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A Study on pest and disease management and weather-based crop diagnostics

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Abstract:

One of the main obstacles to improved agronomic crop yield for achieving the expected produce to support global food security is thought to be disease and pest infestation. Given that cultivated harvests, especially cereals and pulses, are the primary food foundations globally, it is crucial to prioritize the management of their devastating pests and diseases. Currently, pests and diseases that affect agronomic crops are controlled by using pesticides and fungicides, which are chemical methods. Nevertheless, concerns about the long-term viability of agriculture have prompted the widespread and thorough acceptance of integrated pest and disease control strategies. The goal of integrating techniques is to manage different pests and illnesses by implementing specific cultural, mechanical, and biocontrol strategies, therefore limiting the harm that chemicals do to the environment and human health. However, the effectiveness of control measures often relies on their efficient deployment. Various cultural management methods, including cover crops, intercropping, trap crops, certain applications of tillage, and strategic plantation timing are able to potentially decrease pest populations and lessen the severity of diseases. This study presents a fuzzy logic-based framework for managing plant diseases and pests and examines its effects on the agro-industry business. The feasibility of implementing the suggested strategy using little meteorological data, such as temperature and humidity, has been shown. Accurate prediction of these illnesses using climate data can assist farmers in promptly implementing measures to control the diseases.

Keywords: *Agronomic crops, Food security, Pest Management, Fuzzy Logic, Disease forecasting*

Introduction:

Diseases and pests pose significant risks to agronomic crops, resulting in substantial losses for rural families and jeopardizing global food security. Plant diseases and pest insects are views that are anthropocentric. Food productivity and quality are decreased by an insect or bacterium, which is regarded as a pest or disease. Together, these nematodes, insects, and microbes produce several plant diseases. For the food chain in nature, these sorts of connections are highly complex and dynamic. Multiple varieties of pests and illnesses have been documented as having an impact on various crops, ranging from the first stages of seed growth to the conditions in the field. Furthermore, the frequency and intensity of different diseases and pests are typically linked to the timing of planting, the specific genetic characteristics of the plants, and the prevailing environmental circumstances

(Sharma and Sharma 1999). To mitigate the negative impact of diseases and pests on agricultural crops, it is necessary to implement suitable and efficient techniques (Sharma et al., 2015). Pest and disease infestation is recognized as a significant constraint in generating increased yields of cultivated crops to ensure global food safety (Igarashi et al., 2004).

The indiscriminate application of pesticides results in both financial losses for farmers and a decline in crop quality. The primary objective of the Integrated Pest Management (IPM) system is to proactively mitigate pest issues in order to avert any potential economic losses. The objective of the IPM is to minimize the use of pesticides for pest management (Wilson et al 2004.). The literature presents several Integrated Pest Management (IPM) options, such as the efficient usage of synthetic chemicals, the application of natural pesticides, the use of certain crop cultivars, the implementation of crop variations, using biological control through natural enemies, and utilize decision support systems to assist farmers in determining the ideal timing for pesticide application (Bailey et al.2011). Accurate predictions regarding temperature and precipitation are crucial for the agricultural industry. Extreme climate conditions have a detrimental impact on agriculture production, as well as on the prevalence of pests and illnesses. Weather-based forecasting provides farmers with early warnings. This facilitates prompt intervention against diseases

Pest and disease management in agronomic crops:

Crop losses can be reduced by promptly identifying and correctly diagnosing the illness, and then implementing targeted management measures. One common technique for identifying plant pathogens is visual inspection. Usually, it's only feasible after the crop has already suffered significant damage; in this case, remedies will be ineffective or useless. Farmers must be able to identify illnesses in their early stages in order to be protected from the types of harm caused by pathogens. Effective control strategies may be employed to manage pests and diseases that affect different agronomic crops. Possible control approaches include cultural, chemical, biological, or a mix of many strategies. However, the effectiveness of the control measure being implemented often relies on its specific character.

Soil Fumigation:

The primary cause of decreased productivity and increasing losses of agronomic crops worldwide is soil-borne pests and diseases. Some suitable soil disinfestation treatments are needed to achieve greater production while reducing disease- and pest-induced losses (Rokunuzaman et al. 2016; Mihajlovic et al. 2017). It is possible to efficiently disinfect soils against soil-borne diseases using a variety of chemicals, including methyl bromide, metham, and ethylene dibromide. The fusarium root-knot nematode in cotton was managed by soil disinfection using 1, 3-dichloropropene or chloropicrin (Jorgenson et al. 1978). Combining ethylene dibromide with fenamiphos resulted in a considerable reduction in the nematode population and an increase in sugarcane production (Chandler 1984). Fusarium wilt of chickpea was inhibited by bio-fumigation of the soil with an extract from Brassica Alba (Prasad and Kumar 2017).

Seed Treatment:

Reduced productivity and higher losses of agronomic crops worldwide are mostly caused by diseases carried by seeds or insect infestation. Therefore, certain suitable seed treatments are needed to gain increased yield while reducing agronomic crop losses caused by disease and pests (Sharma et al. 2015). For seed treatments, a variety of chemicals are employed. Under field circumstances, treatment of cotton seeds with metalaxyl and Trichoderma virens boosted seedling stand and decreased disease occurrence (Howell et al.1997). Black point disease in wheat was managed with foliar and seed treatment with fungicides (Malaker and Mian 2009). Similarly, to this, treating spring wheat seeds with triadimenol alone or in conjunction with thiram improved grain production by effectively controlling leaf blight (Sharma-Poundyal et al. 2016). Triamefon and propiconazole treatment of sugarcane crops significantly reduced their smut occurrence, resulting in a larger agricultural yield in field settings (Bhuiyan et al. 2015).

Crop Rotation:

Long-term cultivation of the same crop varieties on the same land eventually results in an abundance of disease outbreaks or insect pest infestations in the following years. Thus, it is advantageous to develop acceptable substitute crops in order to lessen the infestation of pathogens or pests in upcoming years (Bankina et al. 2015). An alternative plan including maize, soybeans, triticale-alfalfa, and alfalfa was used to monitor carabid activity (O'Rourke et al. 2008). According to Johnson et al. (2012), using corn as a rotation technique significantly decreased the occurrence of Armadillidium vulgare in soybean crops. A three-year rotation of wheat, soybeans, and corn decreased pests because the populations of granivore and detritivore predators increased (Dunbar et al. 2016). Soybean output rose when rotated with wheat for a year; rotation with cotton did not exhibit any beneficial effects (Ashwarth et al. 2017).

Planting Time:

The frequency and intensity of different insect attacks and illnesses are often related to growth stage, genotype, planting date, and environmental factors. The two main factors that contribute to the epidemic spread of illnesses or pests are relative humidity and temperature in the atmosphere. The ensuing crop development phases are therefore determined by the planting date, which is particularly significant (Sharma and Sharma (1999). Cowpea pod-eating bugs were less likely to invade crops when planting was postponed and combined with pesticide treatment (Kamara et al. 2010). Planting soybeans early resulted in a decrease or complete avoidance of whitefly and aphid infestation when a combination of mung bean, sunflower, and maize was produced as a border trap crop (Abdallah 2012). In sweet sorghum, earlier planting under high, medium, and low densities as single, double, or triple rows revealed an increased frequency of cornstalk borer and armyworm (Cherry et al. 2013). Compared to normal or late planting, there was a notable increase in the invasion of red cotton and dusky bugs in early-sown crops (Shahid et al. 2014). According to Nath et al. (2017), the population of tobacco caterpillars was much greater in the crop seeded on July 20th compared to those sowed on July 5th or June 20th. This resulted in more leaf damage and a reduced produce of groundnut. The cotton crop that was planted previously in December had a higher production compared to those that were planted later (Gilio 2014).

Plant Spacing:

According to Cherry et al. (2013), planting sweet sorghum in single, double, or triple rows at high, medium, and low densities either had no influence at all or very little on the population of armyworms and cornstalk borer. In cowpea, plants had no effect on sucking bugs, blooming thrips, pod borer, or beetles in response to varying planting times (Alghali 1991). The management of pest infestation was achieved by planting cowpeas at 20×30 and 20×60 cm together with pesticide management (Karungi et al. 2000). Lowering the density of autumn plantings resulted in fewer flea beetle attacks, promoting faster canola crop development and early maturity (Lloyd and Stevenson 2005). With noticeably faster vegetative growth and production than a tighter planting design, the occurrence of ramularia leaf spot of cotton was dramatically decreased when cowpeas were embedded at a wider spacing. Moreover, under the severe CLCV assault, high plant density guaranteed excellent cotton yield (Iqbal et al. 2012; Singh et al. 2017).

Intercropping:

When compared to a non-intercropped area, the populations of aphids, whiteflies, Pegomyia mixta, and Cassida vittata were much lower when maize, faba beans, and cabbage were interplanted with sugar beet. However, no discernible effect of transmit intercropping was noted when intercropping cotton, wheat, and alfalfa, or when ladybeetles as well as green bugs were sown in sorghum (Phoofolo et al. 2010). Basil intercropping considerably decreased the pink bollworm invasion in cotton, which ultimately resulted in a higher yield (Schader et al. 2005). Numerous studies have shown that intercropping, where two or more component crops are grown together, may lower the occurrence of bacterial illnesses (Yu 1999), fungal infections (Hao et al. 2010), and bug pests (Basha et al. 2017). In order to get a better understanding of the specific process by which pathogens or pests interact with different intercrop components, leading to the incidence and intensity of diseases or pest infestations, it is necessary to do more study.

Methods of Soil Cultivation (Tillage):

To cultivate agronomic crops, many tillage strategies have been employed. Different agronomic crops' pests and illnesses have been found to be greatly impacted by tillage techniques and procedures. The number of usual predators that prey on flower bugs on cotton was decreased due to the increasing agronomy of rye and crimson clover under conservation tillage (Tillman et al. 2004). The severity of maize rootworm on pods was decreased by reduced tillage, but the number of collembolans, hymenopterans, and acarina rose in peanut crops (Cardo’za et al., 2015). According to Toledo-Souza et al. (2012), cultivating common beans with a no-tillage approach resulted in a considerable reduction in fusarium wilt occurrence and a greater production compared to standard harvesting methods. The use of the strip tillage technique, together with the practice of rye cover crop, resulted in a substantial decrease in the number of young thrips found on cotton and peanut plants. Furthermore, it significantly reduced occurrence of tomato spotted wilt virus in peanuts while simultaneously increasing the output in both produces (Knight et al., 2017).

Fertilizer Application:

The dosage and administration of nutrients may have a considerable impact on the occurrence of insect pests and illnesses. Depending on the crops and their development phases, excessive or insufficient treatment may raise or decrease the population of pests and the prevalence of illnesses. In addition to inhibiting leaf blight, grain discoloration, and brown spots in lowland rice, the combined application of nitrogen (N) and silicon considerably decreased attacks by leaf folders, dead hearts, and stem borer (Malav and Ramani, 2015). The concentrations of soluble carbohydrates, proteins, and silicon were significantly altered by the application of N, phosphorous (P), or potassium (K). Among them, applying K to plant tissues decreased the amount of solvable proteins, free sugars, N, and silicon; also, it significantly decreased the assault of brown plant hoppers on rice (Rashid et al. 2016). Increased agricultural plant output and vegetative growth are attributed to higher doses of N, P, or K fertilizers. Higher NPK dosages, however, also coincide with an increase in the growth and mortality rate of rice brown plant hoppers (Rashid et al. 2017b). When K was applied appropriately, the prevalence of rice borer was decreased and crop yield increased (Sarwar 2012)

Disease forecasting based on weather:

The development of a disease is significantly influenced by the weather. The disease triangle concept provides a clear explanation of the role that weather plays in the development and transmission of diseases (Bos et al. 1995) Figure 1 illustrates the disease triangle notion graphically. Three things need to happen at the same time for sickness to manifest. A susceptible host plant is required initially. Only a few viruses can infect any given variety of plants. Additionally, the plant needs to be in a developmental stage that makes it vulnerable to infection by the pathogen. The existence of an active pathogen is the second prerequisite. There cannot be a disease if there is no pathogen. An environment that the pathogen can employ to infect plants and produce disease is the third requirement. It is possible to stop the disease from spreading if early warning signs of favourable weather conditions are available. This is the main idea behind illness predictions based on weather.

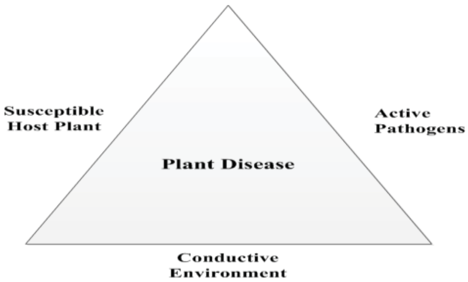

Figure 1: Disease triangle

Use of Fuzzy logic in disease forecasting:

Knowledge bases, neural networks, fuzzy logic, and other techniques can be used to create an expert system. The suggested paper uses fuzzy logic to construct an expert system for disease forecasting. (Zadeh 1965) introduced the initial development of fuzzy set theory and fuzzy logic. The agricultural system is a partially understood and intricate structure. The application of fuzzy logic theory is highly advantageous in the development of a decision support scheme for agricultural systems (Huanga et al.) The research presents the successful application of fuzzy logic in an agricultural system to address many elements of agricultural activities. The paper suggested the potential application of fuzzy logic in a plant disease forecast structure grounded on weather conditions. Weather-based prediction is a technological method that forecasts the likelihood of illnesses occurring based on the current atmospheric conditions in a certain geographical area.

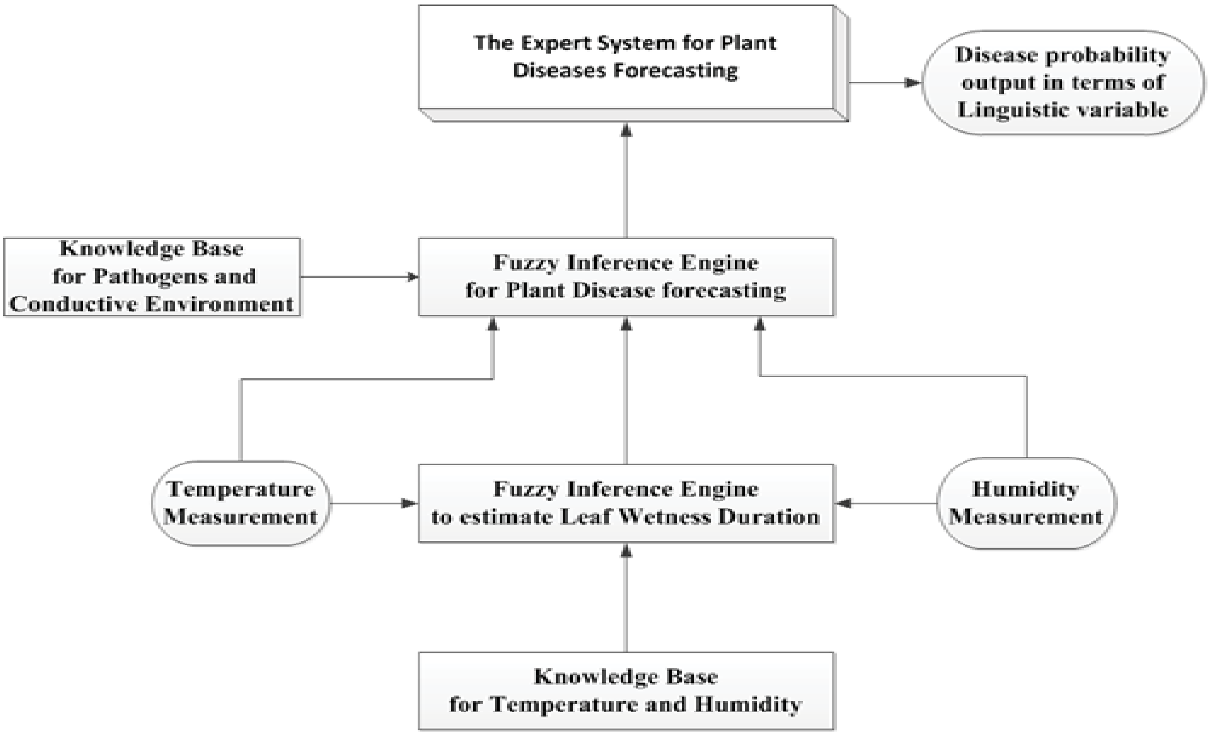

Figure 2: Diagrammatic representation of the weather-based plant disease prediction

A leaf is a vital component of a plant. The majority of infections develop and thrive on the leaf's surface. The duration of leaf wetness is a crucial factor in the development of a disease. Table 1 displays a selection of the sample rules. The suggested study presents the final result in the form of a dialectal variable that provides a primary indication of disease occurrence in the host plant. Timely detection of disease enables the efficient utilization of pesticides on the farm

Regulation No	Regulation
1.	If (Humidity be dry) and (Temperature be very low) and (Leaf wetness duration be very low) then (Disease is very low).
2.	If (Humidity be dry) and (Temperature be very low) and (Leaf wetness duration be low) then (Disease is very low).
3.	If (Humidity be dry) and (Temperature be very low) and (Leaf wetness duration

is medium) then (Disease is very low).

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50. If (Humidity be moderate) and (Temperature be very high) and (Leaf wetness duration be very high) then (Disease is low).

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124. If (Humidity be high) and (Temperature be very high) and (Leaf wetness duration be very high) then (Disease be very high).

125. If (Humidity be very high) and (Temperature be very high) and (Leaf wetness duration be very high) then (Disease is very high).

Table 1: Plant disease estimation using fuzzy rules

Conclusion:

The goal of integrated pest management, or IPM, is to avoid diseases while using pesticides as little as possible. IPM includes weather-based disease prediction as one of its techniques. Many climatic parameters, including temperature, relative humidity, length of leaf wetness, and wind speed, are applied to predict the likelihood of crop disease early on. Various pests and diseases that affect cultivated crops may be successfully accomplished. Nonetheless, the control measure that is used often determines the level of control. While a number of cultural management techniques, including intercropping, cover crops, trap crops, tillage methods, and plantation timing, may lower pest populations and disease severity, they are not equally successful as commercial chemical treatments in field settings. Likewise, the practicality of using biocontrol chemicals and plant extracts is not economically feasible in real-world agricultural settings. Nevertheless, the efficacy of these methods can be augmented by merging them with other control strategies, such as incorporating traditional practices alongside reduced chemical treatments. Further studies should give priority to the advancement of crop varieties that exhibit pest and disease tolerance or even resistance through the utilization of modern biotechnological techniques.

References:

1. Rokunuzzaman M, Hayakawa A, Yamane S, Tanaka S, Ohnishi K (2016) Effect of soil disinfection with chemical and biological methods on bacterial communities. Egypt J Basic Appl Sci 3:141–148 Mihajlović M, Rekanović E,

2. Hrustić J, Grahovac M, Tanović B (2017) Methods for management of soilborne plant pathogens. Pestic Phytomed 32:9–24

3. Jorgenson EC, Hyer AH, Garber RH, Smith SN (1978) Influence of soil fumigation on the Fusarium-root-knot nematode disease complex of cotton in California. J Nematol 10:228–231

4. Khan, S. M., Ali, S., Nawaz, A., Bukhari, S. A. H., Ejaz, S., & Ahmad, S. (2019). Integrated pest and disease management for better agronomic crop production. *Agronomic Crops: Volume 2: Management Practices*, 385-428.

5. Chandler KJ (1984) Plant parasitic nematodes and other organisms as a contributing factor to poor sugarcane root development in north Queensland. Proc Aust Soc Sugar Cane Technol 6:63–67

6. Prasad P, Kumar J (2017) Management of Fusarium wilt of chickpea using brassicas as bio fumigants. Legume Res 40:178–182

7. Sharma KK, Singh US, Sharma P, Kumar A, Sharma L (2015) Seed treatments for sustainable agriculture: A review. J Appl Nat Sci 7:521–539

8. Howell CR, DeVay JE, Garber RH, Batson WE (1997) Field control of cotton seedling diseases with Trichoderma virens in combination with fungicide seed treatments. J Cotton Sci 1:15–20

9. Malaker PK, Mian IH (2009) Effect of seed treatment and foliar spray with fungicides in controlling black point disease of wheat. Bangladesh J Agric Res 34:425–434

10. Sharma-Poundyal D, Sharma RC, Duvalier E (2016) Control of Helminthosporium leaf blight of spring wheat using seed treatments and single foliar spray in Indo-Gangetic plains of Nepal.

11. Tilva, V., Patel, J., & Bhatt, C. (2013, November). Weather-based plant disease forecasting using fuzzy logic. In *2013 Nirma University International Conference on Engineering (NUiCONE)* (pp. 1-5). IEEE.

12. Bhuiyan SA, Croft BJ, Tucker GR (2015) New method of controlling sugarcane smut using flutriafol fungicide. Plant Dis 99:1367

13. Bankina B, Ruza A, Paura L, Priekule I (2015) The effects of soil tillage and crop rotation on the development of winter wheat leaf diseases. Žemdirbystė (Agriculture) 102:67–72

14. O'Rourke ME, Liebman M, Rice ME (2008) Ground beetle (Coleoptera: Carabidae) assemblages in conventional and diversified crop rotation systems. Environ Entomol 37:121–130

15. Johnson WA, Alfaress S, Whitworth RJ, Mccornack BP (2012) Crop residue and residue management effects on Armadillidium vulgare (Isopoda: Armadillidiidae) populations and soybean stand densities. J Econ Entomol 105(5):1629–1639

16. Dunbar MW, Gassmann AJ, O'Neal ME (2016) Impacts of rotation schemes on ground dwelling beneficial arthropods. Environ Entomol 45:1154–1160

17. Ashworth AJ, Allen FL, Saxton AM, Tyler DD (2017) Impact of crop rotations and soil amendments on long-term no-tilled soybean yield. Agron J 109:938–9

18. Cardoza YJ, Drake WL, Jordan DL, Schroeder-Moreno MS, Arellano C, Brandenburg RL (2015) Impact of location, cropping history, tillage, and chlorpyrifos on soil arthropods in peanut. Environ Entomol 44:951–959

19. Toledo-Souza EDS, Silveira PM, Café Filho AC, Lobo Junior M (2012) Fusarium wilt incidence and common bean yield according to the preceding crop and the soil tillage system. Pesqui Agropecu Bras 47:1031–1037

20. Knight IA, Rains GC, Culbreath AK, Toews MD (2017) Thrips counts and disease incidence in response to reflective particle films and conservation tillage in cotton and peanut cropping systems. Entomol Exp Appl 162:19–29

21. Malav JK, Ramani VP (2015) Effect of silicon and nitrogen nutrition on major pest and disease intensity in low land rice. Afr J Agric Res 10:3234–323

22. Rashid MM, Jahan M, Islam KS (2016a) Impact of nitrogen, phosphorus, and potassium on brown planthopper and tolerance of its host rice plants. Rice Sci 23(3):119–131

23. Sharma J, Sharma SK (1999) Influence of time of sowing and spacing levels on powdery mildew and seed yield in pea cv. Arkel. J Mycol Plant Pathol 32(1):117–119

24. Kamara AY, Ekeleme F, Omoigui LO, Abdoulaye T, Amaza P, Chikoye D, Dugji IY (2010) Integrating planting date with insecticide spraying regimes to manage insect pests of cowpea in north-eastern Nigeria. Inter J Pest Manage 56:243–253

25. Abdullah T, Gassa A, Ngatimin SNA, Agus N, Fattah A (2015) Impact of different time planting in soybeans and neem seed extract application to insect population on rice field. Int J Sci Technol Res 4:62–65

26. Cherry R, Wang Y, Nuessly G, Raid R (2013) Effect of planting date and density on insect pests of sweet sorghum grown for biofuel in Southern Florida. J Entomol Sci 48(1):52–60

27. Nath P, Rai SN, Keval R (2017) Effect of sowing dates on the tobacco caterpillar [Spodoptera litura (Fabricius)], population, leaf damage and yield of groundnut. Int J Res Granthaal 5:252–259

28. Alghali AM (1991) the effect of plant spacings on cowpea, (Vigna unguiculata Walp), insect pests and yields in two sites in Nigeria. Insect Sci Appl 2:707–711

29. Karungi J, Adipala E, Ogenga-Latigo MW, Kyamanywa S, Oyobo N (2000) Pest management in cowpea. Integrating planting time and plant density on cowpea field pest's infestation in eastern Uganda. Crop Prot 19:231–236

30. Lloyd MD, Stevenson FC (2005) Managing flea beetles (Phyllotreta spp.) (Coleoptera: Chrysomelidae) in canola with seeding rate, plant density and seed treatment. Agron J 97:1570–1578

31. Schader C, Zaller JG, Köpke U (2005) Cotton-basil intercropping: effects on pests, yields and economical parameters in an organic field in Fayoum Egypt. Biol Agric Hortic 23:59–72

32. Phoofolo MW, Giles KL, Elliott NC (2010) Effects of relay-intercropping sorghum with winter wheat, alfalfa, and cotton on lady beetle (Coleoptera: Coccinellidae) abundance and species composition. Environ Entomol 39:763–774

33. Yu JQ (1999) Allelopathic suppression of Pseudomonas solanacearum infection of tomato (Lycopersicon esculentum) in a tomato-chinese chive (Allium tuberosum) intercropping system. J Chem Ecol 25:2409–2417

34. Hao WY, Ren LX, Ran W, Shen QR (2010) Allelopathic effects of root exudates from watermelon and rice plants on Fusarium oxysporum fist. Niveum. Plant Soil 336:485–497

35. Tillman G, Schomberg H, Phatak S, Mullinix B, Lachnicht S, Timper P, Olson D (2004) Influence of cover crops on insect pests and predators in conservation tillage cotton. J Econ Entomol 97:1217–1232

36. Sarwar M (2012) Effects of potassium fertilization on population buildup of rice stem borers (lepidopteron pests) and rice (Oryza sativa L.) yield. J Cereal Oilseed 3:6–9

37. L Bos and J E Parlevliet, "Concepts and Terminology on Plant/Pest Relationships: Toward Consensus in Plant Pathology and Crop Protection," *Phytopathology*, vol. vol. 33, pp. 69-102, 1995.

38. L.A. Zadeh, "Fuzzy sets", Information and control," pp. 338-353, 1965.

39. Yanbo Huanga et al., "Development of Soft computing in Agricultural and biological engineering," *Computers and Agruculture*, pp. 107-127, 2010.

40. Alastair S. Bailey, G. Mark Tatchell, Gill Davidson, Justin Greaves, Wyn P. Grant David Chandler, "The development, regulation, and use of biopesticides for integrated pest management," 2011.

41. Lewis Wilson, Robert Mensah, Joanne Daly Gary Fitt, "Advances with Integrated Pest Management as a component of sustainable," in *"New directions for* diverse planet", Brisbane, Australia, 2004.s

42. Igarashi S, Utiamada CLC, Igarashi L, Kazuma A, Lopes R (2004) Pyricularia in wheat. 1. Occurrence of Pyricularia sp. in Paraná state. Fitopathol Bras 11:351–352