Fertiliser strategies, drones and apps – New approaches to pest management

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Key messages

- Insect and mite pests of crops carefully select their host plants and prefer plants that are nutritionally unbalanced (stressed).
- Stressed crops reflect sunlight differently compared to healthy crops, so remote sensing technologies can be used to monitor risk of crop infestations by insects and mites.
- Manipulation of crop nutrition through fertilisation can be used to reduce risk of infestations by insects and mites and also to improve sampling/scouting. This will lead to fewer and more efficacious applications of pesticides.
- In this paper, it is argued that recent advances in remote sensing technologies will revolutionize pest management programs and lead to a dramatic shift towards reduction of crop suitability to pests rather than the current reliance on responsive pesticide applications.
- Fewer and more efficacious applications of pesticides will reduce crop management costs and also decrease the risk of target pests developing resistance – so it will extend the longevity of currently available pesticides.

Introduction

A recent review article claims that UAVs (unmanned aerial vehicles) will revolutionize management practices in natural resource management and agriculture (Anderson & Gaston, 2013). The growing interest and use of imaging systems mounted on UAVs is mainly driven by technological improvements, reductions in equipment costs and improvements of classification methods of reflectance data.

The applied use of reflectance data in crop management is based on important assumptions about relationships between "crop status" and the way crops absorb/reflect sunlight. Through photosynthesis, plants utilize light in the visible part of the radiometric spectrum (400-700 nm) as energy source. When/if a crop plant is "stressed" – for instance drought or nutrient deficiency (eg lack of fertiliser) – the crop plant becomes less efficient in its ability to utilize sunlight as energy source in the photosynthesis. As a consequence, the overall reflectance profile from leaves of a stressed crop plant is generally higher than that from "healthy crop" leaves (Carter & Knapp, 2001), because more energy is reflected from leaf surfaces to the atmosphere (not absorbed).

The challenge is therefore to identify specific changes in reflectance profiles which are associated with specific stressors, so that acquisition and classification of crop reflectance data can be used to assess/monitor the status of crop plants. As an analogy, the potential use of crop reflectance data is somewhat similar to how infra-red thermometers are used to measure the body temperature in humans: a radiometric signal in particular wavelengths is emitted and projected onto human skin, and the

reflectance is measured and converted into a prediction of our internal body temperature. The infra-red signal does not penetrate into human tissue, but a classification algorithm has been developed in which the skin surface reflectance signal is used to estimate the internal body temperature.

Similar to the use of an infra-red thermometer, we have recently published a study, in which we demonstrated that potassium levels in crop leaves could be estimated based on surface leaf reflectance (Nansen et al., 2013). In the same study, we also demonstrated that spider mites preferred crop leaves with low potassium levels, and this finding is consistent with a large body of research (Amtmann et al., 2008). More recently, we have shown that also redlegged earth mites and aphids appear to prefer canola plants with low potassium levels.

Discussion

It is therefore argued, that we are indeed at the brink of a revolution in pest management practices in agriculture, in which the concept of "preventive medicine" is deployed to crop management – keeping the crop healthy may reduce the risk of pest infestations and therefore minimize the need for responsive pesticide treatments.

A shift towards preventive crop management is becoming practically and economically feasible, because: 1) remote sensing technologies (camera systems mounted on UAVs) are now available and economically feasible for widespread use in large-scale row-cropping agriculture, 2) there is growing understanding of how reflectance data can be acquired, processed and analysed to estimate the general suitability of a given crop to particular pests, and 3) there is a growing body of research demonstrating how insects and mites tend to prefer crop plants with particular nutritional unbalances. Thus, remote sensing technologies may be deployed as part of automated crop scouting systems so that crop stress can be detected early and pest infestations can either be avoided through precision-applications of required management practices, such as precision-fertilisation.

Alternatively, pest infestations may be detected at an emerging stage and precision-targeted pesticide applications used to eliminate the stressor. There are several very important positive ramifications of precision-targeted pesticide applications (Nansen & Ridsdill-Smith, 2013): 1) Pesticides are only applied WHEN and WHERE they are needed, so the overall use is reduced, 2) With only "hotspots" being treated, pesticides can be applied with much higher spray volume, which increases canopy penetration, reduces risk of drift, and increases the likelihood of target pests acquiring a lethal dosage – so higher performance and less risk of target pests developing resistance.

There are other important reasons why we will likely see a significant shift towards more preventive crop management practices (Nansen & Ridsdill-Smith, 2013): 1) target pests continue to develop resistance – both physiological and behavioural (Martini et al., 2012) – to pesticides, 2) a growing number of pesticides are being phased out, 3) few or no new modes of action are being identified, and 4) the costs associated with pesticide development are increasing, so chemical companies are less likely to pursue new registrations. Thus, exclusive reliance on pesticide applications is becoming increasingly challenging and less likely to be a long-term sustainable pest management strategy.

As part of this scenario in which reliance on pesticide applications is very high, it is also very important to mention that farmers manage larger and larger farms and have less and less labour – so they have to drive faster and use lower spray volumes per hectare in order to complete their pesticide applications. High speed, low spray volume, and

adverse weather conditions lead to low and inconsistent spray coverage and therefore a higher risk of poor pesticide performance.

We have recently developed a freely available phone app (both for Android and IOS) to estimate spray coverage based on spray setting and weather conditions (http://agspsrap31.agric.wa.gov.au/snapcard/). We are hoping farmers and crop consultants will use this decision support tool to optimize pesticide spray applications, so that applications are avoided when weather conditions increase the risk of spray drift, and the likelihood of good spray coverage and canopy penetration is increased. We are also hoping farmers and crop consultants will use this decision support tool to optimize spray settings (for instance, chose the best combination of spray volume and nozzle size). But the reality is often that farmers cannot drive slow enough, use high enough spray volumes, and spray coarsely enough – they simply don't have the time! And that is precisely why the first part of the this paper – the use of remote sensing technologies (camera systems mounted on UAVs) – has to be integrated into efforts towards optimized pesticide spray applications, because it can be used to pinpoint hotspots of WHEN and WHERE applications are needed so that precision rather than broadcast applications are deployed.

Conclusion

There are essentially two opposite approaches to solving a problem (such as a pest infestation in a crop):

1) responsive (or reactive) approach - dealing with the consequences and minimizing the damage, AFTER it has happened, or
2) preventive (or proactive) approach - focusing on prevention and therefore avoiding the problem BEFORE it has happened.

Farmers manage their crops through a combination of these two extreme approaches, but there is a strong bias towards responsive approaches, and in particular an almost exclusive reliance on broadcast pesticide applications. We predict that a growing number of farmers will embrace pest management approaches, which are more in line with modern preventive medicine philosophy in which crop tolerance to pests is minimized through a strong focus on boosting crop health and the crop's inherent pest resistance mechanisms. Only very rarely do insect and mite pests cause moderate to severe economic yield losses every year and in all paddocks within a region. Here, it is argued that the pests are there every year, but crops are able to resist infestation in most combinations of growing seasons and regions.

We need more and better understanding of the environmental factors triggering the crop stress that leads to increased crop suitability to pest attack and therefore economic yield losses. With that knowledge, we can develop preventive pest management strategies and therefore reduce our reliance on pesticide applications. The progress and continuing development in remote sensing and the growing availability of smart phone decision support tools is paving the way for this intriguing and exciting revolution of pest management in broad area cropping.

Acknowledgments

GRDC Project No.: UWA00144, UWA00158

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