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Review on the Mutual effects of Conservation Agriculture and Integrated Pest Management on Pest and Disease Control in Agriculture

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ABSTRACT: Crop pests and pathogens have caused a serious significant yield loss of more than 40% in major crops worldwide in recent years. It is projected that many important crop producing countries will be fully saturated with pests and pathogens in next few years. Endevours to control pests using conventional methods have failed to achieve the goals of sustainable yield in agriculture. This is due to negative effects associated with the used modern agriculture inputs to control insect pests and pathogens. The failure to supply enough food to feed the growing population calls for identifying appropriate method that will sustain yield without harming the environment, human and other organisms. This review used online materials to identify the advantages of combined integrated pest management (IPM) and conservation agriculture (CA) in the agricultural crop production. The benefits farmers accrue as the result of combined appropriate IPM and CA management strategies includes; reduced production cost, slower development of resistance to chemicals. Achieving long term pest, pathogens and weeds control, reduce risks due to pesticides or herbicides use, reduction of emergence of cultivar resistant breaking species/isolates/tribes/strains, ultimately improves yield. Others are low labour requirement, increase water conservation, fertility increase and reduced land degradation. The job that is yet to be done is research on appropriate IPM and CA for specific crops is needed. It is concluded that the appropriate solutions will depend on the effective promotion, monitoring and evaluation of changes in farming practices. This calls for stakeholders including researchers, scientists, political class, the government and farmers come together to discuss issues and lay down laws and regulation that will help the implementation of IPM and CA to rescue the world vulnerable community and the environment.

KEYWORDS: Agricultural systems, Conservation Agriculture, IPM, Yield increase.

1.0 INTRODUCTION

Crop pests and pathogens have afflicted farmers' fields causing significant yield loss since the dawn of agriculture and their menace to global food security still persists (Stukenbrock and McDonald, 2008; Flood, 2010;Savary et al. 2019; Yubak et al., 2022).These organisms are part of the natural environmental system, in which there is a balance between predators, pests and pathogens. They only become 'pest and diseases' when their activities start to damage crops and affect yields (Pretty and Bharucha, 2015; Savary et al., 2019). They lower crop yield by 20 to 35% leading to management cost of up to USD 2,250 per hectare per year (Yubak et al., 2022).Pest and pathogens assemblages significantly correlated with socio-economics, climate and latitude (Bebber et al., 2014) and in doing so they present a barrier to the achievement of global food security and poverty reduction (Pretty and Bharucha, 2015).The intensification of agricultural practice has provided opportunities for certain pests and diseases to thrive in a range of crops (Leak, 2003).Successful disease management in the agriculture system will only be achieved through awareness and integration of techniques to manage the complex interactions between the pathogens/pests, hosts and environments (Bailey, 1996).Traditionally, several method have been employed to manage pests and diseases by commercial and smallholder farmers in different scenario. Each method was without weakness or negative side effects to farmers, consumers or the environment where it was applied. The conventional methods farmers applied were either applied singly or in a combined manner. Here under is the short discussion of the disease management methods commonly used by farmers in the past to present;

1.1. Use of resistant/tolerant cultivars

Growing pest/disease-resistant cultivars is especially useful under subsistence farming in the developing countries (Dar et al., 2006; Bažok, 2022)Host plant resistance is an important strategy to prevent pest emergence and it is suggested for use in the control of

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several pest and disease (Bažok, 2022). Introgression of resistance genes into high yielding varieties and hybrid parents is an important pest and disease management strategy (Kumar et al., 2017).This can help to reduce the risk of infection and pest damage in the agricultural system. Researchers and Breeders all over the world are busy developing resistant cultivars that can be used by smallholder farmers to curb the problem of yield lost due to pest and diseases. High/tolerant levels of plant resistance, which are effective in providing optimum control of the target pest and diseases are available against a few insect and pathogen species. This method have been reported to be reliable and environmentally friendly. The only challenge is many cultivars loss of resistant as the result of pathogen and pests evolution and pest and pathogen pressures, which is wide spread worldwide. It is also difficult in some crops to introduce resistant genes due to complexity of nature that guide their inheritance.

1.2. Chemicals method of pests and disease control

Efforts to protect crops started centuries ago, many societies in the past used lime and wood ash to destroy parasites. The Romans used sulphur and bitumen, a substance derived from crude oil. Substances such as nicotine from tobacco were used from the 16th century on and later copper, lead and mercury as well. After the Second World War the use of true chemical pesticides started and nowadays there are hundreds of chemical pesticides available for use in agriculture. Chemical control is based on substances that are toxic (poisonous) to the pests and pathogens involved (Leake, 2003).When chemical pesticides are applied to protect plants from pests, diseases or overgrowth by weeds, we speak of plant protection products (Dar et al., 2006).

The advantage of using chemical pesticides is widespread due to their relatively low cost, the ease with which they can be applied and their effectiveness, availability and stability. Chemical pesticides are generally fast-acting, which limits the damage done to crops. The negative effects of pesticides are often not just toxic to the organisms for which they were intended, but also to other organisms. The non-selective products are the most harmful, because they kill all kinds of organisms, including harmless and useful species. Even if 90% of the pest population is killed with pesticides, the remaining population multiplies at a much faster rate in the absence of natural enemies (Dar et al., 2006).Pesticide use exerts a powerful selection pressure for changing the genetic make-up of a pest population. Naturally resistant individuals in a pest population are able to survive pesticide treatments. The survivors pass on the resistance trait to their offspring. The result is a much higher percentage of the pest population resistant to a pesticide (Dufour, 2001).

1.3. Cultural practices

Cultural controls are one of the most common and effective ways to control pests and diseases in farmers' fields. This involves using practices such as crop rotation, mulching, tillage, timely sowing, pruning, good field hygiene practices and companion planting to create an unfavorable environment for pests and diseases (Leake, 2003). For example, crop rotation can help to prevent common problems like root rot and whitefly infestations. By growing different crops in different garden areas, you can disrupt the life cycles of pests and diseases and make it difficult for them to establish themselves. Mulching can also help control pests and diseases by creating a barrier between the soil and plants that pests and diseases cannot penetrate. Companion planting is another great way to control pests and diseases. By planting certain crops next to each other, you can create an unfavorable microclimate for pests and reduce the spread of disease.

1.4. Physical Controls

Physical controls, such as barriers, traps, hand picking/physical catching up or destroying of pests and pathogens are a common and effective way to keep pests and pathogens out of the fields. It also utilize some physical component of the environment, such as temperature, humidity, or light, to the detriment of the pest and pathogens (Dufour, 2001).For example, common bugs, such as aphids and beetles can be controlled with sticky traps or insecticidal soap. In addition, physical controls can also help to prevent the spread of diseases.

1.5. Biological control

Cook (1993) stated that best alternative to pesticides is biological control. This method involves of using living organism to check the population pests in the fields. Biological control uses parasites, predators, or pathogens to maintain pest populations below economically damaging levels, and may be either be natural or applied (Dufour, 2001). For example ants were used as the natural enemy of pest insects. Biological control, just like chemical control, has advantages and disadvantages. The advantage is that the natural enemy can become established and this will produce long-term results. The risk of resistance is also much lower since pests cannot build up resistance to being eaten. Natural pest control is much targeted and therefore an effective way to control particular pests. The disadvantages of biological control are that natural enemies may move away and become alien species. In greenhouses this problem can be managed, but not in open fields. Spreading over a larger plot also takes time. Another disadvantage is that pests are never destroyed completely because the natural enemy needs to stay alive and they will therefore never destroy the entire population. Finally, it is not possible to use them before the pest has occurred and this means that some damage will be done to crops.

1.6. Quarantine

The rapid movement of people, food, fiber, and other goods about the globe makes effective quarantine a difficult task. As a consequence, present efforts and methods are not considered to be as effective as formerly. There is a need to develop and implement improved technologies for preventing the introduction of undesirable organisms into the United States. Also a need exists to improve survey and identification capabilities for exotic pests in order to find new introductions before they become too widespread and well-established to be eradicated.

1.7. Prevention

Implementing preventative measures inherently reduces the risk of incidence, and suppressing harmful organisms reduces the possibility of a single species becoming dominant and significantly impacting a cropping system. It is important to prevent the introduction of any pests or pathogen into the field through sources like irrigation water or manure, farmers prevent the chances of a certain disease or pests to occur in the fields (Dufour, 2001). This can involve destroying the nest and laying sites of the pest or pathogen before its occurrence. This can be a joint action and cooperation between all farmers could considerably reduce chances of infection or infestation.

2.0 WHY EMERGENCE, RE-EMERGENCE AND PANDEMIC OF PEST AND DISEASE IN AGRICULTURAL SYSTEM

In the 1940s and 1950s modern agriculture (green revolution) resulted in overuse of pesticides, both in terms of treatment frequency and doses (Paudel et al., 2020). This led to ecological disasters and the impossibility of controlling pest populations due to build-up of pesticide resistance (Paudel et al., 2020). No doubt modern agriculture and industrial agriculture brought tremendous gain in yield through intensive agriculture (Ahmed and Ahmed, 2015). Kumar et al. (2017), reported that the use of pesticides and chemical fertilizers has played a big role in increasing agricultural productivity and in making India self-sufficient in food grain production. The increase in yields can partly be attributed to improved plant pest and disease management, including better understanding of the disease causing organisms and the use of a range of different control measures (Berlin et al., 2018). Intensification of agriculture brought ecological, social and economic concerns resulting to health hazards, environmental and biota pollution, and economic loss (Gold, 1999). Cases of pest and pathogen resistance to pesticides/herbicides have been reported ever since man began using chemicals to protect plants (Bazok, 2022).

Many methods employed intensive agriculture above due to their nature have either contributed to emergence, re-emergence and pandemic of some pests and diseases in the agricultural system. The ability of pathogens and pests to adapt and the speed at which they do so, is central to explaining emergences, resurgence and the extent of the effects they cause on crop plants. Pests and pathogens have been reported to have increase severity/damages on crops in the agricultural system globally due to several factors that favors theirs survival in recent years (Berlin et al., 2018). To understand how new diseases and pest damage emerges, and more generally to understand the spread and maintenance of diseases is essential in designing proper management strategies in crop production. The following factors are involved in emergence, re-emergence and pandemic of some pests and diseases.

2.1. Monoculture/monocropping

Many cropping practices have a significant impact on pest and disease incidence and susceptibility of cropping systems to pests and disease (Bazok, 2022). Growing of the same crop every year, that is the development of large-scale mono-cropped agri-systems, this has facilitated increased problems with pests and diseases, perpetuating the reliance of farmers on synthetic pesticides (Alyokhin, et al., 2013; Belmain et al., 2021). Intensification of agriculture and adoption of large-scale mono-cropping practices, together with plant breeding focused on developing varieties with increased yield, can exacerbate pest and disease problems (Bommarco et al., 2011) and reduce biodiversity (Raven and Wagner, 2021).

2. 2. Monotonous use of chemical for disease and pest control

During the past century (20th C), the use of persistent synthetic agrochemicals was highly efficient and cost-effective with serious negative environmental, health, biodiversity repercussion (Kanter et al., 2018). The repercusion which were often ignored in cost–benefit assessments (Kanter et al., 2018). Disease and pest management in most cases relies primarily on unchecked chemical applications which result in enormous environmental impacts, emergence of new strains due to selection pressure on pathogen populations, reduced efficacy of pesticides resulting in control failures and unmanageable levels of disease (Alyokhin, et al., 2013; Arango-Isaza et al., 2016).

2.3. Inherent instability of agricultural systems

Inherent instability of agricultural ecosystems applies a strong selection pressure towards the traits that help organisms survive potentially catastrophic events such as tillage, crop rotation, and/or application of pesticides (Alyokhin, et al., 2013). It is farther reported that the economic success of synthetic inputs has, however, been achieved at a high cost to the environment through the loss of biodiversity, depletion of soil quality, greenhouse gas emissions, and disrupting the ecosystem services that can otherwise help mitigate losses caused by pests and diseases (Belmain et al., 2021).The use of pesticides in agriculture constitutes a major threat to biodiversity that is endangering agriculture itself (Delaune et al., 2021). When host resistance is unavailable or insufficient to suppress disease epidemics, fungicide application becomes inevitable. In the philosophy of free-disease agriculture currently adopted worldwide, fungicides are often overused to guarantee crop yield and quality, particularly for vegetable and ornamental productions in developed regions (He et al., 2021).

2. 4. Climate change and global warning

Climate change and global warming are of great concern to agriculture worldwide can impact agricultural pests and disease (Skendžic et al., 2021). The changes occurs in several ways resulting in an expansion of their geographic distribution, increased survival during overwintering, increased number of generations, altered synchrony between plants and pests, altered inter-specific interaction, increased risk of invasion by migratory pests, increased incidence of insect-transmitted plant diseases, and reduced effectiveness of biological control, especially natural enemies (Skendžic et al., 2021).Climate change has direct impacts on pests' reproduction, development, survival and dispersal, whereas indirectly affects the relationships between pests, their environment and other insect species such as natural enemies, competitors, vectors and mutualists (Prakash et al., 2014).

2. 5. Co-evolution of hosts, pathogens and pests

Gene-for-gene co-evolution of host and pathogen systems can lead to disease emergence. The gene-for-gene hypothesis, states that, for every gene for virulence in the pathogen, there is a corresponding gene for susceptibility in the susceptible plant species (Anderson et al., 2004).

2.6. Introduction of an avirulent and aliens pests and pathogens

The introduction of an avirulent mutant and alien pests, for example avirulent mutant (strain 1) of Tomato mosaic virus in England to protect tomato seedlings from more-virulent strains (cross-protection) resulted in the emergence of virulent forms of strain 1 in all commercial plantings where the mutant had been released (Anderson et al., 2004).

2.7. Inter-specific hybridization of pests and pathogens

Inter-specific hybridization of pathogens brought together by human activity has resulted in the emergence of several virulent pathogens and pests of plants. Inter-specific hybridization is widely observed within diverse eukaryotic taxa, and is considered an important driver for genome evolution (Depotter et al., 2016). As hybridization fuels genomic and transcriptional alterations, hybrids are adept to respond to environmental changes or to invade novel niches (Depotter et al., 2016). Hybridization influences microbial genome evolution and impacts pathogenicity.

2.8. Pathogen and pest's pollution

The emergence of plant emerging pest and disease, similar to those of humans, wildlife and domestic animals, is driven mainly by anthropogenic environmental change (such as introductions, farming techniques and habitat disturbance), these changes are those largely related to trade, land use and severe weather events (predicted to increase in frequency and severity owing to anthropogenic activities (Bebber et al., 2014).

As a result of disturbances caused in the agricultural system potential pests and diseases are likely to posse a suite of heritable traits that facilitate their adaptation to a crop environment. These often include the ability to detoxify a variety of poisons, high mobility concomitant with the ability to escape unfavorable conditions and to distribute offspring in space, diapause associated with an ability to wait out unfavorable periods and to distribute offspring in time, flexible life histories, behavioral plasticity, and high fecundity (Alyokhin, et al., 2013). All these challenges above calls for designing an appropriate methods that are effective with less harm to the environment.

3.0. WHY DO WE NEED CONSERVATION AGRICULTURE AND INTEGRATED PEST MANAGEMENT

The increase in population has led to the increase in demand for food to feed the fast growing population (Jat et al., 2012). This necessitates an increase in crop productivity with less environmental impact while maintaining good food quality and food security (Berlin et al., 2018). Since need for healthier food and clean and safe living environment is a priority of many societies in the world. Consumption of raw fresh produce is an increasing trend among health conscious consumers in developed countries and as such, many markets have placed zero tolerance of certain pesticide residues on fresh vegetables. This has increased pressure on farmers to refine their pest management systems for maintaining fresh produce's aesthetic quality without using harmful pesticides. As resistance of pests to pesticides and consumer awareness of the health hazards of pesticides increases, there is ever-growing interest in sustainable, alternative pest management strategies. Usage of chemical pesticides is generally limited in undeveloped countries because majority of farmers are resource poor (Fanadzo et al., 2018).There is a demanding need for transformations in the global food production systems towards more efficient, more reliable and more sustainable food production (Findlater et al., 2019). That can ensure food security under the combined pressures of population growth, shifting diets and climate change (Findlater et al., 2019).

Burzman et al., (2015) concludes that the future of crop production is now threatened by emergence of pest resistance and declining availability of active substance in the agricultural eco-system. It is reported that both conservation agriculture and integrated pest management works in the same principle of conserving biodiversity and conservation of natural resources (Ahmed and Ahmed, 2015). So by employing these two important agricultural management strategies can help reversing the hazardous predicted effects brought about by poor agricultural management practices.

4.0 DEFINITIONS OF INTEGRATED PEST MANAGEMENT AND CONSERVATION AGRICULTURE

4.1. Definitions

There are several definitions toiled to define integrated pest management and conservation agriculture, therefore there no single agree definition among scientists and researchers. Each term is defined depending who is defining the terms with reference to what?. This is true with what Deguine et al., (2021) noted that, there so many definitions of integrated pest management for conservation agriculture that generated unnecessary confusion among stakeholders.

4.1.1. Integrated Pest Management (IPM)

Integrated Pest Management is the integration of different pest management techniques (regular cropping practices along with genetic, physical, biological, and chemical means) by promoting socio-economic viability and a reduction in use of chemical pesticides to minimize the risks to the environment and public health (Deguine et al., 2021). Another one is "a holistic 'approach' or 'strategy' to combat plant pests and diseases using all available methods, while minimizing applications of chemical pesticides."

4.1.2. Conservation Agriculture (CA)

Conservation Agriculture is a farming system that prevent losses of arable land while regenerating degraded lands, promotes maintenance of a permanent soil cover, minimum soil disturbance, and diversification of plant species (FAO, 2022).

4.2. Principles of IPM and CA

4.2.1. Integrated Pest Management

In general integrated pest management(IPM) uses ecological-based principles to manage pests and diseases by discoursing rising concern of haphazard use of chemical pesticides as well as related environmental and health issues (Paudel et al., 2020).It is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimises economic, health and environmental risks. The purpose of IPM is to help you make decisions based on careful consideration of costs, risks, and benefits (Kumar et al., 2017).IPM programs take advantage of all appropriate pest management strategies, including the judicious use of pesticides. Preventive pesticide application is limited because the risk of pesticide exposure may outweigh the benefits of control, especially when non-chemical methods provide the same results. An Integrated Pest Management (IPM) program integrates control tactics including cultural practices, variety selection, biological control and insecticides to manage insect pest populations so that economic damage and harmful environmental side effects are minimized. It is a systematic plan which brings together different pest control tactics into one program. With IPM, a farmer uses pesticides as one tool in an overall pest control program (Kumar et al., 2017).

4.2.2. Conservation Agriculture

Conservation Agriculture comprises three principles (1) advanced crop rotations for natural fertilization and to control pests, weeds and diseases (2) the minimization of soil disturbance to improve soil structure, infiltration and water-holding capacity; and (3) permanent organic soil cover to conserve soil moisture (Findlater et al., 2019). It is therefore based on the interrelated principles of minimal mechanical soil disturbance, permanent soil cover with living or dead plant material, and crop diversification through rotation or intercropping. It helps farmers to maintain and boost yields and increase profits, while reversing land degradation, protecting the environment and responding to growing challenges of climate change (CIMMITY). Conservation Agriculture promotes the use of agricultural practices addressing the issues of soil degradation and soil health (Paudel et al., 2020). CA is a natural resource-saving agro-ecological management approach that improves food security through enhancing productivity and increasing farmers' profits (Tabriz et al., 2021). Conservation practices in combination with the crop residue may physically, biologically and structurally alter the local field environment by affecting soil temperature and moisture, competition among micro-organisms and soil disturbance (Paudelet a., 2020). Conservation agriculture embraces integrated pest management, as it aims to incorporate reduced pesticide applications with cover crops, conservation tillage and crop rotation to strengthen natural pest control (Fanadzo et al., 2018).CA promotes the use of agricultural practices addressing the issues of soil degradation and soil health. It is based on three fundamental principles of minimum soil disturbance, continuous mulch, and diversification in cropping patterns (Paudel et al., 2020).

In conclusion; the integrated crop management approach expands on integrated pest management for crop production and conservation agriculture with the goal of optimizing plant health and economic returns, with a minimum negative effect on the environment (McDonald, 2006).

These calls for a pragmatic approach that will combine conservation agriculture and integrated pest management suitably in the agricultural system to maximize their effects. Conventional agriculture, including pest and disease management, is in a constant state of change as a result of scientific developments, societal pressures, and financial constraints (McDonald, 2006).

5.0. POSITIVE IMPACT OF CA AND IPM IN AGRICULTURE

To have positive impacts, conservation agriculture and integrated pest management must be integrated in an optimal manner that will result in increase in yield without causing harm direct to human being, the food web, environment and the economy of the particular area. Several researches have noted that CA and IPM when used separately cannot resolve the challenges faced by farmers in agricultural systems due to some few negative results. Example is when mulch or cover crops are used can become a pest/disease bridge from one season to another. Infact the negative effects due to use of CA and IPM are far less than the benefit accrued as result of combing the two. The following are benefit of IPM and CA when combined.

5.1. Improves yield

Conservation agriculture and integrated pest management boosts productivity and contribute to reducing land degradation and increase food security. Enables farmers to prevent hardpans from forming, protects the soil, increases soil moisture, and restores soil fertility. It is reported that a combine effect of IPM and CA increased yield of different crops by 48% than the conventional agriculture (Paudel et al., 2020). In Tanzania the adoption of CA has increased yield of food crop from an average of 0.5 ton ha^{-1} to 1.5 ton ha^{-1} and subsequent increased maize yield from 12,000 kg to 20,000 kg per 4.8 hectares and 3.75 ton per hectare when intercropped with lablab (Mkonda and He, 2020). Management components of CA contribute to improving the sustainability of agricultural productivity through biodiversity conservation and enhanced natural biological processes at the agro-ecosystem farming level, increased carbon sequestration, and climate change mitigation (Sanchez et al., 2019).

5.2. Reduces production cost

Helps these farmers cut costs (labour, fertilizer) while increasing their yields. Furthermore, it enables vulnerable people to grow more food with less work. It offers them a chance to improve their lives. The reduced usage of pesticides is more cost effective in the long term, as IPM controls pests when there are surges, as opposed to the regularly timed application of pesticides.

5.3. Maintain animal and plant ecology

Ecological balance is maintained with minimum disturbance to ecosystem. Reduction in the use of chemical pesticides with IPM technologies and CA practices strengthens natural enemy populations of insect pests by enhancing environmental diversity (Paudel et al., 2020). Since the use of pesticides may eradicate the pest population at the increasing risk to the non-target organisms result in species loss. While maintaining the balance of the ecosystem by augmenting the soil biota and increasing biological process, pest and pathogens are eradicated (Ahmed and Ahmed, 2015).

5.4. Reduced chemical contamination of food and the environment

The environmental improvements made to the facility to implement an IPM and CA program do enhances long-term stability of the holdings over and above protection against pest. Food chains becomes safe due to less contamination of the environment. This typically signifies less or no pesticides applied in the agriculture ecosystem which result in no or bearable/allowable dosage of pesticides in the food chain/web.

5.5. Reducing Pesticide Use

IPM and CA endeavors to promote sustainable forms of agriculture that pursue sharp reductions in synthetic pesticide use, and thereby resolved myriad socio-economic, environmental, and human health challenges (Deguine et al., 2021). It utilizes suitable techniques and methods against the pests in as compatible manner with the environment as possible and thus, maintaining the pest population levels below those causing economic injury. It carefully considers all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified.

5.6. Slower development of resistance to pesticides.

Pests can develop a resistance to pesticides over time, when chemicals are used repeatedly to treat the same pest/pathogens. Pests and pathogens can easily develop a resistance to the chemical/pesticides via natural selection, where the pests that survive the application of the chemicals will pass on their genes to their offspring (Ahmed and Ahmed, 2015). This leads to the creation of "super pests" but IPM reduces the risk of this occurring as the methods adopted by IPM are natural.

5.7. Long term pest, pathogens and weeds control

IPM and CA may be the only solution to some long-term pest problems where chemical application have not worked. Many of the methods reported to be used by smallholder farmers and commercial producers are wallowed with many weaknesses that lead to failure, re-emergence or resistance of pests and pathogens. This have been a concern to growers that why the need of adopting IPM and CA is inevitable in any crop production endeavors.

5.8. Low labour requirement

IPM and CA will requires less staff time than the conventional system, and required significantly higher labor compared to the improved alternative system of IPM and CA (Paudel et al., 2020).It is report to be economical than the conventional methods of pest and disease control (Ahmed and Ahmed, 2015).

5.9. Reduce risks due to pesticides/herbicides use

Decreases worker, tenant and public exposure to pesticides during agricultural management practices that expose them to pesticides/ herbicides or any other chemicals. Due to the fact that chemicals that are used under IPM and AC are the one that are critically analyzed and approved to be used in a right low dosage, less frequency and at safe to applicators, environment and the crops.

5.10. Reduction of emergence of cultivar resistant breaking species/isolates/tribes/strains/

Under IPM and CA is possible to protect and maintain cultivar resistance for a long time. This is due to reduced populations of pests, pathogens and weeds. For some pests, pathogens and weeds their effect on host are inoculum dependent, under reduce pressure their effects are minimal or less. Different from where population of pests and pathogens grow high and intermingle with each other to evolve much more new strains/isolate/patho-types which can lead to breaking of host resistance. Microbial populations in the rhizosphere increased 50% under zero tillage and more microorganisms (95%) were antagonistic to the take-all fungus than in the populations found in soils under conventional tillage (Herman, 1985).

5.11. Water conservation

It is also widely acknowledged that the increased adoption of CA systems will be critical in growers adapting to future climate change scenarios including increased temperatures, elevated CO2, greater variability in rainfall and increased frequency of droughts. Crop production will become more reliant on the stored soil water benefits associated with adoption of CA to buffer against these climatic changes.

5.12. Reduction on land degradation

Cultivation of soils through intensive tillage can result in faster degradation of soils through water and wind erosion. Conservation actions stop and reverse land degradation due to reduced soil disturbances like tillage activities. The CA specifically aims to address the problems of soil degradation due to water and wind erosion, depletion of organic matter and nutrients from soil, runoff losses of water and labor shortage (Jat et al., 2012). The mulch used in CA promotes more stable soil aggregates as a result of increased microbial activity and better protection of the soil surface (Jat et al., 2012).

5.13. Increase soil fertility

Kumar &Goh (2000) reviewed the effect of crop residues and management practices on soil quality, soil nitrogen dynamics, concluded that crop residues are a significant factor for crop production through their effects on soil physical, chemical and biological functions as well as water and soil quality. Changes in the micro-flora and increased microbial activity under conservation tillage may lead to biological control diseases by antagonism or by competition.

6.0. CHALLENGES FACING CA AND IPM

6.1. Changes in prevalent of pests and pathogens

Significant changes in the prevalence of specific plant pathogens are often observed following the adoption of CA. The increased retention of plant residues provides stubble-borne pathogens with an extended opportunity to survive between crops when host plants are absent during both fallow periods and rotations with non-host species (Bockus and Shroyer 1998).

6.2. More involvement in the technicalities of the method

Individual farmers and all those involved in IPM and CA have to be educated about their options in the various methods available, which often take time.

6.3. Land tenure system

Land ownership is the challenge in implement IPM and CA in agriculture since some people hire the land for growing crops annually. This bears difficult for farmers to invest much money improve a particular part of the land.

6.4. Lack of free grazing areas

Shortage of animal feed is a challenge since animals which graze freely will not spare a field with accumulated vegetation.

6.5. Change of mindsets

Farmers must drop their traditional practice of preparing the land with a hoe or plough, and instead rely on biological tillage by the plant roots and earthworms. The switch also encourages farmers to see their farms as a business rather than merely a way to feed their families.

6.6. Limited crop residues.

Keeping the soil covered is important in conservation agriculture. But it can be difficult. Farmers have many uses for crop residues: as fodder, fencing, roofing and fuel. Livestock keepers let their animals graze on stubble. In drier areas, it is impossible to grow a cover crop in the dry season, and crop residues are a vital source of animal feed.

6.7. Lack of finances

Financial problem is another barrier towards the adoption of conservation agriculture and its related practices (Mkonda et al., 2020). This affects widely from the accessibility to information, tools and equipments. Small holders are mainly incapable of accessing conservation agriculture requirements albeit are cheap. Purchasing some conservation agriculture needs and accessing the related goods which demand some money (Birch-Thomsen et al. 2007). All these happen because most of the small-holders are economically weak and therefore they have weak purchasing power (Mkonda et al., 2020).

7.0. CONCLUSION AND RECOMMENDATIONS

Conservation agriculture and integrated pest management are important example of sustainable agriculture which have recoded increasing the productivity and reliability of food production. It aims at reducing agricultural inputs and future climate risks when adopted comprehensively. Many case studies concluded that Benefit Cost Ratio (BC Ratio) was more for IPM and CA farms compared to Non-IPM-CA farms (Kumar et al., 2017; Ahmed and Ahmed, 2015).Successful pest, disease and weed management will only be achieved in developing countries, through awareness and integration of techniques to manage the complex interactions between the pathogens, pests, hosts and environments.

We hereby recommend the following to be done;

a. Specific researches are needed on major crops so that to find out the optimal combination of technique that can bring about sustainable crop production in agriculture.
b. Training and awareness creation on the importance of IPM and CA on improving yield in agriculture.
c. Stakeholders including the government come together and itemize laws and regulation that will help implementation of IPM and CA in agriculture.
d. Donors need to focus their funds to areas that can help smallholder farmers in implementing IPM and CA.
e. There need for changing the tenure system specifically in developing countries that will accommodate IPM and CA in agriculture.
f. To improve the sustainability food production in agriculture from a plant pathology perspective, research is need on pathogen/pest and microbial interactions in different environments.
g. Researchers need to open up demonstration plots in farmers' fields that will convince and will help the adoption the IPM and CA.

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