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Basics of comparative biodiversity analysis in natural, organic and conventional farming – A preview

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ABSTRACT

The biodiversity is one of the important indicators for evaluation of different production systems with more emphasis at present for natural farming. The natural farming is known for its basic component such as bio-input application, soil health, use of conventional inputs and practices which are known to have significant impact on soil, microorganisms and plant diversity. Being new production system with variation in practices followed, its comparison with modern agrochemical based production system or even with organic production system inevitable. The preview describe differentiation between natural ecosystem, traditional farming and modern agrochemical based farming, some variables and methodologies in the form of indices used for plants, animals and soil microbial properties which are having potential to be used for comparative investigation of NF and other production system. The cropping system indices, weed indices and ecological index such as important values index are major group of indices for plants; while soil microbial properties, identification and characterization of infestation of insect-pest and infection of diseases are major groups of indices for comparative evaluation of microorganisms natural farming with conventional farming. Plant and microbial diversity is much higher with respect to their population as well as functional diversity, while animal diversity is completely different for natural ecosystem and agro ecosystem and can't be comparable.

Keywords: Traditional farming, natural ecosystem, plant diversity, soil microbial properties

The biodiversity indicate the variety and variability of plant species [and animal species as well] and microbial life present in any system. It is the complex achieved after completion of succession in natural ecosystem. In practical point for view for agro-ecosystem, it is the combination of plants, insect, microbes and animal being domesticated and / or available at any farm with their variables interactions. It is also terms in other word as function diversity indicating the part of total diversity which is being utilized to generate the different types of goods and services from agro-ecosystem. At the same time, from natural farming (NF) perspective of diversity, the soil microbial diversity and

diversity of predators and parasitoid for different insect-pest and diseases are important component of function diversity. The plant diversity in agro-ecosystem is achieved through crop rotation, different types inter and mixed cropping; while for natural farming, farming system (FS) and agroforestry (AG) it is wider with inclusion of tree and animal component in NF and AG. For FS it is still much wider with including of wide varieties of plant, insects and animals. The bio-diversity can be also considered in two different ways viz., naturally existing bio-diversity which include all biotic components which even not planned in farm such as weeds, insect-pest and disease causing pathogen, soil and atmospheric micro-flora and micro-fauna; while another type is related with induced diversity through cultivation of plants, application of microbes/bio-inputs and domestication of animals.

The comparative study of biodiversity is essential to understand the ecological as well as economical values of biodiversity achieved due to acceptance any production system. This is more practically significant and important to compare the changes occurred after introduction of natural farming (Table 1). The reduction or no use of any agrochemical, increased uses of fermented bio-inputs rich in microbial population, increases use of organic and in-situ inputs, incorporation of animal in production system, use of organic mulching, incorporation of tree component in production system with increases crop diversity are the major factors affecting the variation in biodiversity in natural farming over conventional farming. Along with this growing of plants used for different bio-input production required in NF (Table 2) will further add to the biodiversity in NF. Besides that, information and collection of changes in biodiversity is also critical to analyze the systems different properties, such as stability, sustainability and ecological footprint. As NF is newly being implemented on large area such comparative study of biodiversity will be worthy to get the number and extent of positive effects in natural farming.

Criteria of analysis of plant diversity – The different ecological indicators such as relative density, relative frequency, relation abundance and important value index are used as criteria for analysis of diversity of plants. For determination of these indicators the representative samples of flora with sufficient number of replicate to represent entire area are needed. For this random sampling through quadrat throughout the field is done which may be repetitive if need to be studied across different time interval. The careful identification of flora and its handling both in-situ and ex-situ is essential to extract complete information. The sample size, number of quadrat and timing of sampling is subjective to objective of study and plant population involved. Beside these primary indices some secondary indices based on biomass accumulation and statistical parameters are also estimated. The generally used statistical tools includes descriptive statistics parameters such as measure of central tendency [mean, mode median, arithmetic/geometric ad harmonic mean], measure of dispersion such as range, mean deviation, standard deviation, coefficient of variation, skiwness an kurtosis], different types of distributions [normal, binomial, poisson, etc.] and other statistical tools. These tools are used for in depth studies and are case specific. The relative density is the ratio of number of individual of a single species occurred in all quadrate to the number of quadrate studied expressed in percentage; while relative abundance is the ratio of number of individual of a single species occurred in all quadrate to the number of quadrate in which a given species occurred expressed in percentage. The relative frequency indicates number of quadrant in which species

occurred to the total number of quadrant studied expressed as percentage. The summation of relative density, relative abundance and relative frequency is important value index. These four indices will gives broad ideal about distribution of plant species. Besides that, if the area under consideration is large, than such basic parameter study also serve as important indicators as sample size and resources required for secondary and statistical indices are higher. Besides that, these parameters will be also useful in case of plant flora shift study and dynamics of plants/ weed in different production systems.

The economic importance of plant diversity can be assessed through various cropping system indices such as multiple cropping index, land use efficiency index and cropping intensity index, relative yield index, relative spread index, diversity index, harvest diversity index, land equivalent ratio, monitory equivalent ratio, relative yield total, area harvest equivalent ratio, relative crowding coefficient, competition ratio, competition index, arc. Even though the indices are large in number, their significance and use are specific and required some basic requirement to meet such as intercropping, sequential cropping and availability of information on land and yield obtained. These indices are commonly used in intercropping system as well as in rainfed agriculture for evaluating the production efficiencies across different level of natural and artificial resources used. The another variables to study the economic impact of unwanted vegetation (weed) diversity on crop production potential includes weed management indices such as weed control index, weed control efficiency, weed index and weed smothering efficiency. The major drawback these indices are that in all of them weeds are considered as composite population without accounting their taxonomic position. Even with this drawback the attempt to determine family wise potential to cause damage and identification of major niche to different species or family of weeds will add to the comparative plant diversity studies across natural and other production systems.

Criteria for analysis of animal diversity- The domesticated and naturally found animals are the two basic categories for analysis for their positive and negative effect as well as their distribution across three ecosystem viz., natural ecosystem, conventional farming and modern production system. The agriculture census is one potential avenue for documentation of population and diversity of domesticated animal in agriculture; while non-accountability of non-insect pest, non-domesticated animal receding in the human settlement area as well as wild animal is major consideration of its use. For both IFS and NF diversity of animal is expected to be higher and need to consider both domesticated and non-domesticated animal.

Criteria for analysis of microbial diversity- The study of soil microbial diversity is essential in natural farming as several soils microbial properties are acting as indicators of soil health (Shahane and Shivay, 2021) and soil health is important component of natural farming. These properties have their own role and significance which is having economic and practical significance in natural farming and other type of production systems as well (Table 3). The serial dilution followed by inoculation of microbes in artificial media in-vitro is most common and suitable method for preliminary enumeration of soil microbial diversity for bacteria, fungi and actinomycetes. Besides that, different enzyme activities can be also used for determination of soil microbial diversity. In most recent and advanced tools such as soil genomic study and its detailed description will also work very effectively for study of soil biodiversity; while such methods requires a detailed understanding of the taxonomy

and sophisticated procedures. The soil sampling and testing of its pH is one of the most commonly known methods to get the rough idea about types/ group of microorganisms comparatively prominent in soil. Besides that other soil physical and chemical property will have indirect effect on soil microbial diversity through affecting the growing condition and supply of carbon and energy sources to microorganisms. The soil moisture content, presence of plants and it type [legumes versus non-legumes] and soil organic carbon/ organic matter are major deciding factors affecting the soil microbial diversity. In natural farming different types of fermented bio-inputs used viz., *Beejamrutha*, *Jeevamrutha*, *GhanaJeevamrutha*, etc. These bio-inputs are known for their richness in microbial diversity and effective microorganisms which further add to increase in microbial diversity.

The less or no use of agrochemicals for biotic stress management will avoid the adverse effect on microbial diversity as well as insect diversity and contributes to improvement in microbial diversity. These inputs used and management practices followed are completely different in natural and conventional agrochemical based production system; therefore comparative study of microbial diversity will be worthy for which knowledge of biodiversity analysis is essential.

The study of insect-pest infestation and diseases infection through identification of diseases and insect-pest occurred in the field in particular season/ crop/year is another way to study biodiversity in agro-ecosystem irrespective of production system. This type diversity carrying economic importance considering the potential to cause damage to crop plants and affect the returns from the plants. The identification and accounting the different insect-pest and disease causing pathogen and study of economic threshold levels are the direct ways for study of such biodiversity; while study of losses caused by the microbes is indirect way to determine their diversity.

Table 1. Comparison of natural ecosystem, traditional farming and modern farming in qualitative criteria

S.N.	Particular	Natural ecosystem	Traditional farming	Modern farming (Agrochemical based farming)
1.	Human involvement	Very less or no need	Moderate involvement, productive and ecofriendly	Must at all stages of production process.
2.	Productivity level and scale	Optimum as affected mostly by environment ; Wider spectrum [GPP, NPP]	Attempt to increase over NE with positive effect of environment; narrow scale	Productivity is major aim; high to very high; very narrow scale addressing single or only few crops.
3.	Profitability	Not applicable	Moderate	High to very high
4.	Provisional services	Low production and less use	Improvement over NE; meet family need [mostly for subsistence].	Higher to very high [commercial activity].
5.	Ecological and other services	Very high	Moderate	Moderate to low

6.	Involvement of risk	No applicable	Moderate	High and accelerated by resource degradation and climate changes
7.	Succession	Regular activity as affected by environmental conditions	Moderate to low	Not applicable except changes in crop species or varieties to be grown or development of insect-pest resistance or herbicide resistance
8.	Input	Not applicable	Low input, organic input and in-situ input	Mostly purchased, inorganic and ex-situ inputs
9.	Management	Not applicable	Supported by ITKs	Well-developed body of knowledge based on fact based scientific investigations.
10.	Impact of climate and climate changes	Low to moderate	Moderate to high	Very high
11.	Mechanization	Not applicable	Potential and possibilities explored with ITKs; support livelihood	High mecahnization with economic gain and are commercial; Done at large scale
12.	Automation	Not applicable	Potential exist	High and explored.
13.	Climate resilience	Very high	Moderate to high	Low to moderate
14.	Diversity	High and unplanned diversity not in reach of management practices	Moderate to high; planned and manageable	Moderate to low; highly planned and manageable.
15.	Distribution of life forms	Unplanned and governed by natural resources	Supported by natural resources	Supported by agro-climatic situation and policies
16.	Density of life forms	Very high	Moderate	Moderate to low
17.	Degradation of natural resources	Very low to low	Moderate	High to very high
18.	Soil	Healthy soil with no accelerated degradation	Healthy soil management practices.	Concerns of soil health and accelerated soil degradation
19.	Plants	Diversity	Functional diversity	Less to very less diversity; monoculture
20.	Water	Rainfall as major source and no management	Management of water through traditional methods of water harvesting;	Well planned and accountable water management of both rainfall and below ground water

			possibility for irrigation systems.	
21.	Stability	More stable	Achieved stability and more stable and modern farming	Unstable and fragil nature
22.	Sustainability	More sustainable	Possibility to become sustainable	Concerns of sustainability and less sustainable
23.	Ecological footprint	Low	Moderate	High
24.	Ecological functions and responsibilities	High and large in numbers	High to moderate and comparatively less than NE	Lower than both NE and traditional farming
25.	Impact on human being	Low for provisional services and very high to high for other three types of services	Moderate for all provisional, ecological, cultural and recreational services	High for provisional services and low for other three types of services

Table 2. List of the plants grown in natural farming for production of different bio-inputs

Neem leaves (*Azadirachta indica*)	Mango leaves (*Mangifera indica*)
Karanj leaves (*Pongamia pinnata*)	*Lantana leaves* (*Lantana camara*)
custard apple leaves (*Annona sqamosa*)	*Cassia leaves* (*Cassia tora*)
Castor leaves (*Ricinus communis*)	Guava leaves (*Psidium guava*)
Datura leaves (*Datura metel*)	Pomegranate leaves (*Punica granatum*)
Calatropis leaves (*Calatropis procera)*	Drumstick leaves (*Moringa oleifera*)
Vitex leaves (*Vitex negundo*)	Coffee leaves (*Coffea arabica*)
Datura leaves (*Datura stramonium*)	Mahua leaves (*Maduca indica*)
Nerium leaves (*Nerium indica*)	Coco leaves (*Theobroma cacao*)
Hibiscus leaves (*Hibiscus rosa*)	Acacia leaves (*Acacia nilotica*)
Psoralea leaves (*Psoralea corylifolia*)	Bitter Gourd leaves (*Momordica charantia*)
Chilli (*Capsicum annuum*)	Turmeric (*Curcuma longa*)
Garlic (*Allium sativum*)	Onion (*Allium cepa*)

Table 3. Role and significance of soil biological properties.

S. N.	Soil biological properties	Significance
1.	Acetylene reductase activity (n mole ethylene g^{-1} hr^{-1})	Index of nitrogenase (responsible for nitrogen fixation in microorganisms) enzyme activity

2.	Soil chlorophyll (mg g^{-1})	Soil chlorophyll is measured as an indicator of cyanobacterial colonization and growth in soil
3.	Dehydrogenase activity (µg TPF g^{-1} soil h^{1})	Indicator of microbial activity
4.	Microbial biomass carbon (MBC) (µg g^{-1}soil)	Indicator of live microbial biomass present in the soil
5.	Alkaline phosphatase activity (µg PNP g^{-1} soil h^{-1})	Indicator of phosphorus mobilization and solubilisation capacity of soil macro- and micro-biota and plants as well.
6.	Polysaccharides (mg kg^{-1} of soil)	-
7.	The population count of soil microbes (bacteria, fungi, and actinomycetes)	Indication of overall microbes- bacteria, fungi, and actinomycetes
8.	Microbial biomass nitrogen	Index of nitrogen in soil live microbial biomass
9.	Soil respiration rate	To know about the general activity of below-ground biomass
10.	Total extractable phospholipid fatty acids (PLFA)	To evaluate the microbial community structure
11.	Catabolic response profile (CRP)	Microbial functional diversity
12.	Urease enzyme activity	To know about the hydrolysis of applied urea or animal manure to yield ammonia
13.	Arthropod populations	Used to define soil quality due to involvement in different soil processes
14.	Earthworm populations	Indicator of soil fertility
15.	Nematode population	Economic losses due to damage to plants (mainly roots)
16.	Presence and abundance of mycorrhizal fungi	Important for the mobilization of nutrients due to their extensive network of hyphae

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