

Effects of Natural Farming on Crop Physiology

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The world's agricultural system is challenged by food security, soil degradation, loss of biodiversity, rising production costs, and climate change. The Green Revolution did boost agricultural output with the use of fertilizers and agrochemicals, but the extensive use also led to soil erosion, loss of biodiversity and environmental issues. India has an extensive legacy of eco-friendly and resource-efficient farming practices. Vrikshayurveda, or the "Science of Plant Life," is traditional knowledge pertaining to plant health, physiology, illnesses and pest management. Natural farming is the process of working with natural processes to create healthy crops while maintaining soil health. It focuses on minimal external inputs and eschews synthetic fertilizers, herbicides and insecticides. Natural farming was popularized internationally by Masanobu Fukuoka. Zero Budget Natural Farming (ZBNF) was popularized in India by Subhash Palekar. ZBNF stresses the use of indigenous biological resources and microbial inputs such as Bijamrita and Jivamrita to improve soil microbial activity and plant growth.

Zero Budget Natural Farming

Principles The four pillars of ZBNF are Jivamrita, Bijamrita, Acchadana (mulching) and Whapasa (moisture control). Other approaches include intercropping, contour and bund systems and use of natural pest-management formulations such as Neemastra, Agniastra and Brahmastra.

Jivamrit

Jivamrita is a microbiological rich liquid formulation created mostly from cow dung, cow urine, jaggery, flour and water. It is used to promote beneficial bacteria and boost nutrient availability. Microorganisms in soil play a significant role in carbon and nitrogen cycle, decomposition, mineralization, nutrient transformation, and biological control. Plant growth promoting rhizobacteria (PGPR), phosphate solubilizing bacteria, nitrogen fixing bacteria, cyanobacteria and mycorrhizal fungi help in soil fertility and plant growth. Jivamrita is generally applied at intervals, either as an irrigation or directly onto the soil. Its microbial activity can increase the availability of nutrients, and promote healthy plant growth.

Bijamrita

Bijamrita is a traditional seed treatment preparation created from cow dung, cow urine, lime, water and a little soil. It acts as a microbial inoculum and has been documented to protect seeds and young roots against soil- and seed-borne diseases. The beneficial microorganisms present in Bijamrita and Jivamrita may aid in plant growth through mobilization of nutrients and generation of growth promoting chemicals including indole acetic acid (IAA) and gibberellins. Previous studies cited in the text have reported that organic liquid treatments improved seed germination, seedling growth, root and shoot development and seedling vigor. The treatment of maize and finger millet seed with bijamrita has been found to improve the germination (Jha et al., 2020). Pawar et al. (2015) have reported similar results in case of

garden pea under biofertilizer treatment. Bijamrita treatment also resulted in better seedling morphological and biochemical traits in maize.

Whapasa and Mulching

Mulching or Acchadana is covering the soil with suitable plant wastes or living cover crops. Mulching lowers evaporation, conserves soil moisture, improves soil conditions and promotes microorganisms and earthworms. Cover crops can help with weed control, nitrogen fixation, and organic matter buildup. Whapasa is the equilibrium of air and water in the soil. Good soil aeration, moisture management, water holding capacity and soil structure also play a part in crop growth, especially under drought situation.

Natural Pest Management

ZBNF recommends pest management using botanical and cow-based products. Important formulations are Neemastra, Agniastra, Brahmastra and extracts of Dashparni. These concoctions are made using locally available ingredients including neem leaves, cow urine, cow dung, garlic, chili and other plant elements. Traditionally they are used against sucking pests, borers, leaf rollers and other agricultural pests. However, although various claims have been made on the benefits of natural farming and Panchagavya based goods, the book underlines the need for scientific proof for widespread adoption and application of these approaches.

Impact on Crop Physiology

Crop physiology is the science that provides the framework for understanding seed germination, seedling growth, vegetative growth, flowering, fruit set, nutrient use, hormone interactions, and responses to biotic and abiotic challenges. Understanding these processes can aid in enhancing crop management and productivity. The book cites several research that show the effect of organic and natural farming inputs on crop growth and productivity. Naresh et al. (2018) reported that the yield of capsicum fruits increased with the use of Panchagavya. Vennila and Jayanthi (2008) reported increase in number, weight and yield of fruits in okra following the application of Panchagavya. Nileemas and Sreenivasa (2011) revealed that the use of liquid organic manure enhanced the biological activity and nutrient availability in the soil for tomato cultivation. Panwar et al. (2013) reported that farmyard manure, vermicompost and application of Jivamrita improved the sweet corn production and microbial populations. Application of organic fertilizer has also been connected with enhancement of photosynthesis, nitrogen fixation, nitrogen buildup and nutrient concentration in crops.

Seed Germination and Seedling Development

Natural farming says that seed treatment is crucial. Germination, seedling vigor and protection against soil- and seed-borne diseases have been reported to be improved in bijamrita-treated seeds. The text quotes studies that show that organic liquid formulations can improve the length of roots, shoots and total seedlings. Combined organic treatments increased biochemical changes during seed germination (Karuppaswamy and Malliga, 2013). Germination of maize and finger millet was improved by application of Bijeamrita (Jha et al., 2020). These benefits may be due to helpful bacteria and their synthesis of plant growth stimulating chemicals such as IAA and gibberellins.

Effects of Microbes

Microorganisms are essential to natural farming as they are involved in nutrient cycling, decomposition of organic debris, encouragement of plant development, and suppression of disease. A study of soybean rhizosphere microbiomes found increased bacterial diversity under nature farming compared to conventional farming. The genera *Rhizobium*, *Burkholderia* and *Streptomyces* also contributed to the disparities across the farming systems. *Burkholderia bryophila* was discovered to display antagonistic action against plant diseases and production of plant growth-promoting chemicals such as ACC deaminase and siderophores.

Jivamrita and other inputs from natural farming may thereby affect soil microbial communities and boost nutrient availability through increased microbial activity. Chlorophyll and Nutrients Chlorophyll is essential for photosynthesis and is highly sensitive to environmental and dietary conditions. The results of the study revealed that organic soil amendments were more effective in stabilizing chlorophyll content under moisture stress conditions than inorganic fertilizers (Namrata et al., 2019). Natural farming practices had a positive effect on the concentration of chlorophyll in cowpea, reported Yadav et al. (2023). Nitrogen is especially required in enough amounts for the production of chlorophyll and protein, whereas phosphorus and potassium are involved in energy metabolism, photosynthesis, membrane activities and enzymatic processes. Higher availability of N, P and K can also be achieved through natural agricultural methods. Yadav et al. (2023) reported that the treatments associated with natural farming practices had higher nutrient values as nutrients were easily available and converted to plant accessible forms. Biological nitrogen fixation and synthesis of growth-promoting chemicals may further contribute to the nutrient usage.

Soil and Growing Health

Natural farming inputs influence physiological and biochemical processes of root development, photosynthesis, protein synthesis and biological nitrogen fixation. Natural farming techniques improved the growth of pigeon pea as indicated by increase in plant height, leaf area and dry matter accumulation (Singh et al., 2023). Natural and organic inputs can improve biological properties of soil. Natural farming inputs improved soil organic carbon, nitrogen availability and microbial activity (Darjee et al., 2023). Jivamrita and Ghanjeevamrit were related with higher microbial activity and phosphorus availability. Soils receiving natural farming inputs also had increased microbial biomass carbon and microbial biomass nitrogen.

Natural Farming and Abiotic Stress

Climate change has increased both the frequency and intensity of abiotic stresses such as drought, flooding, severe temperatures, salinity, heavy-metal stress and nutritional imbalance. These stressors can adversely affect plant development, productivity and quality and may improve the formation of reactive oxygen species (ROS). Biofertilizers, microbial biopriming, biostimulants, mulches, and biochar have potential roles in reducing abiotic stress, together with organic inputs. Biofertilizers increase soil health and stimulate the beneficial bacteria that enable plants to survive stress. PGPR can synthesize phytohormones such as IAA and GA₃, improve drought response mechanisms and ROS scavenging activity. Arbuscular mycorrhizal fungi can also improve soil health and plant defense mechanisms to increase stress tolerance.

Summary

Natural farming and ZBNF offer a method that decreases reliance on synthetic agricultural inputs and increases the use of biological processes. The main elements of ZBNF are Jivamrita, Bijamrita, mulching and Whapasa, along with natural pest-management formulations. The research examined suggest possible benefits in seed germination, seedling vigor, microbial activity, nutrient availability, chlorophyll stability, crop growth and soil biological health. Beneficial microorganisms are particularly significant, as they play a role in nutrient cycling, plant growth promotion, disease control and stress tolerance. However, many of the claims made on natural farming inputs needs more systematic scientific validation under varied soil, climatic and cropping situations. Thus, future studies should be targeted on standardized formulations, microbial characterization, long term soil health and crop yield along with physiological and biochemical mechanisms to explain the reported benefits.