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RESEARCH ARTICLE

EXPERIMENTATION OF AN APPLICATION OF EARLY DIAGNOSIS AND INVENTORY OF SOYBEAN DISEASES (GLYCINE MAX (L.) MERR.) IN BURKINA FASO

Fidèle Bawomon Neya[1], Abasse Ouedraogo[2], Elisabeth Aboubié Zongo[3], Elise Sanon[4], Gilles Ibié Thio[5] and Kadidia Koita[6]

1. Assistant Professor, University Center of Gaoua, Nazi BONI University, Bobo Dioulasso, 01P.O Box 1091, Bobo-Dioulasso 01, Burkina Faso.
2. Research Scholar, Life and Earth Sciences Unit, Joseph KI-ZERBO University, Ouagadougou, 03P.O Box7021,Ouagadougou 03, Burkina Faso.
3. Junior lecturer, Institute for the Environment and Agricultural Research (INERA/CNRST), Ouagadougou 01P.O. Box 476,Ouagadougou 01, Burkina Faso.
4. Senior lecturer, Life and Earth Sciences Unit, Joseph KI-ZERBO University, Ouagadougou, 03P.O. Box 7021, Ouagadougou 03 Burkina Faso.
5. Senior lecturer, Institute for the Environment and Agricultural Research (INERA/CNRST), Ouagadougou 01P.O. Box 476,Ouagadougou 01, Burkina Faso.
6. Full Professor, Life and Earth Sciences Unit, Joseph KI-ZERBO University, Ouagadougou, 03P.O. Box 7021, Ouagadougou 03, Burkina Faso.

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Abstract

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Glycine max (L.) Merr also known as soya or soybean plays an important role in legume production in Burkina Faso. Every year, the country produces an average of 30,000 tonnes of soybean. It is grown for its oilseeds, which are rich in protein, fat, minerals and vitamins, making it an important food and feed crop. In addition, soya production is profitable for growers because it provides a real source of income through marketing operations. The lack of fertile land, adequate rainfall and phytosanitary protection in soya cultivation are not conducive for efficient production. Ignorance and lack of knowledge of the diseases encountered in soya production make it even more difficult to protect the crop, which further limits production.In order to improve knowledge of soybean diseases in Burkina Faso, an inventory of diseases associated with this crop was carried out using a plant pathology diagnostic application. In this study, the Plantix-Crop Doctor application, based on artificial intelligence with deep learning, was used in an Alpha Lattice experimental device. A disease identification form from the « Quebec Agriculture and Agri-Food Research Centre » was used as a reference. Among the diseases identified were Septoria leaf spot, grey leaf spot, anthracnose, bacterial blight, soybean blight, sudden death syndrome, downy mildew, powdery mildew and soybean rust. This list provides a database of soybean diseases; that must be controlled by methods that consider environmental protection. The "Plantix - your crop doctor" application can be relied on to diagnose soybean diseases so that they can be treated at an early stage.

Corresponding Author:- Fidèle Bawomon Neya
Address:- Assistant Professor, University Center of Gaoua, Nazi BONI University, 01P.O Box 1091, Bobo-Dioulasso 01, Burkina Faso.

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Introduction:-

Soya or soybean (Glycine max (L.) Merr.) is considered to be the world's most important legume in terms of production and marketing (Hartman et al. 2011). In fact, world production of soya beans is rising sharply, estimated at over 371 million tonnes with an average yield of 28,697 kg/ha and a sown area of 129,523,964 ha (FAOSTAT 2021). Over the same period, West Africa sowed an area of 1,486,209 ha, producing 1,537,921 tonnes at a yield of 10,148 kg/ha. In Burkina Faso, soya is the fourth most important cash crop after cotton, groundnuts and sesame (MARHRH/DPSAA, 2011). Production has continued to rise since 2017 (18,500 tonnes) until 2020 (9,813 tonnes). In 2021, production fell sharply to 55,000 tonnes (FAOSTAT, 2021). The average yield over the last five years is 11,000 kg/ha for an average area of around 44,000 ha sown over the same period (FAOSTAT 2021). Soya is used in animal and human food and helps to strengthen the resilience of poor households in the face of food insecurity (Pimentel et al. 2005). Soybean is a very important source of lipids, proteins, carbohydrates, isoflavones and minerals (Hou et al. 2009). The lipid (20%) and protein (50%) content make soya an oil and protein plant. In Burkina Faso, soya is a fast-growing crop that holds great promise for the development of the agricultural sector (G. I. Thio et al. 2022). In addition, soya production is profitable for growers because it provides a real source of income through marketing operations (APME 2A 2009). However, there is very little data on soybean diseases and other pests in Burkina Faso, which hampers efficient phytosanitary control of the crop. The overall aim of this study is to document an inventory of soybean diseases in Burkina Faso using the Plantix-crop doctor application, based on artificial intelligence with deep learning. this will provide information on the diversity of soybean diseases in Burkina Faso in order to identify appropriate phytosanitary methods for increasing its production. To do this, we will (i) experiment with the Plantix-crop doctor application for diagnosing plant pathologies, including soybean pathologies, and (ii) compile an inventory of diseases associated with soybean cultivation in the Central and Upper Basins regions of Burkina Faso.

Materials and Methods:-

Study sites

The study was conducted at Gampela in the Centre region of Farako-Bâ in the Hauts-Bassins region (Figure1). The Gampela experimental site is located on the Ouagadougou - Fada N'Gourma road ((6˚31'0" N, 3˚23'10" E)) and covers approximately 490 hectares. Average rainfall varies between 700 and 900 mm. The second site is Farako-Bâ located on the Bobo-Dioulasso - Banfora road and covers an area of 375 hectares ((04°19'34"W,11°05'32"N)). Average rainfall is between 1,000 and 1,200 mm, with heavy rains in August and September.

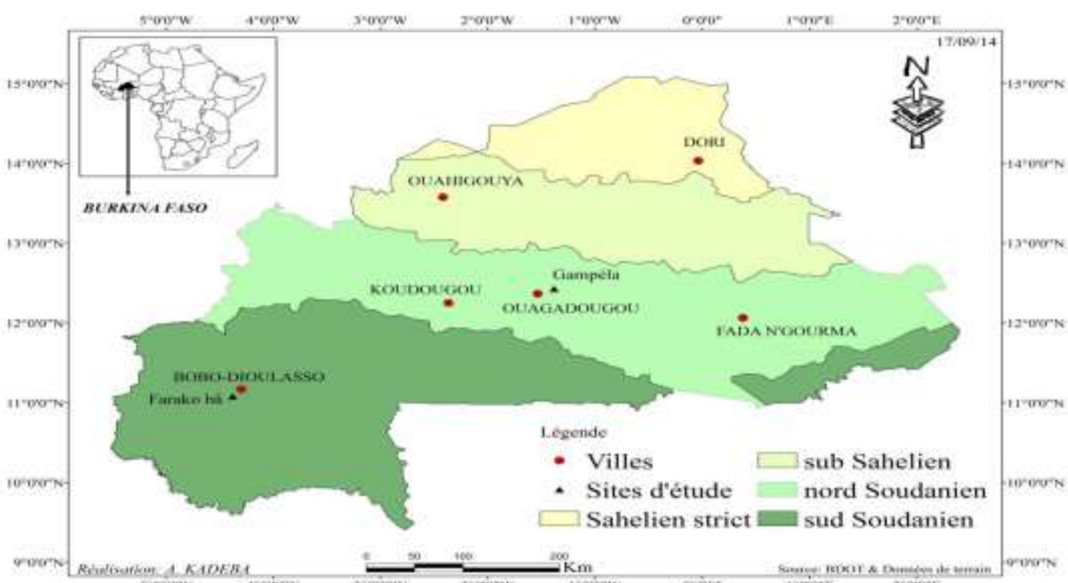

Figure 1:- Experimental sites.

Plant material
The plant material on which the observations were made consists of 37 lines developed by the International Institute of Tropical Agriculture (IITA) and 3 local soybean varieties (G196, G197 and G175).

Description material:
- **Disease identification sheet**
In this study, we used a soybean disease identification sheet developed by a group of field crop protection experts from the « Quebec Agriculture and Agri-Food Research Centre ». This sheet from the « Plant health warning network - Warning N° 26 - Arable crops - 7 August 2015 » (https://www.craaq.qc.ca/Publications-du-craaq) is used to describe and identify soybean diseases, supported with images of symptoms appearing in fields. In the context of our study, it was used as a supporting witness in the use of the Plantix-crop doctor application in order to reduce as much as possible the errors that could be linked to observations in the fields. In fact, during observations, it is possible to have connection deficit linked to the use of artificial intelligence; or because of symptoms that would be due to physiological disorders.

- **The Plantix-crop doctor application**
Plantix (Figure 2) is a mobile application that provides decision support directly on the smartphone or laptop. The platform features tabs that include: "Calculator", "Pests and diseases", "Growing tips", "Take a picture" and the important "Read the diagnosis" section (Figure 2b). In this study we used two parameters: take a photo and read the diagnosis. Using image recognition, the application is able to identify the type of plant, the type of disease associated with the symptoms, the pest or a nutrient deficiency. Plantix takes advantage of deep learning technologies based on a neural network.

It also provides information on treatment and preventive measures. The network learns more from new images sent daily by Plantix users around the world (Zinzou K. M. S. 2019).

The use of this application requires basic prior knowledge; hence, the use of the soybean disease identification sheet as described above.

Figure 2:- Plantix. A: logos; B: Plantix platform.

Methodology:-

Experimental set-up

In the fields surveyed at the two locations, observations were made using an Alpha Lattice experimental design with three replicates. Each replicate was separated by 2 m and consists of five blocks 80 cm apart. The elementary plot contains four lines of 5 m each spaced 50 cm apart. Each seedling contains three seeds/pod.

Method for inventorying and identifying diseases on experimental sites

Surveys were carried out in the experimental plots to visually identify disease symptoms on soybean plants. When a symptom was visually spotted, a photo was taken in detail to show the outline of the vegetative organ concerned. Using the Plantix application, each symptom photo is submitted to the database. The Plantix application then gives the name of the disease in question that the symptoms reveal. In all cases, even if two diseases are proposed, a comparison of the symptoms proposed by the disease sheet, the symptoms in the field and the photo submitted to the Plantix application is carried out to definitively identify the corresponding disease.

Results:-

Inventory of diseases identified on soybean at the Gampèla and Farakoba sites

Surveys at the Gampèla and Farakoba experimental sites revealed various symptoms on almost all vegetative parts of the plant. Symptoms such as Chlorosis, red spots, brown spots, necrosis, small spots, irregular greyish yellow spots on leaves, stems, collars and roots were all observed. A variety could show several symptoms. In all, 9 diseases were inventoried at the sites: soybean blight (fig. 3A), Septoria leaf spot (fig. 3B), downy mildew (fig. 3C), soybean powdery mildew (fig.3 D), soybean rust (fig. 3E), anthracnose (fig. 3F), sudden death syndrome (fig. 3G), bacterial blight (fig. 3H) and grey cercosporiose of soybean (fig.3I). Diseases such as anthracnose, Septoria leaf spot, grey cercosporiosis, rust and sudden death syndrome were found at both study sites (Farako-Bâ and Gampela). Sclerotinia rot, downy mildew and powdery mildew were identified mainly at the Gampela site and fire blight only at the Farako-Bâ site.

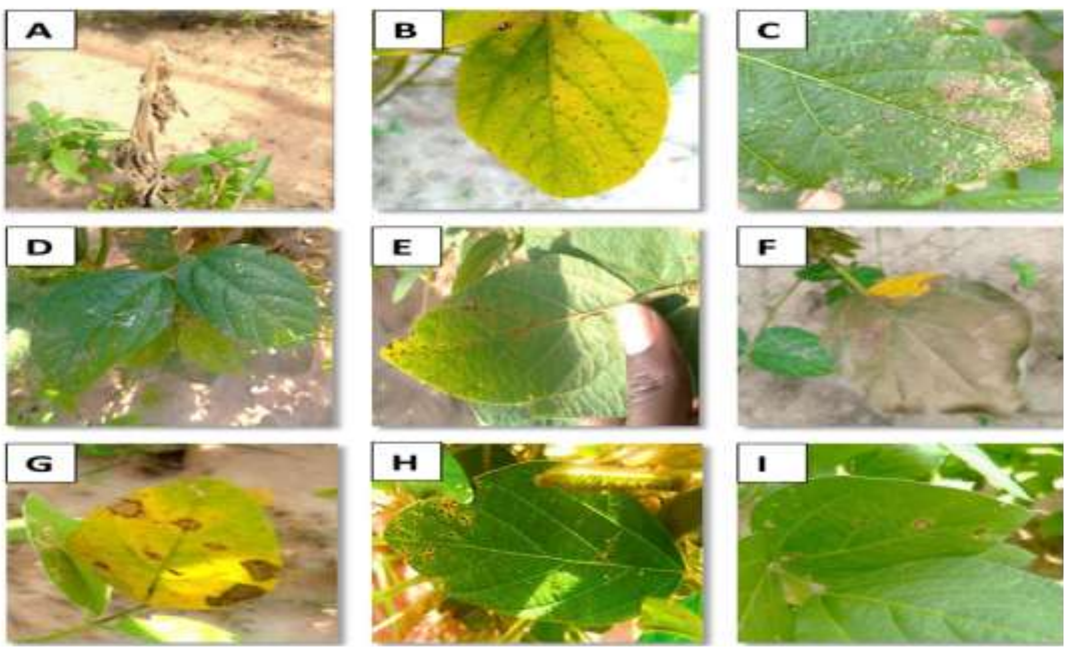

Figure 3:- Symptoms observed:**A-**Sclerotinia rot; **B-**Septor spot; **C-**Mildew; **D**-Oidium**; E-**Rust; **F-**Anthracnose; **G-**Sudden death syndrome; **H-**Bacterial blight; **I-**Grey mercosporium blight.

Other symptoms on soybean without identification of associated diseases at the Gampèla and Farakoba sites

Other symptoms were encountered, but the associated diseases could not be identified using the Plantix application and the recognition form. These symptoms more closely resembled physiological disorders in general and nutritional deficiencies in particular. These symptoms included discolouration of the interveinal spaces (Figure 4: A), blistering and deformation of the leaves (Figure 4: B), greyish discolouration starting at the top of the leaf blade and invading the entire leaf blade, leaving the basal part green (Figure 4: F), purple discolouration of the leaf blade (Figure 4: C), pale dry spots along the tips which migrate towards the centre of the leaf (Figure 4 :D) and finally discolouration in places on the leaf blade (Figure 4: E).

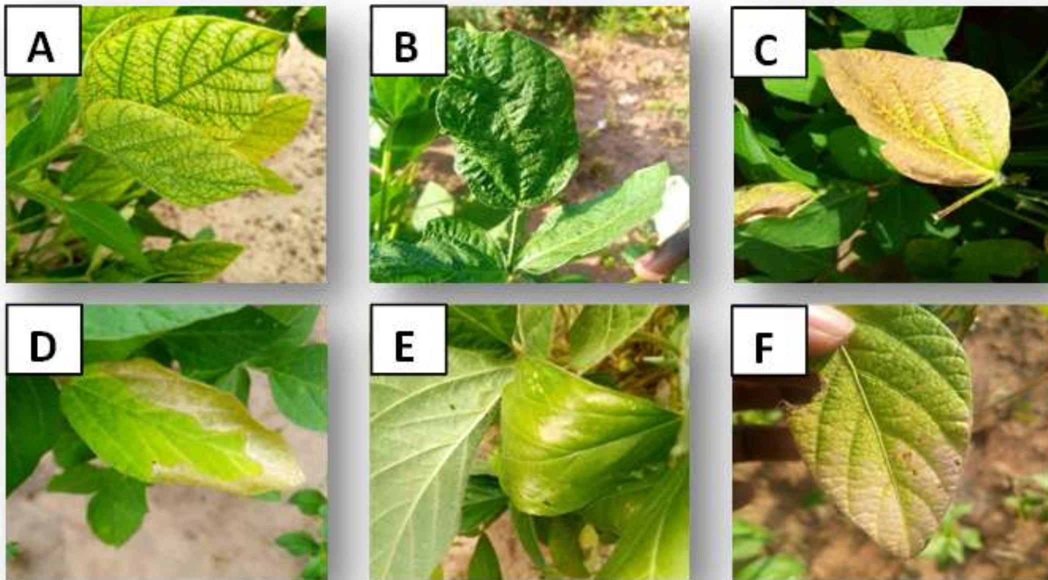

Figure 4:- Other symptoms encountered whose associated illnesses were not identified.

Discussion:-

In the era of technology and the proliferation of artificial intelligence and deep learning, many mobile applications are available for the detection, diagnosis and treatment of plant diseases (Siddiqua, A. K. et al. 2022). Through work based on these technologies, this study established or explored the collaborative solution between image processing and plant pathology. These solutions will make it possible to reduce the human labour time required by using algorithms to facilitate the identification of plant diseases (Ait Elkadi K. et al. 2020). In a context where extreme climatic conditions are making the identification of diseases in the field more complex, artificial intelligence could help in efficient phytosanitary treatment through effective and early diagnosis of crop diseases. However, most applications cannot be used as a complete solution for the detection, diagnosis and treatment of plant diseases. To this end, the applicability of these applications for pathogen detection, identification and treatment has been evaluated and only one application, Plantix - your crop doctor, was able to successfully identify plants from images, detect plant diseases, maintain a rich plant database and suggest potential treatments for the disease presented (Siddiqua A. K. et al. 2022). As part of this study, field observations were made using the Plantix-your crop doctor application. This identified nine (09) diseases. While for some diseases the symptoms are quite recognisable, this is not the case for others where the symptoms are not sufficiently distinct. Hartam et al. (2015) stated that there was a similarity between fire blight and rust as well as Septoria leaf spot but fire blight does not cause watery or translucent spots on the underside of leaves. As a result, it looks more like Septoria leaf spot. Powdery mildew and grey cercosporiosis show fairly characteristic symptoms. The Plantix application, your crop doctor based on deep learning, when the photos are in sharp focus, helps to resolve these problems of confusion or misindentification. The heterogeneous presence of the diseases inventoried on the sites surveyed could be due to the climatic and agro-pedological conditions which differ from one site to another.

According to Thio et al. (2022), soybean genotypes are adapted to specific agroecological regions and phenotypes are strongly influenced by environmental factors. It should also be noted that one and the same parasite can also induce different foliar symptoms depending on the factors surrounding the onset of the disease. According to Howell (2003), lesions are colonised not only by pathogens, but also by saprophytes. Mouria et al. (2003) have shown that a lesion can be initiated by a facultative pathogen and subsequently colonised by other pathogens. Symptoms whose diseases could not be identified would be typical of viruses or could be linked to nutritional deficiencies or excesses in mineral elements. For example, symptoms of manganese (Mn) deficiency mainly appear as chlorosis between the veins (yellow leaves and veins remaining green) (Fig. :2-A), initially on the young leaves of a plant, as Mn is not mobile in the plant (Bohner, H. and K. Reid. 2007). Potassium (K) deficiency mainly manifests itself as chlorosis along the leaflet margins (Fig. :2-F), starting at the tips. Chlorotic areas can spread over more than half the leaflet surface, with the basal part remaining green (Duval et al., 2017). Morphological observation and diagnosis in the field are long and fastidious and require confirmed experience. Moreover, morphological characteristics and symptoms in the field are influenced by growing conditions and can lead to misidentification (Diguta (2010); Brigitte D. et al. (2015); Duval, B., and D. Ruel. Ruel (2017)). According to Blancard et al (2003) modern tools for detecting and characterising diseases and pathogens should not obscure the true nature of plant disease diagnosis, i.e. placing the emphasis on knowledge of the field and symptomatology. However, in the context of climate change, where it is becoming increasingly difficult to easily associate symptoms in the field with a given pathology without the risk of making mistakes, plant disease diagnosis should not be overshadowed by applications using artificial intelligence and based on deep learning. At the end of this study, a reliable diagnosis emerged with identification of soybean pathologies without any great difficulty, which confirms the reliability of Plantix as indicated by Siddiqua A. K. et al. (2022).

Conclusion:-

This study shows that the use of the "Plantix - your crop doctor" application is reliable for diagnosing soybean diseases. A total of nine diseases were identified in the course of the study. These were soya bean blight, anthracnose, septoria leaf spot, soya bean grey cercosporiosis, soybean rust, sudden death syndrome, downy mildew, soybean powdery mildew and bacterial blight. Other symptoms were encountered, but the associated diseases could not be identified. Environmental and climatic conditions are thought to influence the heterogeneous distribution of the diseases inventoried. Based on this study, we believe that the "Plantix - your crop doctor" application should be used to diagnose plant diseases in a context of climate change, where it is becoming increasingly difficult to rely solely on symptoms in the field for early management of soybean diseases. It would be necessary to identify the pathogens that are associated with these inventoried diseases; then, further studies based on molecular biology could be carried out to refine the results. Pest control methods that consider environmental protection would be best suited to the management of the plant diseases identified.

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Declaration of interest

The authors have no conflicts of interest to declare in relation to the content of this article.

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