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Yaya Tesfa[1]* and Jemal Bekere [2]

*Melkassa Agricultural Research Center, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia*

## Abstract

Maize-legume cropping systems are practiced under conventional crop production (CP) which has resulted in soil degradation and frequent crop failure, which may be slowed or reversed with conservation agriculture (CA). Traditional plant tissue sampling and analysis is time taking and destructive method; whereas optical sensor techniques LQ SDUWLFXODU QRUPDOL]HG GL‡HUHQFH YHJHWDWLYH LQGH[ 1'9, DUH DQ LQ\ assessment. CA can improve soil health and crop productivity. However, CA has not been well studied considering GL‡HUHQW FURS DQG VRLO SDUDPHWHUV IRU LWV LPSDFW RQ VRLO DQG PDL]H SU SURGXFWLYLW\ VXVWDLQDEOH LQWHQVL¿FDWLRQ WHFKQRORJLHV QHHG WR GHPR HQYLURQPHQWDO LPSDFWV WKURXJK WKH FRQVHUYDWLRQ RI UHVRXUFHV DQG PD PDQDJHPHQW SUDFWLFHV ZKLFK VWRUH DQG FRQVHUYH DV PXFK UDLQZDWHU DV LQ¿OWUDWLRQ RSSRUWXQLW\ WLPH DQG LQFUHDVH WKH ZDWHU VWRUDJH FDSDFLW (WKLRSLD 7KLV UHYLHZ FRQFOXGHV WKDW ]HUR WLOODJH ZLWK UHVLGXH UHWHQ\ throughout the plot, avoiding soil degradation as well as reducing plant competition and as such spatial variability.

**Keywords:** Conservation agriculture; Normalized di erence vegetative indexl soil moisture

## Introduction

Maize (Zea mays L) and common bean (Phaseoulus vulgaris L.) are planted by small scale and commercial farmers in monocropping, intercropping or rotation cropping system as a strategy for improving food security. Maize and common bean are important crops in Ethiopia and are mostly grown by resource-poor farmers in risky farming systems. Maize is the second most important main staple and common bean is an important dietary protein source for the rural poor smallholder farmers in Ethiopia. e two crops are mutual to each other when used in rotation and intercropping systems, but these cropping systems are practiced under conventional crop production (CP) which has resulted in soil degradation and frequent crop failure especially in the semiarid regions. e CP practice which involved cereal monoculture with repeated tillage and without crop residue retention has contributed to soil degradation and poor harvests in the semiarid Central Ri Valley of Ethiopia (Liben et al., 2017) [1].

Smallholder farmers in Ethiopia practice crop rotation only a er crop yield reduction is observed due to soil degradation or crop disease build up in the eld. Maize intercropping with an early maturing legume is practiced to reduce the risk of total crop loss in the semiarid agro ecologies in cases of high probability of soil water de cits occurring during early reproductive stages of maize. Liben et al. (2017) showed importance of improved maize and common bean-based cropping systems practices to reverse negative e ects of soil degradation and rainfall variability on maize and legume production in the semiarid Central Ri Valley of Ethiopia. It is becoming increasingly recognized that agriculture is an important cause of environmental degradation. e solution recommended is to manage the resources so that they are neither degraded nor depleted and ensure a sustained production for inconsistent and require more localized evaluation and adaptation (Liben et al., 2017, 2018).

According to Govaerts et al. (2007a) CA has many advantages over CP which included soil moisture retention which allows earlier planting for longer maturity varieties, reduced runo and evaporation, reduced erosion, soil water conservation, and less labor and dra power demand, and improved crop yields. CA improves soil properties

*Corresponding author: Yaya Tesfa, Melkassa Agricultural Research Center, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia, E mail: yaya.tesfa@gmail.com

Received: 6HS 0DQXVFULSW 1R DFV Editor Assigned: 04-6HS SUH 4& 1R DFVW Reviewed: 36HS 4& 1R DFVW Revised: 6HS 0DQXVFULSW 1R DFVW Published: 6HS '2,

Citation: Tesfa Y, Bekere J &URSSLQJ 6\VWHPV WKURXJK Monitoring and Soil Moisture Measurement in Maize-Bean Crops. Adv Crop Sci Tech 12: .

performance assessments. Traditional plant tissue sampling and analysis is time taking, labour intensive and requires collection of several samples from representative areas to adequately characterize variability found on crop eld. is is time taken and destructive method which results unnecessary applications of fertilizer N and result in nutrient runo and leaching with ultimate contamination of surface and groundwater [5]. e Green seeker™ handheld normalized di erence vegetative index (NDVI) sensor (Ntech Industries USA) was tested as a tool to measure within plot spatial variability and maize crop management (Govaerts et al., 2007a; Liben et al., 2018). e ability to accurately predict yield of eld crops such as maize allows producers, economic agencies, and buyers to make decisions with respect to crop management, pricing and available markets. Optical crop sensor techniques in particular, NDVI are used to estimate yield by providing an instantaneous, non-destructive, and quantitative assessment of the crop's ability to intercept radiation stages photosynthesize (Ma et al., 1996) [6].

Development of optical sensors that can reliably identify nutrient de ciencies may reduce time spent and allow for site-speci c applications of fertilizers. e NDVI is successful in predicting photosynthetic activity, because this vegetation index includes both near infrared and red light. Plant photosynthetic activity is determined by chlorophyll content and activity. e relationship between leaf N and leaf chlorophyll has been demonstrated for maize (Chapman, 1997) and wheat (Evans, 1989). erefore, spectral re ectance data can be used to compute a variety of vegetative indices which are well correlated with agronomic and biophysical plant parameters related to photosynthetic activity and plant productivity (Adamsen et al., 1999; Ma et al., 2001) [7].

Recent advances in precision agriculture technology have led to the development of ground-based optical sensors (or crop canopy sensors) that calculate NDVI readings. Active sensors have their own source of light energy and allow for the determination of NDVI at speci c times and locations throughout the growing season without the need for ambient illumination or ight concerns. Crop canopy sensors are relatively small in size and contain an integrated light source. ey operate by directing visible light (VIS) (400–700 nm) as well as near infrared (NIR) (700–1300 nm) light at the plant canopy of interest (Campbell, 2002). Both water and N stresses altered re ectance and lowered normalized di erence vegetative index (NDVI) values. It suggests that it may be possible to use spatial and temporal patterns of plant re ectance spectral index for in-season water and N management (Plant et al., 2000) [8]. As plants become stressed, they exhibit decreased re ectance in the near-infrared (NIR) spectral region due to decreased cell layers and increased re ectance in the red spectral region due to decreased chlorophyll content (Guyot, 1990). Monitoring this change in spectral re ectance may reliably indicate changes in plant growth or physiological status and can be used to evaluate cropping system performance under di erent tillage systems (Carter, 1994) [9].

e NDVI has been used in many di erent ways, including estimation of crop yields and end-of-season aboveground dry biomass. Soil texture, moisture, plant cover, and landscape surface roughness could a ect soil and plant re ectance the visible and NIR wavelength regions (Asner, 1998). As water and N availability are recognized as limiting factors for maize production in the semi-arid of Ethiopia, optical sensor data could be the basis for water, N, and crop management. Stress events, such as drought, reduced spectral estimates of absorbed radiation and NDVI in corn and soybean canopies (Daughtry et al., 1992). Ethiopian farmers follow traditional fertilization practices which is based upon wide regional recommendations which fail to account for the intra- eld variability and temporal variability of the crop nutrient requirement. is problem can be addressed with the help of NDVI which is a precision agriculture tool. Yield prediction models based on early growth stage parameters are one desired goal to enable precision farming approaches to improve production [10].

Understanding the relationship among crop re ectance, water and N inputs, and eld heterogeneity would be useful for further evaluation of Optical sensor as a tool for moisture and fertilization monitoring. But there are only few studies that assessed the role of NDVI index to measure impact of crop management practices on crop growth and yield in Ethiopia. Yields can be measured as an end of season static result of seasonal crop performance, but these results do not re ect the uctuations of the crop's performance throughout the season.

To understand and evaluate cropping systems, and to ne-tune resource management, insight in crop performance over time is crucial [11].

vulnerability to extreme climatic events such as longer dry spell, erosion, high evaporation and can reduces crop water requirement by 30 percent. CA makes better use of soil water and facilitates deeper rooting of crops and rain water in ltration reducing the danger of soil erosion and downstream  ooding. In addition, it conserves and enhances biodiversity in the  eld, and eliminates power-intensive soil tillage, thus reducing the drudgery and labour required for crop production by more than 50 percent for small scale farmers (http://www.fao.org/ag/ca/) [15].

## Conservation agriculture for climate change and variability

Climate change has both direct and indirect e ects on agricultural productivity including changing rainfall patterns droughts,  ooding, land degradation and the geographical redistribution of pests and diseases. Global food security, global environmental preservation as well as farmer level increased livelihood should be the main goals of a sustainable farming system in today's world plagued by degraded soils as a result of unsustainable crop management practices.  e multitude of rural farmers as well as the three billion urban consumers must rely on sustainable food production systems for their livelihoods [16].

Climatic shocks can be disastrous, particularly in the semi-arid regions of Ethiopia, and discourage the sustainable adoption of improved seeds and agricultural practices (FAO, 2015). Most of the risks associated with discontinuing adopted technologies originate from the recurrent droughts and dry spells (Kassie et al., 2013) that strongly depress crop yield (Segele and Lamb, 2005).  e variable rainfall, coupled with the absence of reliable agro-meteorological forecasts, in uences the sustainable use of improved seeds and fertilizer technologies (Kassie et al., 2013). To cope with unfavorable rainfall conditions, farmers use various risk diversion strategies such as desisting from investing in fertilizers and improved seeds (Kassie et al., 2013; Yosef and Asmamaw, 2015), and adjusting the cropping calendar, crop, and crop variety to be grown, practicing intercropping wlHj8 iaI 8 stratili tltu42 TwCderoved y3

decomposition legume residue [27].

the e ect of one parameter, the NDVI has to be considered as a measurement of amalgamated plant growth re ecting various plant growth factors.

Crop growth and development as well as yield are the integrated evaluators that show the ef ciency of the chosen agricultural management system within the boundaries of the agro-ecological environment.

Any crop cultivars selected for the given agro-ecological zone, will act as an integrated evaluator of all environmental factors thus showing how management in uences and determines resource-use ef ciency. Crop performance was measured during the 2004, 2006 and 2008 crop cycles with an optical handheld NDVI sensor in the di erent management treatments of a long-term sustainability initiated in 1991 by CIMMYT by incorporating di erent tillage practices (zero tillage compared to conventional tillage), residue management (residue removal and retention) and crop rotations (mono cropping vs. a maize/wheat rotation). Based on this long-term experiment the long-term e ects of tillage, residue management, and crop rotation on crop yield, on physical and chemical soil quality, on root rot and nematode populations, plus the interactions and e ects on yield of root rot, nematodes, and water dynamics and in ltration is observed. Zero tillage with residue retention and crop rotation resulted in a soil with good physical, chemical and biological qualities, and high, stable crop yields, compared to conventional tillage and zero tillage without residue (Govaerts et al., 2005, 2006a, b, 2007a, b, c, 2008a, b, and 2009) [28].

## Conclusions

Crop production systems which improve soil fertility and yield through conserving resources, environmentally non-degrading, technically appropriate, and economically and socially acceptable was suggested for regions with poor soil and erratic rainfall.

Conservation agriculture played a vital role in terms of maize growth and yield. Rotational and intercropping under conservation agriculture were very advantageous as compared to monocropping under conventional crop production. Crop rotation and intercropping practices integrated with in situ water conservation methods are used in sustainable crop production. Integrating intercropping practice to Tied-ridge and zero-tillage can maximize growth resources use and increase crop production. Crop production in the next decade will have to produce more food from less land by making more e cient use of natural resources and with minimal impact on the environment. Only by doing this will food production keep pace with demand and the productivity of land be preserved for future generations.

Optical sensor is playing an important role in monitoring and controlling crop management systems. ere is a need for faster, more accurate, and possibly more economical methods such as normalized di erence vegetative index (NDVI) is needed for collecting crop

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