CLOVER ROOT CURCULIO BIOLOGY AND CONTROL

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ABSTRACT

Clover root curculio (CRC; *Sitona hispidulus*) is a pest of alfalfa and clovers. While damage from adults is negligible in established stands, root damage from larvae can have economically significant impacts. Severe root damage can reduce forage yield, decrease stand longevity, decrease winter hardiness, increase winter heaving, and increase plant pathogen infection. In the past, control predominately relied on environmentally persistent, soil-active insecticide applications since phased-out leaving producers with few management options for established stands. Since CRC biology and control has been mostly researched in the eastern U.S., our regional understanding in the West has been too inadequate to begin developing up-to-date management strategies timed to when life stages susceptible to control are present. The objective of this study was to determine the timing of CRC life stages, including the damaging larval stage and overwintering stages, in the Intermountain West. From 2015 to 2018, field surveys were completed in Utah, Idaho, and California using multiple sampling techniques to capture all life stages. The observed CRC larval period is similar to many of those reported in the East. Egg hatch began in early spring (April). Larval development primarily took place until late June to early July, when the most pupation occurred, with very few larvae being found by August. A noteworthy difference observed in the biology of CRC in the West was the primary overwintering stage compared to what has been reported in many areas of the East. Overwintered eggs likely had a higher contribution to damaging spring larval populations in Utah where adult spring activity was low presumably due to high overwintering mortality. In California, it is suspected that eggs laid in spring by overwintering adults influenced larval populations more than overwintered eggs. Continually improving our fundamental understanding of regional variation in life stage timing is a necessary to develop effective management strategies.

Key Words: Clover root curculio, pest management, alfalfa

INTRODUCTION

CRC is an introduced pest of alfalfa and clovers that is found across North America. Like other weevil pests in alfalfa, the adults feed on leaves causing negligible damage in established stands. However, serious seedling injury can occur during establishment when CRC adult populations are high. Eggs are deposited at the soil surface within the alfalfa crown and larvae move belowground after hatching. As newly hatched first instars, they seek out and feed within root nodules where rhizobia fix atmospheric nitrogen used by the plant. As larvae grow, they begin feeding on the small fibrous roots and eventually begin feeding on the taproot and crown where they sever and girdle roots, interrupt water and nutrient transport, and leave behind characteristic

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feeding lesions. Yearly damage is accumulative, increasing as stands age, and often goes unnoticed until the second year of damage once aboveground growth declines (Dickason et al. 1968, Godfrey and Yeargan 1987). Severe root damage can directly stunt plant growth, reduce crown densities, reduce hold hardiness, increase winter heaving, delay spring “green-up”, and impede postharvest regrowth (Godfrey and Yeargan 1987, Godfrey and Yeargan 1989, Hower et al. 1995). Wounding also exposes roots to a suite of soil-borne phytopathogens such as root rots, crown rots, fungal wilts, and bacterial wilts which can synergistically reduce yields further and degrade stand life faster than either pest would alone (Leach et al. 1963, Dickason et al. 1968, Godfrey and Yeargan 1989). Due to the highly interconnected, complex nature of the effects both indirect and direct damage induce, quantifying their economic impact is difficult. One recent estimate of larval damage value in four-year rotation alfalfa hay production ranged from an $8 (three annual cuts) to a $59 (four annual cuts) loss per acre (Rim et al. 2019). Producers can mitigate CRC damage though cultural controls such as rotating to non-host crops (e.g. small grains, grass forages, row crops). By avoiding planting new legume forages next to fields with high CRC densities, damage to new stands can be reduced. Also removing stands at the end of their productive life minimizes continual economic losses from accumulative CRC damage. When feasible, spring seeding allows roots to grow larger before their first year of damage reducing injury relatively. Optimizing irrigation and fertility promotes healthy plants which recover from damage quicker. Since the phase-out of carbofuran and many other soil-active insecticides, there are no curative chemical control options for larvae when economically significant damage is occurring. So far, prophylactic insecticide applications targeting adults for subsequent larval control have not been highly successful so far nor recommended (Kalb et al. 1994, Wenninger and Shewmaker 2014). Such applications require comprehensive knowledge of CRC biology and timing to be effective, which had not been available in the West until recently, but are beginning to be investigated with our improved understanding (R. Long, pers. comm.).

In the eastern U.S., eggs primarily hatch in early spring and the larval period lasts until mid-May to mid-June until pupation occurs. After developing underground in the pupal stage for one to three weeks, adults emerge in mid-summer. After a short period of feeding activity, the adults undergo an inactive period of aestivation, or oversummering, where they conceal themselves in sheltered areas near the soil surface to bypass harsh summer conditions and complete their development (Phillips and Ditman 1962, Roberts et al. 1982). In some eastern states, CRC have been found to immigrate to areas outside of the field in bordering habitats such as woodlands to aestivate. Adults return to the fields in early fall by gradually by crawling or occasionally flying (Culik and Weaver 1994). After aestivation, adults resume activity to feed, mate, and lay eggs until winter temperatures cease activity. Adult activity may resume whenever temperatures are sufficiently warm during winter until spring (≥ 10° C; Bigger 1930). CRC has been reported to overwinter primarily as both eggs or adults depending on location (Bigger 1930, Phillips and Ditman 1962). Adults that overwinter successfully resume oviposition once spring temperatures warm; however, winter mortality can be highly variable (Roberts et al. 1979, Quinn and Hower 1985). This can have an effect on the relative contribution of fall versus spring lain eggs to subsequent damaging larval populations. For example, in Illinois (Bigger 1930) and Kentucky (Ng et al. 1977) spring oviposition is a major contributor to the next generation. In Pennsylvania (Quinn and Hower 1985) and Delaware (Dysart 1990), overwintered eggs drive larval numbers.

There was been very little Western research into regional CRC biology or control. In order to develop effective management strategies that can be used to target susceptible life stages, more regionally adapted information is needed for the Intermountain West. From 2015 to 2018, alfalfa fields in Utah, Idaho, and California were sampled to determine life stage timing including the damaging larval stage and overwintering stages.

METHODS

In 2015, production fields were sampled for CRC life stages in Cache Valley, northern Utah. In 2016, sampling was increased to better capture phenology across all life stages. Adults were sampled with an insect suction sampling device so that active adults on the foliage and inactive adults on the soil surface were both collected. Four 30 meter transects were sampled for each field. Fields were sampled from June to September 2015 (5 sample dates). Seven fields were likewise sampled from April to December 2016 (10 sample dates). Larvae and pupae were sampled by randomly taking 11 cm diameter × 28 cm deep soil cores centered around an alfalfa crown so that roots and the surrounding soil were kept intact. Cores were wet-sieved with water through a standard sieve set so insects could be recovered. Soil cores were collected from the previously mentioned fields from June to July 2015 (5 sample dates, 16 cores per field) and from May to August 2016 (6 sample dates, 8 cores per field). Additional cores were taken in October and December 2016 to check for possible fall hatched larvae. Eggs were sampled by collecting a 7.6 cm × 7.6 cm soil sample approximately 2.5 cm deep placed adjacent to alfalfa crowns. Samples were frozen until processed using a similar floatation and wet-sieving process.

In Magic Valley, southern Idaho, larvae were sampled in three fields from April to October 2018 (15 sample dates). In Tule Lake, in northern California’s intermountain Klamath Basin, larvae were sampled in three fields from April to October 2018 (17 sample dates). Soil cores were collected and processed using similar methods to that described above. Additionally, adult foliar activity was monitored using a standard 38 cm diameter sweep net and egg densities were sampled by collecting and processing soil cores using the same methods as described above.

RESULTS

Adult CRC populations in Utah were moderate when first sampled July 2015 (Fig. 1a) and very low when first sampled May 2016 (0.75 per sample; Fig. 1b). In California, adult abundances were also generally found at low densities in early April with activity increasing in May and declining thereafter. Utah CRC adults exhibited two distinct annual peaks occurring mid-July and late August in 2015 and early August and early October in 2016 (Fig. 1). In California, the low spring-summer peak in adult abundance was much less pronounced than the peak occurring late September (Fig. 2). Moderate numbers of eggs were found in Utah when sampling began in April 2016 (6.75 per sample). Egg densities began accumulating late September (4.18 per sample) until sampling was ended in December (13.09 per sample) as adults continued to oviposit although the rate of egg laying was reduced considerably during November 2016 (Fig. 1b). In California, eggs were at low densities when sampling began in April and increased rapidly reaching high densities for approximately one month. Only a moderate number of eggs were found in October (Fig. 3). When sampling began in June 2015 in Utah, larval populations had already peaked and reached very low numbers by late July (Fig. 1a). Egg hatch began in early April 2016 in Utah with larval development and densities peaking in June. By mid-July, larvae began to pupate with very few larvae left by August 2016. In both years, pupal densities peaked at the end of June to early July (Fig. 1b). Idaho larval populations also began increasing in April and declining by July. By early August, larval densities were very low (Fig. 3). In California, larval densities peaked in mid-April and reached low densities by July (Fig. 2).

DISCUSSION

Our generic understanding of CRC timing from the eastern U.S. is that eggs hatch early in spring, larvae develop into mid-summer when pupation occurs, adults are active after summer aestivation, and they overwinter to resume reproduction in spring. This is generally similar to our data from the Intermountain West with some important exceptions. While adult activity peaked in Utah in early October 2016, there were very few adults by early December. Egg densities continued to increase during fall until sampling ended which indicates that fall lain eggs were the main overwintering life stage (Fig. 1b). This is in contrast to many eastern locations where adults are reported to be the primary overwintering stage. In California, early April egg densities were very low but increased quickly afterwards. Compared to the egg densities found in spring 2018, fall peak densities were moderate comparatively (Fig. 2). It is suspected that overwintered adults and spring lain eggs contributed highly to larval populations. There were also dissimilarities in adult peak abundances between Utah and California. Two distinct annual peaks occurred in Utah during both sample years that were relatively comparable in magnitude (Fig. 1). This is most likely due to adults during summer aestivation being buried down inside alfalfa crowns, where they were difficult to capture, or they had emigrated from the field to other neighboring habitat. In California, the earlier occurring peak in late spring to early summer was much less extreme than the fall peak observed. It is worth noting that the growing season in Cache Valley, Utah is slightly longer on average than that of Tule Lake, California which could impact population dynamics. The larval period observed all locations were very similar beginning in early April and ending in late July to early August. The peak larval density in California occurred about one month before those of Utah or Idaho. Generally speaking, the larval period observed in the West, starting early spring and pupating midsummer is similar to reports from most Eastern locales.

CONCLUSION

Our understanding of CRC biology, timing of life stages, and damage mostly comes from research in the Eastern U.S., most of which was conducted during a time when applications of soil-active, highly environmentally persistent insecticides were commonplace. The lack of modern, widespread research into CRC phenology has left producers and researchers with many knowledge gaps to overcome in order to begin developing effective management strategies. While much of the reported eastern phenology is similar to what was observed in the Intermountain West, there were some regional differences particularly for overwintering life stages which greatly informs management plan development and timing strategies.

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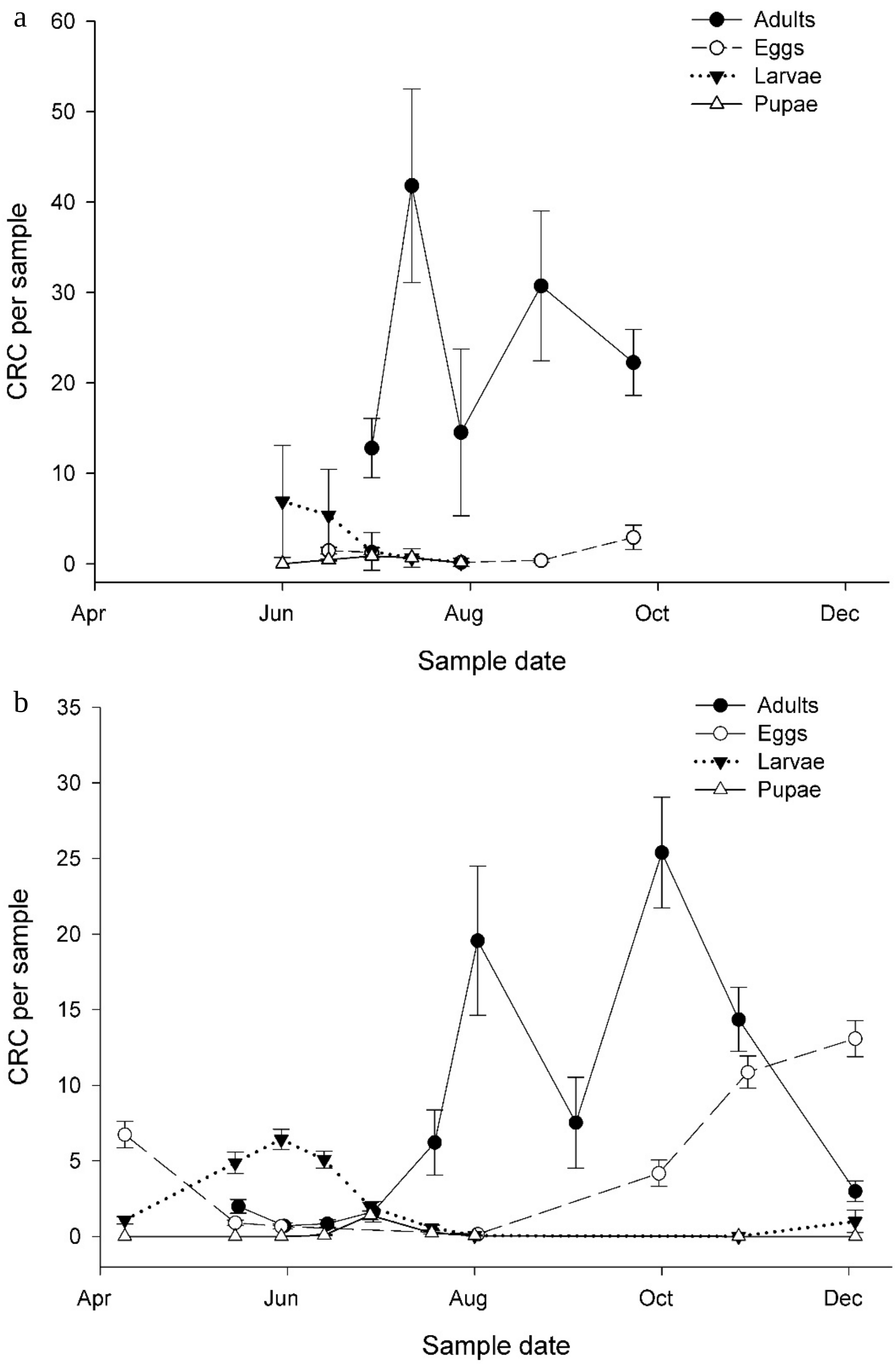

Figure 1. Seasonal distribution of CRC life stages found in Cache Valley, Utah in (a) 2015 and (b) 2016. Values are means ±1 SE.

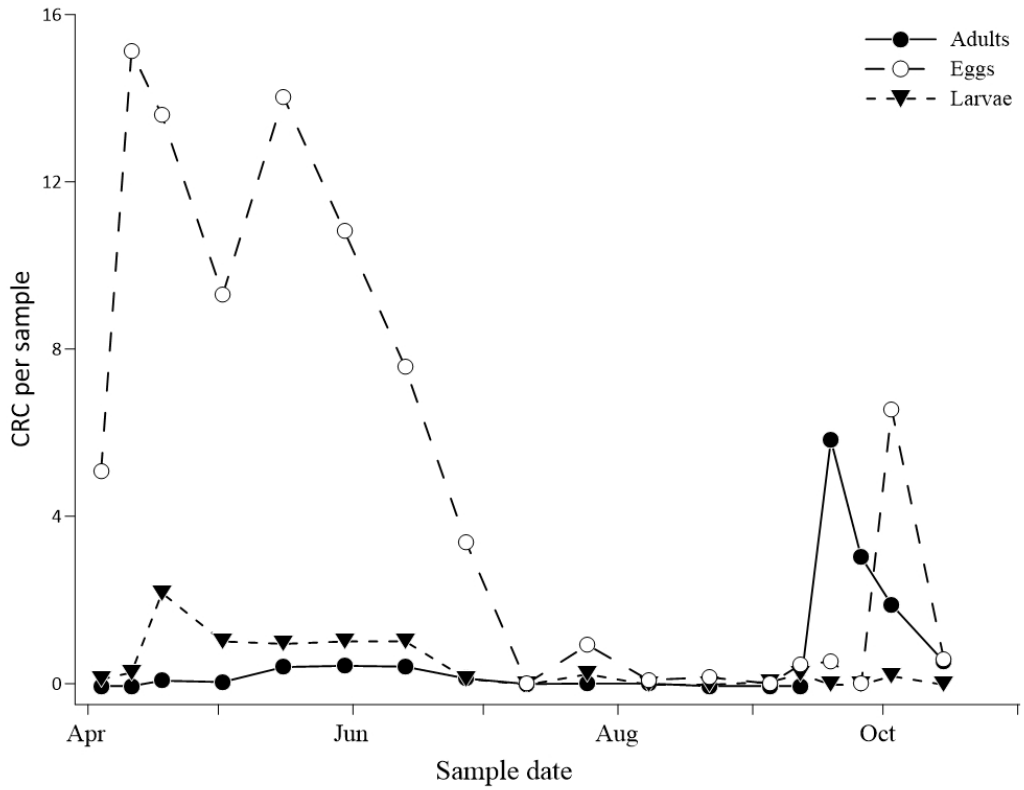

Figure 2. Seasonal distribution of CRC life stages found in Tule Lake, California in 2018. Values are means.

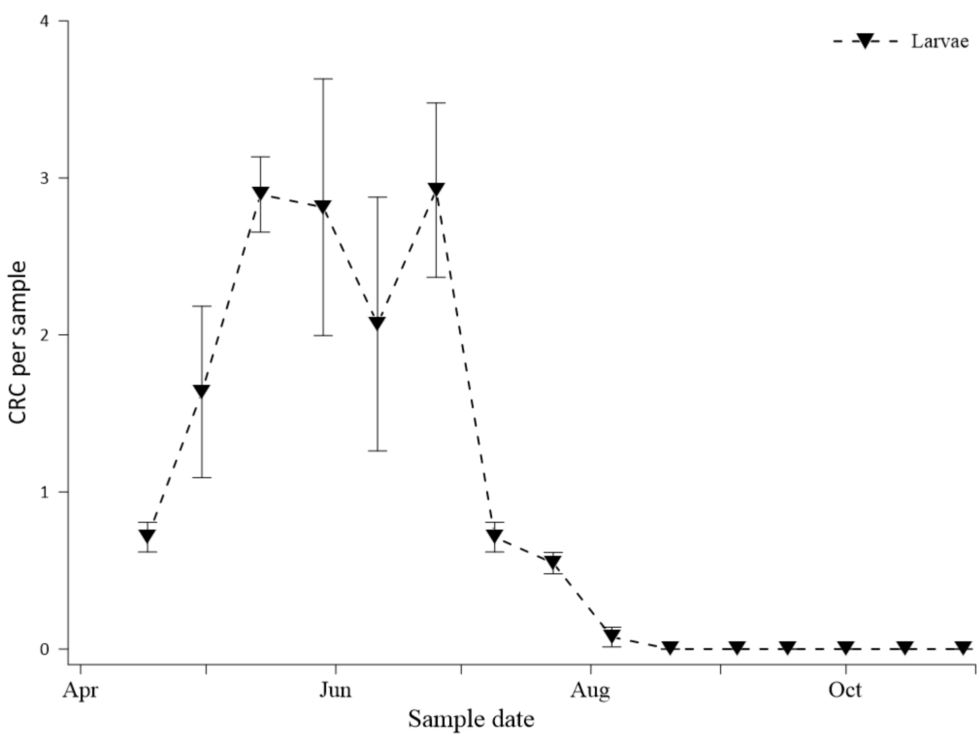

Figure 3. Seasonal distribution of CRC larvae found in Magic Valley, Idaho in 2018. Values are means ±1 SE