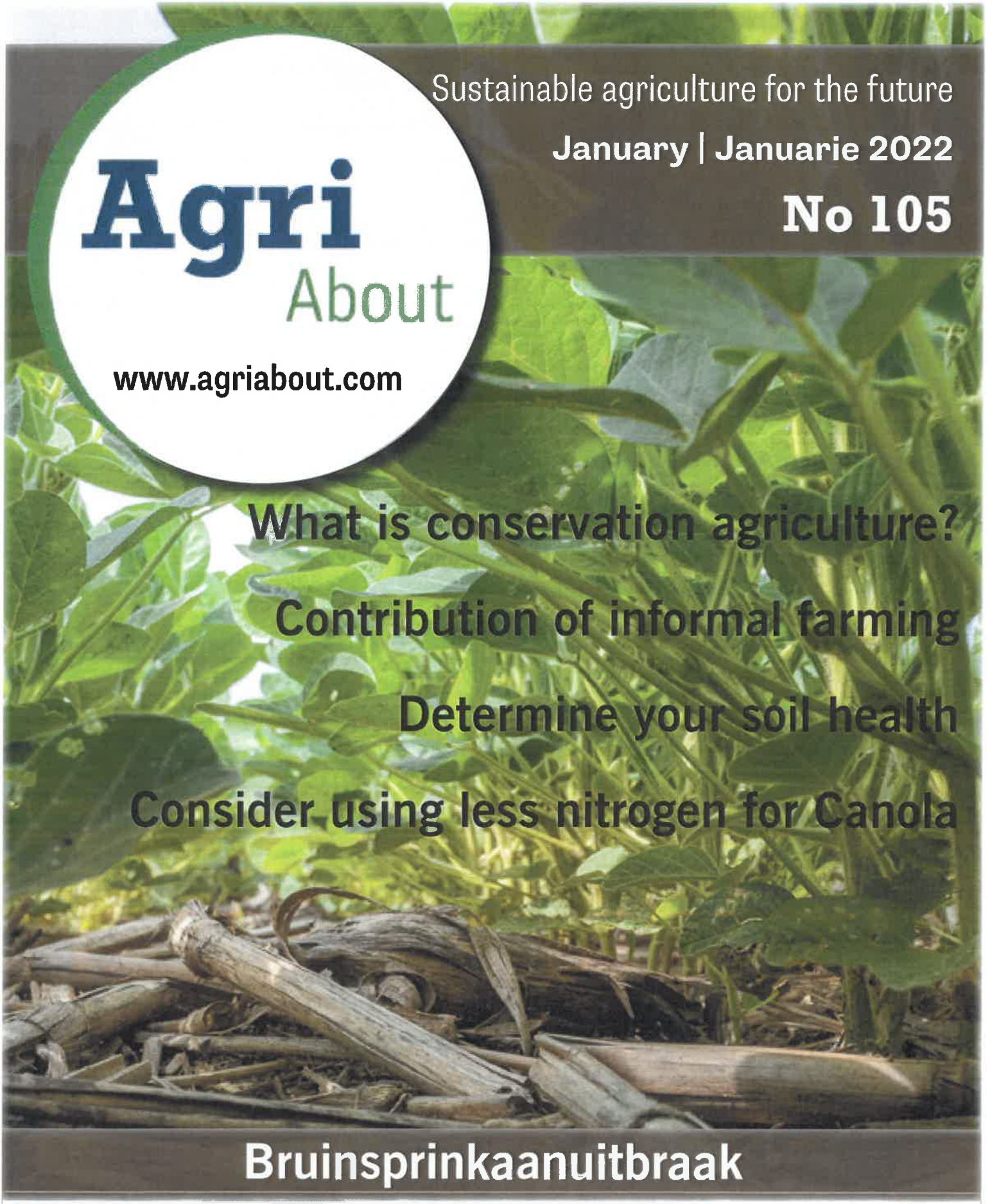

Sustainable agriculture for the future

January | Januarie 2022

No 105

Agri About

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Determine your soil health using biotic and abiotic indicators in one package – YourSoilTM

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ARC-Plant Health Protection

Soil is a living system and the foundation of crop production. Soil health is defined as the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (Doran & Zeiss, 2000). Soil health can be determined by examining the biotic and abiotic characteristics of a soil. The biotic aspect of soil includes the living organisms living within the soil system. The abiotic aspect includes the non-living characteristics of the soil which includes the physical and chemical status. Due to the importance of the biotic and abiotic characteristics of the soil especially in agricultural soils, determining the soil health status is important to ensure healthy, efficient and sustainable crop production. Improving the soil health status of a soil may decrease the input costs and increase the sustainability of the soil.

Soil organisms including bacteria, fungi and nematodes, play an important role in the soil ecosystem and are frequently used as biological indicators of soil health for various reasons. Biological indicator organisms play important roles in nutrient cycling and mineralisation in soil ecosystems. They also form part of the soil food web as primary consumers and secondary consumers (of organic matter and other organisms). These organisms react rapidly to environmental change and are therefore well suited for monitoring soil health. Because soil is such a complex system, the use of soil organisms as biological indicator organisms is a unique and effective tool for determining the biotic aspects of the health status of the soil. The structure, physical and chemical characteristics (abiotic) of the soil are directly linked to the biotic aspects of soil as many abiotic characteristics influence the presence and abundance of soil organisms. Here the focus is on soil as a natural resource: its formation, classification and mapping; physical, chemical, biological and fertility properties - linked to the sustainable use and management of soils.

YourSoil™ is a new service package offered by ARC- Plant Health and Protection (PHP) and ARC- Natural Resources and Engineering (NRE) that measures biotic and abiotic components in soil. This package service includes various tests that focusses on determining soil health.

The biotic aspect of YourSoil™ is based on the presence of biological indicator organisms in the soil and include various tests that are widely accepted to determine the health of the soil. The abiotic aspect is based on the structure, physical and chemical condition of the soil and includes the certain tests of plant material. The client can choose all or only some of the tests offered in the package which includes the following tests:

- Nematodes: Nematodes are known to be one of the most diverse and abundant organisms in the soil environment. Although the plant-feeding nematodes (plant-parasitic nematodes) are usually the focus in agriculture due to the damage they cause to crops, the largest percentage of nematodes in the soil are beneficial organisms. These nematodes play an important role in various soil systems and are also involved in the soil food web (as a food source to other organisms and predators that feed on various organisms). Nematodes are often used as biological indicators of soil health because they occur in large numbers in the soil and respond rapidly to any changes in the soil ecosystem. A faunal analysis of nematodes is the test that is included in the YourSoil™ package and includes the identification of plant-feeding nematode species and free-living nematode genera. In this test, the number and type of free-living nematodes are used to determine the soil health status. This is done using various indices to classify the soil into one of four specific groups based on different indices. Each group has specific characteristics that indicate the soil health status of the soil.
- Rhizobacteria: These bacteria, also known as the Phyto-friendly soil microbes, occur in the rhizosphere (area around the root system) of plants and therefore represent the part of the soil with the highest microbial activity. Rhizobacteria play important roles in improving the soil ecosystem functions and services as well as in the biogeochemical cycling of soil nutrients. Rhizobacteria also have a high root colonization ability and facilitate vegetation through various modes of action, including solubilisation of phosphorus, production of phytohormones, chelation of iron (Fe) and its availability to plants; as well as the production of metabolites such as ACC deaminase activity that alleviates various abiotic stresses in plants by regulating the level of ethylene. The presence of these microorganisms in large quantities in a given soil is a good microbial indication of soil health. The YourSoil™ package includes the following tests of Rhizobacteria analysis: microbial profiles in the soil using metagenomics, identification of important bacterial indicators of soil health, community level physiological profiling (CLPP) using the Biolog microplate, which measures the utilization of 31 carbon sources to compile a profile, and microbial enzyme activities.
- Soilborne plant pathogens: Root diseases are without a doubt one of the most

important yield-limiting factors in crop production. These diseases are often caused by a complex of pathogens that seriously harm the health of the root, as diseased roots cannot absorb water and nutrients optimally. Although root health is an important component of soil health and is essential to optimize crop yields, farmers are often unaware of the root status of their crops. The reason for this is that many root diseases do not cause visual symptoms on the soil. The YourSoil™ package includes root health assessment test done under greenhouse conditions. The test is done by planting annual crops in the client's soil to detect any pathogens, as a control the pathogens are eliminated from the same soil, planted to the annual crop and the severity of root rot is rated.

- Fungi: Fungi are a diverse group of organisms in the soil environment and include both pathogens and beneficial groups. These organisms play various roles in the soil and the health status thereof. Most fungi support plant growth; fungal hyphae physically bind soil particles together, creating stable aggregates that help increase water infiltration and soil water-holding capacity. Various fungal species are pathogens of other soil organisms that ensure balance in the soil ecosystem and fungi are also decomposers of organic matter and play a major role in the circulation of nutrients in the soil. YourSoil™ includes the morphological identification of fungal species; measurement of disease load in a sample while providing species specificity for the possible pathogen; molecular identification and comparisons of relationships amongst species based on DNA.
- Abiotic indicators: Chemical and physical indicators are used to determine the soil health condition as well as the determination of nutrient cycling and supply to plants. These tests also include the determination of the storing capacity and release of nutrients, soil pH, organic matter, macronutrients and micronutrients available in the plants and whether they are in usable quantities. Soil structure is also tested to determine if sufficient depth and stable soil structure for balanced plant growth environment is effective.

The following abiotic tests are included in YourSoil™

- Sample preparation: drying and milling (10 g - 250 g); washing, drying and milling; milling only; digestion (open tube); microwave digestion.
- Farmer Package: top or middle soil analyses: P (Bray No 1 or 2); K, Ca, Mg, Na (Ammonium Acetate); pH (water); Exchangeable acidity; Resistance; Texture (3 Fractions).
- Determination on sample as received: ashing and moisture content.
- Determinations of Dry-Oxidation: total nitrogen and total nitrogen and carbon
- Determinations on digested samples of various element : Ca, Mg, P, K, Na, Fe, Mn, Zn, Cu, Al, B; ICP-OES trace elements, (e.g. As, Pb, Cd, Ni, V, Co, Cr, Mo); Semi-Quantitative scan (ICP-MS) (Li, Be, Ti ,V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Mo, Cd, Sn, Sb, Te, Cs, Ba, La, W, Pt, Hg, Tl, Pb, Bi, U)
- Determinations of nitrate, nitrite, chloride, fluoride, sulphate; pH and electrical conductivity (EC) on extracted samples.

There are various aspects of the YourSoil™ package that is unique. Firstly, not only are the abovementioned tests included but the package also includes an option to receive recommendations from a specialist. These recommendations may include selection of follow-up crops in a rotation cycle to minimize soilborne plant diseases; integrated management strategies for soilborne plant diseases; effects of conservation agricultural practices on soilborne plant diseases; effects of nursery practices on soilborne plant diseases; and recommendations for fertilizers (on most vegetable, grain crops and fruit crops). Secondly, a combination of these tests enables the client to identify aspects in their soil samples that require attention and thus promote crop production. The YourSoil™ package also enables the client to choose a combination of the tests and receive one quotation and one detailed report.

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