A Review :

Pest management strategies in precision farming

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SUMMARY

Knowledge of within field variability allows producers to identify and characterize the site-specific management needs for an individual field or management zones within a field. Precision agricultural technologies and site-specific management strategies allow producers to differentially target crop production inputs to those fields or management zones that are likely to provide the greatest benefits. Insect pest management still represents one of the greatest variable expenses incurred by a cotton producer in Louisiana (USA). Cotton integrated pest management (IPM) utilizes chemical control strategies for insects by targeting only those populations that exceed an economic action level to initiate treatment. In Tamil Nadu precision farming project (TNPF), study has revealed that adoption of precision farming has led to 80 % increase in yield in tomato and 34% in brinjal. Increase in gross margin has been found as 165 and 67%, respectively in tomato and brinjal farming. Lack of finance and credit facilities have been identified as the major constraints in non-adoption of precision farming.

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Insects, diseases and weeds are the major pests that the farmer encounters during crop cultivation. Although, there are various means of pest management *viz.,* cultural, mechanical, biological control etc., farmers continue to rely upon chemical control for its greater efficacy, easy handling and quick results. But the over-application of pesticides leads to the problem of chemical residues in soil as well as in the produce. Hence, it is essential to apply appropriate amount of pesticides. Considerable variability exists in the population dynamics of pests over every piece of land. However, in conventional agriculture, without considering this variability pesticides are being applied at a uniform rate throughout the field. Precision pest management (PPM) emphasizes on this aspect and deals with judicious pest management at micro-level wherein only required quantities of pesticides are applied giving due consideration to the existing variability of pests.

Precision farming:

Precision farming is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for the purpose of improving crop performance and environmental quality (Biswas *et al.,* 2008).

Precision pest management (PPM):

PPM deals with judicious pest management at micro-level wherein only required quantities of pesticides are applied giving due consideration to the existing variability of pests. It is also defined as the art and science of utilizing advanced technologies for enhancing crop yield while minimizing potential environmental threat to the planet (Khosla, 2001).

Components of precision pest management:

Geographical information system (GIS), Global positioning system (GPS), Remote sensing (RS) and Farmer are the major components of precision farming (Sharma *et al.*, 2005).

Geographical information system (GIS):

As the precision pest management is information based and concerned with spatial and temporal variability of pest population, GIS is the part and parcel of it. GIS is the key to extracting value from information on pest population dynamics. GIS is the brain of precision farming system and it is the spatial analysis capabilities of GIS that enable precision farming (Clark and McGucken, 1996). But due to complex nature of available GIS software packages, non-specialists may find it difficult to practice in pest management. Therefore, some simple, easy to use formats need to be developed for suitability of this technology in production agriculture including pest management. The pest population dynamics could be better understood through computer simulation modeling and linking of GIS with these models are crucial for precision management (Goodchild *et al*., 1993).

Global positioning system (GPS):

All the aspects of precision agriculture require positioning information and it can efficiently be provided by the GPS. It was initially developed by the US military. GPS provides accurate positional informational which is useful in locating the existing spatial variability. The inherent accuracy of GPS is about 5m, which is based on a 95 % probability that the position given will be within 5m of the true value position (Sharma *et al*., 2005). Development of precise GIS/GPS auto-navigation systems increased the efficiency of the field operations in precision agriculture. Although the GPS signal is ubiquitous, there are problems in making available GPS for pest management and the agricultural practices at the required precision (Saunders *et al*., 1991). Simplification of the system with wider use is urgently needed to solve the problem.

Remote sensing (RS):

Remote sensing is already being used for soil mapping, terrain analysis, crop stress, yield mapping and estimation of soil organic matter, but on a scale larger than what is required for precision agriculture. Remote sensing at high resolution can be of great use in precision pest management because of its capacity to monitor the spatial variability (Moran *et al*., 1991).

Farmer:

Precision pest management is information and knowledge based practice. Therefore, farmers have to be trained adequately so that they can monitor the dynamics of pests and take right decision at the right movement (Biswas *et al*., 2008).

Aims of precision farming:

The main aims of precision farming include increased production efficiency, improved production quality, more efficient chemical use, energy conservation, soil and ground water protection (Biswas *et al*., 2008).

Most precision agricultural technologies have focused on agronomic inputs to increase yields or reduce input costs (Srinivasan, 2006). Lambert and Lowenberg-DeBoer (2000) reported that over 70% of the research efforts focussed on variable rate application of general agronomic inputs (nutrients, seeding rates, irrigation etc.). Precision insect pest management tools for integrated pest management were not addressed in 'The Handbook of Precision Agriculture', a review of current precision agriculture techniques and research around the world (Srinivasan, 2006).

Precision pest management in different crops:

The potential profitability of site-specific nitrogen management in corn was found to range from 11 to 72 dollars per hectare when compared to a uniform application (Malzer *et al.,* 1996).

Nitrogen fertilizer usage was reduced by 30 to 121 lbs/ha with variable rate application when compared to broad cast treatment. The net return per hectare was $12 to $35 higher using variable rates of nitrogen when compared to the broadcast treatment (Koch *et al*., 2003). Lewis *et al*. (2002) found the reduced PGR use by 40% using a variable rate strategy based on NDVI images as compared to whole field broadcast treatment.

Remotely-sensed data when used as the basis for variable rate cotton harvest aid application, reduced total pesticide requirements by 18% while maintaining yield and fibre quality (Fridgen *et al*., 2003).

Read and Stevens (2002) used GPS technologies to generate detailed records of treatment locations when applying restricted use of pesticides for the control of mosquitoes. A promising site specific management technology that can reduce insect pest management input is based on the concept of spatially variable insecticide (SVI) application. This application is assessed when an economic threshold is reached, but they are only applied to those areas of field requiring treatment for the pest problem. Most prescription for a SVI application have relied upon remotely sensed data used to generate vegetation indices related to plant health and are indirectly related to insect pest numbers. One such vegetation measurement is the Normalized Difference Vegetation Index (NDVI) which has been used to develop prescription for SVI application to the most vigorously growing zones of field for control of plant bug (Heteroptera: Miridae) in cotton (Willers *et al.,* 1999).

SVI treatments based upon remotely sensed data have resulted in 20 to 40% reduction in insecticides compared to whole field broad cast application (Dupont *et al*., 2000).

Khalilian *et al*. (2003) used variable application rates of aldicarb (Temik 15G, Bayer Crop Science, Research Triangle Park, NC) and 1, 3-Dichloropropene (Telone II, Dow AgroSciences, indianapolis, IN) using prescription based on soil texture. Both treatments increased yield by 5% when compared to that in non-treated areas, Temik and Telone use was reduced by 34 and 78 % respectively, while using the variable rate application strategies across field against nematode in cotton.

A variable rate pesticide application system was developed and tested during 2001 for an agricultural aircraft in Louisiana. Using technology available to the agricultural aviation industry, a variable rate prescription of insecticide was successfully applied to a cotton field in 2002. These studies compared the efficacy and value of spatially variable insecticide (SVI) applications based on yield maps to the producer standard, whole-field broadcast treatments. Insecticide prescriptions were created from historical yield and production data. Treatments included whole-field broadcast sprays, yield-based SVI sprays, and profit-based SVI sprays. Twenty-two SVI applications were made to test fields from 2002-2005 using two aircraft equipped with on-board computer systems. SVI technologies reduced crop input costs for insect pest management, but did not significantly impact yield or crop profit within the conditions of these tests. Insecticide costs were reduced by $12 to $35 per hectare depending on the application frequency and SVI strategy. There was a 13% to 32% reduction in hectares treated in the SVI treatment strategies compared to the whole-field broadcast (producer standard). These studies showed that variable rate application of pesticides can be accomplished using an agricultural aircraft. Intra-field management zones for reducing crop inputs (insecticides) were developed from yield and profit maps. SVI prescriptions can allow producers to manage crop production costs by restricting inputs in Louisiana (USA) cotton fields (Temple, 2007).

The share in total variable cost in the case of precision farmers was highest for fertilizer (27.15%), followed by human labour (25.04%),. Within the cost on human labour, 72.21 per cent was paid out to hired labour and the rest was imputed value of family labour. In non-precision farming, plant protection chemical was found to be the major input, accounting for 31.06 per cent of the total cost, followed by human labour (25.47%), fertilizer (9.70%) and seedlings (7.90%). The gross margin calculated as the difference between the gross return and variable cost, was 166 per cent higher in precision than non-precision farming in tomato production in Tamil Nadu precision farming project (TNPFP) (Maheshwari *et al*., 2008).

Due to precision farming project has increased the income levels of the farmers of TNPFP besides empowering them in marketing. Cabbage and cauliflower farmers achieved yield of 60 t/ha each (20% increase) as against 50 tonnes by other farmers. Farmers who raised tomato achieved 65 t/ha (an increase of 63% over non-project farmer) as against 40 t/ha while chilli farmers achieved yield of 29 t/ha as against 1.5 t/ha (an increase of 95%) (Vadivel *et al*., 2008).

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The lack of finance and credit facilities were the most important reasons for non-adoption of precision farming in TNPFP. Obtaining credit was difficult process, because farmers could not produce collateral security. Drip installation and use of water-soluble fertilizers were very expensive and required credit. Because of output price fluctuations, farmers were not ready to make investments. Lack of knowledge about precision farming technologies was another important constraint, because a majority of small farmers were illiterate and were not able to follow and adopt latest technologies. Labour scarcity was also a problem in adopting precision farming. Due to urbanization and migration, there was a scarcity of labour for agricultural operations. Since precision farming was highly labour intensive technology and operations were time-bound, farmers faced the dearth of labour, especially during stacking and harvesting (Maheshwari *et al*., 2008).

Conclusion:

Precision farming gives farmers the ability to more effectively use crop inputs including fertilizers, pesticides, tillage and irrigation. More effective use of inputs means greater crop yield and quality, without polluting the environment. However, pest management research in precision farming is meagre and hence, needs immediate attention of the scientists.

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