵盖面广, 几乎涉及所有领域(表 1)。本文将从九个方面概述我国白背飞虱研究进展(表 1)。

### 1 生物学特点

白背飞虱可以在 18 种作物和杂草上完成生活史。水稻是最适宜的寄主, 其次是普通野生稻和稗

草<sup>[43]</sup>。白背飞虱喜择稗草产卵, 但若虫死亡率较高<sup>[24,95]</sup>。除水稻外, 其他寄主只能勉强完成一个世代<sup>[115]</sup>。

白背飞虱通过口针刺吸稻株韧皮部汁液为害水稻, 高龄若虫和成虫的取食量较大<sup>[39]</sup>。其取食会导致水稻各种氨基酸含量<sup>[136,140]</sup>、光合作用速率、叶绿素含量、保护酶活性发生变化<sup>[10]</sup>。在白背飞虱的取食过程中, 有可能传播其他病害和病毒, 如云南烟草丛枝症<sup>[122]</sup>。

白背飞虱 1 年可发生 3~4 代<sup>[121]</sup>, 若虫一般有 5 龄<sup>[44,84]</sup>。雌雄虫在羽化的时间、交配的次数上存在差异。雄成虫较雌成虫羽化早, 雌成虫一生只交配 1 次, 雄成虫可交配 3~4 次<sup>[186]</sup>。雌虫产卵前期

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表1 白背飞虱参考文献分类一览表

Table 1. Category list of literatures cited on *S. furcifera*.

文献分类 Category	参考文献 Literature cited
专题综述 Review	11,29,72, 73,104,166,185,189
生物学特点 Biology	5,10,24,27,39,42,43,44,79,84,90,91,92,95,100,115,121,122,132,136,140,183,184,186,211
迁飞规律 Migration	2,13,25,54,83,115,120,123,131,142,202,206
发生特点 Occurrence character	3,7,17,18,19,35,36,47,53,60,81,87,98,112,113,114,116,118,120,126,133,151,153,154,159,160,163,164,172,180,193,195,203,205,206,209
种群动态 Population dynamics	16,33,38,40,41,49,50,51,82,92,108,110,111,135,138,139,168,177,207,212
为害损失与防治指标 Yield loss and control threshold	1,4,52,55,61,106,109,119,144,169,190,194,196,197,200,213
水稻抗性 Varietal resistance	6,10,26,28,29,30,31,32,33,34,57,58,59,65,66,68,69,70,71,72,73,74,75,76,77,78,80,84,85,88,101,102,103,104,107,117,124,125,129,146,147,148,152,155,161,167,169,171,174,175,176,179,182,187,189,204
综合治理 Integrated pest management	
综合防治 Integrated management	3, 7, 8,11,60,81,133,145,160,163,213
抗虫品种 Resistant variety	8,11,14
农业防治 Agricultural control	198
生物防治 Biological control	22,23,63,64,92,93,94,96,97,105,127,128,156,157,162,170,173,182,184,191
化学防治 Chemical control	9,12,15,20,21,37,44,45,46,56,62,67,86,89,130,143,145,149,158,165,166,181,188,192,199,208,210
分子生物学 Molecular biology	48
与褐飞虱的关系 Related to <i>Nilaparvata lugens</i>	46,99,134,135,137,141,150,201,214

以迁入代最短,产卵量以迁入代和第2代最多,产卵的时间白天多于夜晚,产卵的部位集中于稻株基部叶鞘内,产卵趋性因水稻的品种、叶色、生育期的不同而不同<sup>[42,79,211]</sup>。另外,吕万明<sup>[91,92]</sup>还对雌虫生殖系统的构造及胚胎发育进行了观察,将卵的胚胎发育分为7个历期:胚盘期、胚带期、黄斑期、眼点期、胸节期、腹节期和待孵期。

白背飞虱存在着形态和行为的多态现象,即迁飞型(以长翅型为代表)和居留型(以短翅型为代表)<sup>[5,184]</sup>。温度对白背飞虱翅型的分化起着重要的作用。在日平均气温18~24℃范围内,温度与短翅型呈负相关;低于18℃或高于24℃,短翅型成虫出现的概率极低<sup>[5]</sup>。一般情况下,白背飞虱短翅型雄虫极少见,1979年和1980年在四川贵州等地有少量短翅型雄虫发生<sup>[27]</sup>。

白背飞虱的耐饥力随温度的升高而减弱;各龄若虫的耐饥力随虫龄的增加而加强。成虫羽化后3d耐饥力较强,以后逐渐减弱<sup>[43]</sup>。适宜若虫的生存温度为25℃以上、30℃以下,超过30℃或低于20℃均对若虫的生长不利。白背飞虱各虫态的抗寒力较弱,在10℃以下,随温度的降低,成若虫会依次出现活动缓慢、生理失调、低温冻害三种情况<sup>[132]</sup>。对高温的忍耐力以卵期较强,成、若虫的生存率随温度的

升高而下降<sup>[100]</sup>。

## 2 迁飞规律

白背飞虱作为一种迁飞性害虫大面积猖獗为害<sup>[123]</sup>。南方各省对其越冬问题进行了大量的研究<sup>[54]</sup>。暖冬年份在北纬26°以南的再生稻、落粒苗和冬秧上有少数虫量越冬,冷冬年份能越冬的为1月平均气温在10℃以上,绝对低温在0℃以上<sup>[115]</sup>。

运用飞机航捕、高空捕虫网、灯光诱测和田间系统调查等测报方法<sup>[13,25,142]</sup>,对白背飞虱进行监测,明确了其迁飞规律。每年3月中、下旬,白背飞虱从中南半岛迁入我国,并随西南气流不断北迁,6月下旬~7月初,虫源可到达我国东北。白背飞虱主要迁入代繁殖一代后就有长翅型成虫外迁。8月下旬以后,随季风方向的转变,在东北气流的运送下,开始向南回迁<sup>[115]</sup>。胡国文等根据高空流场的分析,将造成不同迁飞途径的气流情况,归纳为春季北迁、夏季北迁、秋季回迁和台风影响等4组共13个流型<sup>[131]</sup>。

由于不同地区白背飞虱的迁飞途径和迁入时期的不同,导致各主要稻区的主害代虫源性质有较大的差异<sup>[113,202,206]</sup>。例如,长江中下游和江淮稻区主害代虫源为前期迁入虫源,而西南稻区则以近期

迁入为主,前期迁入虫源为辅<sup>[2]</sup>。不同虫源性质的成虫,其飞翔能力也有差别<sup>[83]</sup>。

### 3 发生特点

由于白背飞虱连年发生严重,全国各地都对白背飞虱在当地发生的规律进行了研究<sup>[17,19,47,53,87,98,112,116,120,151,153,159,193,195,203,205]</sup>。迁入期的早迟、迁入峰次的多少、迁入虫量以及增殖倍数的大小,都与白背飞虱发生程度的轻重有着显著的相关性<sup>[36,133,154,160,209]</sup>。

对白背飞虱的预测,包括发生趋势、发生期和发生量的预测,采取的方法主要为回归分析<sup>[7,172,180]</sup>。陈海新等<sup>[7]</sup>应用回归分析法,对江苏省高邮市1983~1997年的资料进行了分析,建立了中、短期预测模型,经历史资料回归验证,符合率达85%以上。

白背飞虱的严重发生与多种因素有关。首先,杂交稻种植面积的扩大会导致白背飞虱大发生<sup>[98,114,118,164]</sup>。唐启义等<sup>[126]</sup>对湖南和广西两地1981~1987年杂交水稻的种植面积和白背飞虱的发生量进行关联分析表明,白背飞虱在大区域范围内为害加重和猖獗频率上升与杂交稻种植面积的扩大密切相关。其次,化学农药的大量使用,不仅使白背飞虱产生抗药性,而且会破坏害虫与天敌之间的自然平衡<sup>[81]</sup>。还有,适宜的气候条件有利于白背飞虱个体的生长发育和种群扩散<sup>[18]</sup>。

胡国文等<sup>[35]</sup>根据我国各稻区白背飞虱资料的分析结果,以主要为害时期为一级标准将我国稻区白背飞虱的发生分为5个主害带:5、6、9月主害带,6、7月主害带,7、8月主害带,7月主害带和8月主害带。以始见期、主要迁入期为二级标准,分为16个区。这为全国性的联合监测、异地中长期测报和防治工作提供了依据。广东省也对本省的白背飞虱进行了划区<sup>[3]</sup>。

### 4 种群动态

全国各个地区,如安徽的安庆地区<sup>[82,139]</sup>、四川的泸州地区<sup>[111]</sup>等,对当地白背飞虱的主要降落范围、害虫的田间消长规律进行了分析,建立了预测预报模型,以便于控制和管理。黄荣华<sup>[49]</sup>在明确白背飞虱若虫空间分布型的基础上,根据Kuno和Iwao的序贯抽样公式,分别制作了序贯抽样图和表。吕雨土等<sup>[92]</sup>根据灰色系统关联分析的基本原理,提出了白背飞虱种群动态的加权关联度预测法,对种群的发生情况进行了预测。

白背飞虱的种群数量与迁入虫量<sup>[207]</sup>、迁入主峰期<sup>[212]</sup>呈显著相关。卵期不存在密度效应;若虫、成虫期密度效应明显,随着密度的增加,若虫生存率、成虫产卵量和寿命呈幂函数曲线下下降<sup>[108]</sup>。成虫取食杂交稻的繁殖能力显著大于取食常规稻的繁殖力;各代成虫的繁殖力也有显著差别,表现出第一代>迁入代>第二代,在低密度虫口下,成虫繁殖力无明显的差别<sup>[207]</sup>。白背飞虱在抗虫品种上难以形成有害种群。

各种自然因素也是影响种群兴衰的重要因素。首先,白背飞虱在不同类型的水稻品种上和水稻的不同生育期,其分布、趋性、发育和繁殖力是不同的<sup>[40,41,138,177]</sup>。其次,环境因子对白背飞虱的种群增长也有重要的作用,包括气候、天敌及栽培措施等<sup>[16,38,40,41,110]</sup>。

制作生命表是种群生态研究的重要方法。种群生命表包括自然种群生命表和实验种群生命表<sup>[168]</sup>。建立白背飞虱的自然种群生命表,一般采用室内实验种群、田间笼罩实验种群和自然种群系统相结合的方法,按作用因子组配,用于分析自然种群消长机制和评价各生态因子的作用<sup>[50,51]</sup>。

### 5 为害损失和防治指标

白背飞虱对水稻经济产量结构的影响,主要表现在千粒重的下降和秕谷率的增加<sup>[55]</sup>;稻穗在前中期受害,其总粒数和有效穗数减少<sup>[61]</sup>。经济允许损失水平随稻谷的价格、防治成本、防治效果不同而波动<sup>[119,169,190]</sup>。张夕林对白背飞虱在梗稻上的为害损失进行了研究<sup>[194,196,197]</sup>,结果表明,水稻的产量损失与二代白背飞虱百丛虫量呈极显著正相关。

防治指标的确定受以下各因素的影响:(1)虫口密度与产量损失的关系,(2)允许损失量,(3)防治投资与产出比<sup>[4]</sup>。防治指标一般以虫口密度为标准,白背飞虱种群发展与生态研究协作组把我国高产地区的白背飞虱防治指标确定为1000~1500头/百丛,低产地区为1500~2000头/百丛<sup>[1]</sup>。早稻、中稻、晚稻以及再生稻,其各自的防治指标有所不同<sup>[52,109,144,194,200]</sup>。

根据稻飞虱为害量、水稻被害状和产量损失三者间的关系,可将原防治指标中的虫口密度改为水稻受害的形态防治指标。其中,可将稻褐色卵条斑株率作为稻飞虱形态防治指标的基准<sup>[106]</sup>。

### 6 品种抗虫性

水稻对害虫的抗性机制是多方面的,可分为物

理抗性和化学抗性。物理抗性方面,叶海芳<sup>[167]</sup>发现,水稻叶鞘的表面结构如硅细胞群、刺毛、木栓组织、蜡被层等能干扰白背飞虱的栖息行为,与水稻对白背飞虱的抗性相关。

对昆虫的各种行为具有负作用的稻株化学成分,大致可分为:(1)挥发性次生物质。刘光杰<sup>[28,73]</sup>采用蒸馏法提取了稻株挥发性次生物质,并进行了生测,发现感虫品种 TN1 的粗提物较抗虫品种 RHT 更吸引白背飞虱。(2)非挥发性次生物质。刘光杰等<sup>[71,74]</sup>发现抗虫稻株体内存在使白背飞虱拒食的活性成分。肖英方<sup>[155]</sup>发现次生代谢物质苯酚对白背飞虱的生长发育可产生不良影响。(3)稻株营养物质和昆虫酶活性的抑制剂。稻株体内的总氮和游离氨基酸的含量与品种抗性分别呈极显著和显著相关,可溶性糖含量过高也不利于白背飞虱的生长发育<sup>[66,80,85,161,174,175]</sup>。取食抗虫品种的白背飞虱,其体内的羧酸酯酶 CarE、酸性磷酸酶 AcpE 和碱性磷酸酶 AkpE 的活力被抑制,不能正常生长发育<sup>[148]</sup>。

另外,通过对白背飞虱取食抗虫品种后的糖类物质分析,刘光杰等<sup>[68]</sup>提出一种假设,认为在白背飞虱体内存在两种独立的消化和吸收机制,一种机制控制摄入食物的量,第二种机制则控制摄入食物的消化和吸收。同时还认为,某些植物生长调节剂和化合物也会对白背飞虱的取食产卵等行为产生影响<sup>[75,76,78]</sup>。

鉴定水稻品种的抗性是水稻抗虫性育种的一个重要环节,包括对不同水稻品种的拒抗性测定、抗生性测定和耐害性测定<sup>[30,31,65,124,125,176]</sup>。测定的指标主要包括 3 个方面,即品种为害度(品种受害级别、死苗率),害虫生物指标(卵孵化率、若虫存活率、若虫羽化率、成虫产卵量、成虫蜜露排泄量),以及两者的综合指标(抗性比值=蜜露面积率×生存率×产卵率×苗期受害率×1000)<sup>[176]</sup>。唐健等<sup>[124]</sup>认为若虫生存率和蜜露排泄量是衡量品种抗性最主要的两个指标,并提出了“主分量分析法”。我国从 20 世纪 70 年代末期开始稻种资源抗白背飞虱的筛选鉴定工作<sup>[32]</sup>,筛选鉴定出了大量的抗性材料<sup>[6,26,34,103,107,117,129,152,182,204]</sup>,采用的鉴定方法主要是苗期群体鉴定和田间成株期抗性鉴定。巫国瑞<sup>[146]</sup>认为苗期群体鉴定法虽然快速,但是结果不稳定,适宜初筛。刘光杰<sup>[70,77]</sup>认为,分蘖期接虫鉴定更能准确地反映水稻品种的抗性水平。

确定抗白背飞虱基因是水稻抗虫性研究的另一

重要方面。刘志岩等<sup>[88]</sup>将 ARC10239 携带的抗白背飞虱基因 *Wbph2* 定位于水稻第 6 染色体上,与之连锁的 RFLP 标记是 RZ667,连锁距离为 25.6 cM。刘光杰等<sup>[69]</sup>将 RHT 的抗性基因成功的转入恢复系浙辐 802 中,构建的近等基因系表现出明显的抗虫性。李西明等<sup>[57~59]</sup>自 1984 年开始对我国鉴定出的白背飞虱抗源材料进行分析,明确了鬼衣谷等 6 个品种的遗传规律,并发现和命名了抗性基因 *Wbph6(t)*。马良勇等<sup>[102]</sup>将 *Wbph6(t)* 定位于第 11 染色体短臂,与 SSLP 标记 RM167 的遗传距离为 21.2 cM。

选育抗虫性新品种在近年来日益受到重视。已育成的抗白背飞虱品种有湘抗 32 选 5、HA79317-4、浙丽 1 号等<sup>[29]</sup>。江西省选育出的赣早粳 28 号,推广面积已达到 3 万  $\text{hm}^2$ <sup>[171]</sup>。此外还选育出了几个抗白背飞虱的杂交稻组合<sup>[33,187]</sup>。同时,水稻抗虫品种的推广可能引起生物型的分化。马巨法等<sup>[101]</sup>用来自不同地区的白背飞虱虫源,分别在 TN1、N22、ARC10239 和 Rathu Heenati 四个品种上测定其若(成)虫存活率,证明我国的白背飞虱尚无生物型的分化。

## 7 综合治理

综合治理是综合运用抗虫品种、农业防治、生物防治和化学防治等措施对白背飞虱种群进行治理,以期获得最大的经济、生态和社会效益<sup>[3,7,8,11,60,81,133,145,160,163,213]</sup>。

以抗白背飞虱品种为基础的水稻综合治理技术和策略,具有许多比其他管理技术更优的特点<sup>[14]</sup>。据统计,我国选育成的抗虫杂交稻组合,种植面积已达到 500 万  $\text{hm}^2$ <sup>[11]</sup>。使用抗虫品种可以减少农药的使用量,降低生产成本,同时减少对环境的污染。但为了避免由于害虫生物型的分化引起抗性消失,在同一地区应尽量避免品种单一化<sup>[11]</sup>。

农业防治,主要包括水肥管理、合理种植等农业措施,如烤田<sup>[198]</sup>,可通过创造有利于水稻天敌种群的稳定发展,而不利于白背飞虱的农田生态环境,来减轻飞虱的发生为害。

生物防治近年来日益受到重视。稻飞虱的田间消长和天敌存在着相关关系,可以利用天敌来控制白背飞虱<sup>[93,94]</sup>。在稻田生态系统中,对白背飞虱种群起控制作用的寄生性天敌主要为寄生蜂,捕食性天敌包括蜘蛛和昆虫<sup>[96,97,127,128,191]</sup>。卵期天敌主要为寄生蜂和黑肩绿盲蝽<sup>[22]</sup>;不同生境来源的卵

寄生蜂有不同的寄主和选择特性<sup>[173]</sup>;在盲蝽与飞虱卵数量比(B/E)较低时,盲蝽个体对飞虱卵的控制效应很强,但群体效应很差,在B/E较高的时候正好相反<sup>[64]</sup>。成虫和若虫期的天敌主要为蜘蛛<sup>[23]</sup>,不同种类的蜘蛛对飞虱的捕食作用有较大的差别,其中以食虫沟瘤蛛和拟水狼蛛的捕食作用最大<sup>[63,105,156,157,170,184]</sup>。另外,还可采取稻田养蟹的方法来控制白背飞虱<sup>[162]</sup>。

化学防治见效快、使用广。因此,药剂防治仍然是防治白背飞虱的主要手段。为了药剂的科学合理使用,对各种药剂进行了药效实验,种类有吡虫啉<sup>[67]</sup>、扑虱灵<sup>[45,130,208]</sup>、吡虫啉<sup>[12,37,192]</sup>、稻麦灵<sup>[149]</sup>、阿克泰<sup>[210]</sup>、苦参碱<sup>[89]</sup>、灭幼酮<sup>[199]</sup>、优乐得<sup>[208]</sup>、锐劲特<sup>[158]</sup>等。但是,杀虫剂在杀死害虫的同时,也杀灭了害虫的天敌,影响稻田生态系统。因而,在药效实验的同时,要进行对天敌的安全性试验<sup>[56]</sup>。一般来讲,选择性杀虫剂对天敌相对安全<sup>[12,37,86]</sup>。另外,除草剂和杀菌剂对白背飞虱成虫有杀伤作用<sup>[9]</sup>。长期施用化学药剂,必然引起害虫再猖獗和害虫抗药性的提高<sup>[143,181,188]</sup>,对此,国内学者进行了大量研究,认为农药导致害虫再猖獗的生态机制有三种:(1)大量杀死同一生态环境中的竞争种,(2)杀死害虫的天敌,(3)刺激剩余害虫的繁殖<sup>[20,21]</sup>,并提出了“害虫再猖獗指数IPR”来评价杀虫剂激发害虫再猖獗的效应<sup>[15]</sup>。在白背飞虱的抗药性方面,认为其机制是靶部位敏感性的降低与代谢降解增强<sup>[166]</sup>,同时进行了抗药性监测和抗药性治理方面的研究<sup>[62,165]</sup>。

## 8 分子生物学

关于白背飞虱分子生物学方面的研究还较少。黄立华等<sup>[48]</sup>证明了白背飞虱体内存在着 mariner 转座子,其分布广泛,同源性高,是一种非常优秀的转基因载体,对飞虱乃至其他昆虫的转基因研究有重要作用。

## 9 与褐飞虱的关系

通常,白背飞虱与褐飞虱混合发生,对营养和生态位的竞争使两种飞虱之间存在着程度不同的互作效应,即一种飞虱的羽化、性别、翅型等生物学特性都受到异种飞虱的影响<sup>[134,135,141]</sup>。

关于两种飞虱的营养竞争,存在着两种截然相反的观点。一种认为:被取食后稻株体内营养成分的不平衡,导致后来取食的异种飞虱发育受阻,即两

种飞虱存在着一定程度的营养竞争关系<sup>[150]</sup>。另一种观点则认为:飞虱的取食行为改变了寄主植物与外界的物理和化学信息联系,使寄主植物的营养和挥发性次生物质发生变化,从而有利于吸引异种飞虱栖息于同一植株上<sup>[201]</sup>。

无论是种间还是种内,密度对两种飞虱种群均表现为一定的负效应。比较而言,褐飞虱比白背飞虱更耐拥挤,褐飞虱在田间的居留比率高于白背飞虱<sup>[99]</sup>。在自然条件下,两个种不可能占据相同的生态位。白背飞虱大都栖息于较高的稻株部位,而褐飞虱常栖息于较低的部位<sup>[134]</sup>。

两种飞虱混合为害引起的产量损失比单一白背飞虱为害有加重趋势,褐飞虱虫口比例的增加对种间混合为害有促进作用<sup>[137]</sup>。另外,应用杀虫剂防治白背飞虱会对褐飞虱的种群数量产生影响<sup>[46]</sup>;稻田耕作方式和品种布局的不同,能引起两种飞虱各自种群数量的变化,两者会交替成为田间的优势种群<sup>[214]</sup>。

## 10 结束语

当前,施用化学杀虫剂防治白背飞虱以及其他水稻害虫,仍然是稻农普遍采用的害虫防治手段。化学农药的过量施用将导致白背飞虱等害虫抗药性的产生,同时也带来严重的环境污染和农产品安全问题。为了适应加入WTO,提高农产品在国际市场上的竞争力,严格控制农产品中农药残留量,实现稻米生产的无害化是当前水稻害虫治理工作所面临的巨大挑战。因此,未来的水稻害虫治理应该以解决水稻害虫治理过程中对农田和生活环境污染的问题,切实做到少施农药,节省用工,降低水稻生产成本,要在水稻丰产的同时,让农民增收。

为了实现水稻害虫的可持续治理,加强品种抗虫性的研究与利用显得尤为重要。利用现代分子生物技术和基因工程技术,结合常规育种方法,可培育出更多更好的抗虫品种。同时,还必须从稻田生态系统的整体出发,加强品种、害虫、农药施用、天敌、水稻产量、生产成本等水稻生产要素之间相互关系的深入了解,以制定出较为完善的水稻害虫可持续治理策略与体系,在不久的将来实现水稻生产的无害化。

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