## **Climate Change and Pests**



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## Introduction

One of the greatest threats to agriculture today is climate change.

Climate change is likely to result in yield losses due to many factors, including shifting and unpredictable temperatures and precipitation patterns. This is especially true for farmers in regions that have higher temperatures, degraded land, or fewer resources to make quick adaptations in a rapidly changing climate.<sup>1</sup> And, the most impacted regions are likely to be regions where food insecurity and sovereignty is already a threat, such as sub-Saharan Africa and parts of Asia.<sup>2,3</sup>

Pest damage in particular is a challenge for farmers that is expected to worsen as climate change progresses; this is predicted for a number of reasons, including shifting interactions among climate, crops, insect pests, and natural enemies of these pests.

The good news? Increased biodiversity on-farm can reduce pest damage without the use of chemical pesticides, and can improve farmers' resilience in the face of climate change.

# Impacts of climate change on insect pests

Climate change will alter the habitat, biology, and behavior of insect pests—ultimately changing how farmers can successfully control for insect-related yield loss.

First, climate change induced stress makes crops more susceptible to pest damage by reducing innate resistance.<sup>4</sup> Under stressful conditions, the natural defense mechanisms of plants are weakened, making them easier targets for insect pests. This decreased natural resistance may be compounded by other environmental changes. Higher levels of atmospheric carbon dioxide may lead to higher carbon to nitrogen ratios in crops under conventional fertilizer management practices—resulting in a lower quality food source for insects.<sup>5</sup> A potential consequence of changing nutritional content will be higher insect feeding rates to compensate for the lower nutritional value of crop plants in those systems.<sup>6</sup>

Regions with rising temperatures will see warmer summer days, fewer cold days and frosts, and earlier springs. These variables, combined, are likely to shorten the time needed for insects to reproduce, and will reduce cold stress on



insects.<sup>7</sup> Although earlier springs will allow farmers to plant sooner, potentially increasing yields, this will come with the tradeoff of earlier pest colonization of crops and more insect generations per year. For example, in Europe, the first observation dates for 20 species of aphids have advanced by eight days per degree Celsius increase of average temperatures in January and February.<sup>8</sup>

Warming temperatures will also allow pests currently restricted by colder weather to expand their ranges.<sup>9</sup> Areas that are currently too cold for some insects will warm, allowing pests to spread into new regions, posing a threat to more crops. Although it is possible that temperature changes will lead to more of a shift in the range of insect habitats rather than an overall expansion, farmers will still have to adapt to managing new insect pests.<sup>10</sup>

Climate change is projected to modify weather event patterns and precipitation levels. Drought stress not only increases the susceptibility of crop plants to insect damage, but can also mask disease symptoms in plants—delaying detection until significant damage has already occurred.<sup>11</sup> Furthermore, drought can influence the behavior of pests themselves, increasing their movement and spread, also leading to an increase of insect-borne crop disease transmission.<sup>12</sup>

Clearly, a combination of changes in temperature and precipitation will make pest management a more difficult endeavor for farmers as climate change worsens. Innovative, adaptive practices will be the key to maintaining production levels without relying on chemical pesticides.

#### Impacts on beneficial organisms

One key component of non-chemical-based pest management is the potential for **biological control** provided by the

predators and **parasitoids** (a type of parasite) of crop pests, so it is important to also consider the effects climate change will have on these beneficial organisms. The life cycle of parasitoids are closely linked to their pest hosts, which is known as seasonal synchrony.13 This means that the timing of parasitoid reproduction and activity has evolved to coincide with those of their hosts. When that synchrony is disrupted by climate change, parasitoids may be less able to find and parasitize their hosts, leading to less effective biological control. Since parasitoids and predators are higher up on the food chain than crops and their respective pests, it is expected that they will be more significantly impacted by the effects of climate change. This is because organisms that are found in higher trophic levels will have to combat both the direct environmental changes in temperature and precipitation as well as changes in the organisms that they feed on and parasitize.14

A major adaptation found in some insects is **diapause**, which is a state of low metabolic activity and reduced physical activity, enabling increased protection from environmental extremes.<sup>15</sup> For many parasitoids, the timing of their diapause is closely linked to that of their hosts.<sup>16</sup> Consequently, if pest life cycles are modified by climate change, the availability of suitable hosts for natural enemies will be impacted as well. This means that natural enemies will have to adapt their overwintering strategies in response to both changes in temperature with warmer, shorter winters and shifts in host availability.<sup>17</sup> As annual weather trends become more volatile, there may be selection for parasitoids within populations that demonstrate **plasticity**, or the ability to shift when they enter diapause depending on conditions.<sup>18</sup>

Other potential challenges that will arise include changes in the quality of parasitoids' insect hosts due to changes in plant nutrient composition, ranges of insect hosts shifting differently and at different rates than those of their natural enemies, and the ability of parasitoids to survive thermal extremes and move in response to changes.<sup>19</sup> Overall, the effects of climate change on insect interactions will impact the ways in which natural enemies provide biological control of insect pests in agricultural landscapes.

Supporting a diverse community of natural enemies would be beneficial in providing multiple sources of control in the face of increasingly variable climatic conditions.<sup>20</sup> Habitat management strategies such as managing non-crop areas, cover cropping, and intercropping can provide more and better food and habitat resources for natural enemy communities in agricultural landscapes.<sup>21</sup> A broader diversity of natural enemies will be more resilient in response to shifting conditions. Having multiple natural enemy species with different ideal environments will be a more adaptable means of pest management compared to relying on a single solution.

### **Policy**

Widespread use of chemical pesticides has led to mounting negative human and environmental health harms, including threats to biodiversity, stress on ecosystem function, and reduction or elimination of valuable species including beneficial insects such as pollinators and natural enemies. In addition, continued reliance on pesticides exacerbates pest problems by increasing cases of pesticide resistance, depletion of natural enemy populations, and pest resurgence.<sup>22</sup>

Policies designed to diversify farming systems and improve habitat management practices offer multiple benefits. In terms of pest management, habitat management can play two main roles. By providing more biodiverse farm landscapes that make it both more difficult for pests to colonize crops and easier for a diversity of natural enemies to sur-



vive, pest damage is reduced without the use of chemical pesticides.<sup>23</sup> Since specific climate change impacts vary by region, successful management will have to include solutions unique to each region.<sup>24</sup> Therefore, regionally specific habitat management that caters to local climate conditions, pests, and natural enemies will be the most effective response.

A number of current policies have aspects that are valuable in supporting natural enemy populations which will facilitate successful pest management without reliance on the use of chemical pesticides. The expansion of policies that establish and promote these habitat management techniques will provide farmers with multiple means of combating worsening pest infestations due to climate change.

#### **Notes**

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