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Aaron M. Ender

Huron University College, Western University, aender@uwo.ca

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The Exacerbation of Agricultural Pests as a Result of Climate Change

Aaron Ender, Huron University College

Abstract: This paper focuses on the effect of anthropogenic climate on agricultural pests and global food supplies. It explores the challenges twenty-first-century agriculture faces in light of a climate in flux. This paper will outline the empirical evidence and predictive modeling which demonstrate that climate change has a three-fold effect on exacerbating agricultural pest pressures: it creates ideal conditions for pest populations, causes an asynchrony between pest and host plant development, and forces pests to migrate into formerly inhospitable regions. Consideration is given to varied effects of climate change that could mitigate the problem of agricultural pests, though ultimately the net effect of climate change is to the detriment of contemporary agriculture. The paper concludes by arguing that Integrated Pest Management (IPM) techniques offer a limited but sustainable, and ultimately most effective, defensive measure against climate change-induced pests.

Keywords: Agricultural Pests; Climate Change; Ecology; Food Supply; Integrated Pest Management

Creating ideal conditions for pest flourishing

As some areas of the world warm, ideal breeding grounds are created for pests. Field observations demonstrate that climate change aggravates pest pressure on agricultural systems. For example, Caffarra et al. (2011) observe that “in southern Spain the extraordinarily high temperatures recorded in the spring-summer of 2006 resulted in [the] European grapevine moth [population] completing four complete generations as opposed to the usual three” (p. 97). Due to increased temperatures, a substantially larger pest population emerged in a short period of time, straining crop supply. An extra generation of pests in one year leads to less crops being used for the intended consumers, as they are being destroyed by pests, which in turn nourishes them and allows them to thrive. This provides pests with the ability to generate more offspring, continuing the cycle of pest damage on crops.

While this is just one pest in one year, Ouyang, et al. (2014) found a similar trend in China during a thirty-seven-year study, suggesting that as plants thrive in warmer conditions, so do pests, perpetuating the issue of pest pressure on crops. They state that the population of the cotton bollworm, a pervasive pest in Asia, peaked in 1992 at a population size eleven times more abundant than ever recorded (p. 3367). They explain that higher temperatures lead to an extended season for the plants, thus increasing their biomass. This increase creates more food resources for the pests, resulting in a higher carrying capacity and allowing a greater number of pests to thrive (p. 3371). If we do not act against climate change, agroecosystems can become equipped with plentiful resources benefiting pests, paradoxically straining the cropland as a result of having more abundant

crops. The more pests in an area, more crop resources they tarnish, which can lead to catastrophic results in regions that rely on local farmers for sustenance.

While pests find optimal resources in warmer climates and breed more, natural parasites of pests tend to dwindle in overall number as the temperature rises. The lack of parasites leaves abundant agricultural pests with few natural enemies, allowing them to go unchecked in the agroecosystem. Thomson (2009) explains that there may be few host pests during the parasites' vulnerable stage and many parasites may perish before hosts become available (p. 301). Wilson (2015) furthers the study of pest parasites and finds that parasites are not as resilient as their hosts in increased temperatures, inferring that as some climates continue to warm, pests will eventually be rid of their natural predators (p. 745). Since many pests and parasites are ectothermic animals, which rely on ambient temperature for body heat, they face certain temperature limits. Wilson found that the parasites of an invasive species of slug all had a lower temperature threshold, with a steep population decrease when temperatures reach between 18°C-20°C (p. 743). While Wilson only studies one type of pest and parasite, he demonstrates that as temperatures increase in some areas, the agricultural system may face an unencumbered pest population, which produces undesirable effects on the agroecosystem.

Climate change-induced pest and plant asynchrony

Not only can climate change create ideal conditions for agricultural pests, but it can also change pest and plant development cycles. This causes pests in warmer regions to flourish before plants fully develop, allowing the pests to damage the agroecosystem.

Luedeling (2011) explains that ectotherms will likely react rapidly to climate change, and since many plant pests are ectotherms, it is important to predict the effects of climate change on these organisms (p. 228). Pests tend to respond to ambient temperature, and in warmer areas, they develop more rapidly. Caffarra (2011) states that increasing temperature is predicted to have a detrimental effect on crop yield because of the asynchrony between the larvae occurrence of grapevine moths and the larvae-resistant stage of the grapevine. Specifically, the grapevine moth was reported to develop one month earlier than normal as a result of increased temperatures. Due to increased temperatures, plants face more severe damage due to a misaligning of plant and pest development cycles, further aggravating pest pressures on the agricultural system.

Climate change has the potential to create more fertile pests that demand more food, while plants lose nutrients due to increasing carbon dioxide, exacerbating damage as a result of further asynchrony. Finlay (2011) predicts that with faster plant development in warmer climates, the fertility of multivoltine species, which includes many agricultural pests, will also increase (p. 409). As temperatures rise and plant development cycles become more rapid, the productivity and fertility of the pests quickly increase, escalating the issue. Thomson (2009) states that higher levels of carbon dioxide reduce the nutritional value of plants, resulting in the pests consuming more plants in order to acquire equivalent nutrition (p. 297). This creates further upsets the natural balance by means of climate change-induced asynchrony: as pest species increasingly flourish and plants lose nutrients, pests have the potential to decimate food supplies in some regions just to maintain their normal levels of nutrition while producing more offspring, which will in turn lead to greater pest pressure on the food supply. This change

of the natural balance can lead to the extinction of the plant species on which the pests prey, and by extension, other animals in the ecosystem that rely on the same crop. This effect can be pervasive, and as the changes to the ecosystem become more rapid, its effects will begin to increasingly affect the abundance and quality of crop supplies for humans.

Pest migration as a result of climate change

While some agricultural pests are predicted to thrive in their native regions due to climate change, those unfit for warmer temperatures may migrate toward cooler areas, damaging crops unequipped for invasive pest species. In this way, pest damage can become exacerbated both in current regions, and in new regions previously unaffected by certain pest species. Chidawanyika (2012) states that “increasing frequency and severity of extreme temperatures...may modify...insect population dynamics...Hence, insects must be able to cope physiologically or compensate behaviorally with such changes in ambient temperature” (p. 1172). Since rapid pest evolution is rare, researchers such as Chidawanyika predict that agricultural pest migration will become an increasingly pressing issue. Further, Thomson (2009) predicts that cold-intolerant species may increase their geographic range in the future, expanding into formerly inhospitable areas that will begin to warm, resulting in increased damages in new territories (p. 299). Thus, if climate change continues to go unchecked, some species of pests will encounter ideal breeding conditions in their native areas, and others will push outwards and damage new regions. This has the potential to result in widespread food supply threats, as both the

native pest areas and other, new regions could face unprecedented numbers of pests.

Kocmankova et al. (2011) model a similar trend of agricultural pests expanding their habitable territory. They found that the Colorado potato beetle may be able to broaden their domain up to 120% with an average northward movement of 400 kilometers (p. 193). The predictive models account for the years of 2021 to 2050, when pests are predicted to gain a large area of habitable territory. If pests migrate at the rate Kocmankova et al. predict, crop regions could face a rapid influx of invasive pests, threatening the regional food supply.

Pest migration has also been recorded through field observations. Nandudu (2014) states that coffee leaf rust disease caused by the Black coffee twig borer, which has normally only affected coffee plants at altitudes below 1,400m above sea level, has now reached 1,800m above sea level. Nandudu states that this is evidence of rising temperatures in the region, since these pests migrate to higher altitudes with cooler temperatures (p. 3). Rather than moving in latitude, the Black coffee twig borers are moving in altitude, which damages crops in far more elevated locations than the industry is accustomed to. Nandudu notes that 85% of the coffee farms in Uganda are family-operated and are facing alarmingly low yields (p. 2). Morelle (2013) states that field observations have also shown some insects migrating at a rate of 20km per year away from the equator (p. 2). While some pests have been recorded moving outwards, others move upwards into cooler areas, and both behaviors pose threats to crops. As pests continue to migrate, farms will be faced with non-native pests, leaving them vulnerable to damage for which they are unprepared, and which may be insurmountable for some local, family-owned farms that supply staple foods.

Integrated pest management techniques

Integrated Pest Management (IPM) techniques offer a sustainable solution to pest problems than traditional pesticides. The IPM Institute of North America outlines their techniques as involving cultivating naturally pest-resistant crops, predicting pest outbreaks to prevent crop damage, and controlling the environment by using natural pest predators as biological controls (p. 1). In effect, “IPM means responding to pest problems with the most effective, least-risk option...Any action taken is designed to target the troublesome pest, and limit the impact on other organisms and the environment” (p. 1). IPM advocates discourage broad-spectrum management, such as pesticides like Round-Up that kill all organisms, even those which are beneficial to the agroecosystem. IPM reduces pesticide usage and incorporates aspects of sustainable farming, such as soil preparation and the use of natural pest enemies in the agroecosystem (p. 1-2). Because broad-spectrum pesticides can kill beneficial organisms and lead to pests developing pesticide resistance, IPM aims to solely eliminate target pests, and advocates only for small pesticide usage as a last resort (p. 1). The holistic approach of IPM techniques is superior to traditional pesticide usage, since it provides farmers with a method of removing harmful pests, retaining useful organisms, and preventing pest pressures from occurring, using forecasting and strategic planting. IPM provides a sustainable response to pest pressures, which will become increasingly important as climate change continues to exacerbate pest pressures.

However, the use of IPM is not sufficient on its own to combat the pest problem

caused by climate change. IPM involves the “least-risk solutions to prevent pest trouble or respond to problems when they arise” (p. 2). For example, Vietnamese rice farmers faced pest pressure from the green leaf hopper, which developed pesticide resistance. The International Rice Research Institute (2013) challenged 950 Vietnamese farmers to practice IPM, and their plots yielded both more and better quality crops by ridding themselves of the pests. Further, some farmers cut their pesticide usage fivefold with these techniques (p. 1). IPM helps to prevent crop damage, but it will not fight the root cause of increasing pest pressures. While IPM presents a superior option for protecting crops compared to traditional strategies, its use will require a constant combat scenario between farmers and pests. Since IPM requires constant monitoring of the crop conditions, and responding to pest issues based on specific cases rather than a mass spray of pesticides, there will be no point at which farmers will be able to stop IPM practices. As pest pressures increase, farmers will need more frequent and more powerful IPM usage, draining time and resources. While pesticide use also involves a continual process of killing pests as they come, it does not require as diligent monitoring or as precise treatment as IPM. Further, even if we are able to overcome the time requirement of IPM, Chidawanyika (2012) states that “inevitably, the efficacy of biological control systems is highly dependent on natural enemy-prey interactions, which will likely be modified by changing climates” (p. 1). IPM will work well under existing conditions, but it will need to adapt quickly under increasing climate change. If we wish to combat pest pressures most effectively and prevent potentially catastrophic damage to crop supplies, climate change itself must be addressed.

Conclusion

Climate change threatens global crop supplies by improving breeding grounds for some pests; allowing others to damage vulnerable plants; and pushing non-native pests into areas that are unequipped for them. While farmers have implemented strategies to fight pests, such as IPM, pests will continue to flourish until climate change is addressed. A perfect solution is unlikely, but by using IPM as a preventative measure to ward off pests, crop damage can be mitigated while researchers address climate change.

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AARON ENDER is a second-year undergraduate student pursuing an Honours Specialization in Philosophy with a Minor in English at Huron University College. His primary interests in this field of study are Ethics, Political Philosophy, and Logic. Upon the completion of this program, he intends to pursue the field of Law.