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Mini Review

Sustainable Management Practices to Enhance Rainfed Soybean Productivity under Changing Climate

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Abstract

Soybean being rainfed crop encounters various problems associated with climate change. Flood, poor distribution of rainfall, dry spell at critical stage during cropping season, pest and disease incidence, imbalance nutrient application and soil degradation resulted stagnation in country soybean productivity (<1.0 tones ha-1). Therefore, adaption of climate smart sustainable management practices could be viable options. The development of crop specific sustainable management practices under changing climate is continuous process. Hence, effort has made to describe some of the sustainable management (conservation agriculture, integrated crop management, organic farming and natural farming) practices in rainfed soybean to enhance productivity, restore soil fertility and farm profitability under changing climate.

Introduction

Soybean *(Glycine max L.)* Merrill is the leading oilseed crop of India and world. Currently, in India, soybean is grown with an area of 12.19 million hectares (m ha) with the production of 11.23 million tonnes (mt) and productivity 921 kg ha-1. Soybean contributes around 47.02% to the total oilseed area and 35.98% to the total oilseed production in the country [1]. Being rainfed crop (90% area) encounter different production constraints [2]. The low soybean productivity (<1.0 t ha^{-1}) is mainly attributed to biotic and abiotic stresses, unpredictable patterns of climate change, such as extreme variation in rainfall pattern resulting in runoff and soil loss thereby affecting soil fertility in one or two months of cropping period. Moreover, dry spells and high temperature at critical growth stages [3] also affects crop growth. Hence, adaptation of climate smart sustainable agriculture management practices such as conservation agriculture (CA)/Natural farming (NF)/organic farming (OF)/Agri-horticultural system (AHS) could be a viable option, since CA/NF/OF/AHS imbibes the natural ecosystems and address the adverse impact of climate change along with secondary generation problems (Decline in total factor productivity) more effectively without hampering soybean productivity. The available research results suggested that, a huge potential for improving soybean productivity with employing sustainable management practices under rainfed ecosystem [4-8]. Hence, impetus has given to discuss improved sustainable management practices to enhance soybean productivity under rainfed conditions.

Sustainable Management Practices (SMPS) Options in Soybean Production

Sustainable management practices are holistic management practices, which can improve the food and fodder needs of present generations without endangering resource base for future generations [9]. SPMs are integrated systems of plant and animal production practices having a site-specific application and in long term helps to; satisfy human food and fiber needs, enhance environmental quality and the natural resource base upon which the agricultural economy depends [10]. The most commonly used sustainable management practices in soybean production are conservation agriculture practices, integrated crop management practices, organic farming, natural farming practices and agri-horticultural systems (Table 1).

Table 1: Effect of sustainable management practices on soybean growth, seed yield, quality and soil health.

Sustainable Management Practices	Actual Practices Followed	Effect on Soybean	Reference
Conservation agriculture (CA)	• Minimum tillage • Zero tillage • Crop residue retention • Broad bed furrow • Raised bed planting	Improved germination percentage.	[20]
		Enhanced soybean growth and crop yield	[21,22]
		Improved physiological parameters	[23,24]
		Enhanced N, P, K and micronutrients content and uptake in seed and straw	[25,26]
		Enhanced protein, oil, and amino acid content in seeds	[27,28]
		Improved soil physical and chemical properties	[29,30]
		Improved beneficial soil enzymes and microbes	[21,31]
		Increase net returns and B:C ratio	[32,33]
Integrated crop management (ICM)	• Integrated nutrient management (INM) • Integrated weed management (IWM) • Integrated pest management (IPM)	Improved germination percentage (INM).	[34]
		Enhanced soybean growth and yield (INM/IPM/IWM)	[25,35,36]
		Improved physiological parameters (INM)	[37]
		Enhanced N, P, K and micronutrients content and uptake in seed and straw(INM)	[38]
		Enhanced protein, oil, and amino acid content in seeds (INM)	[39]
		Improved soil physical and chemical properties (INM)	[40,41]
		Improved beneficial soil enzymes and microbes (INM)	[42]
		Increase net returns and B:C ratio (INM/IPM/IWM)	[43-46]
Organic farming (OF)	• Farm yard manure • Crop residue mulching • Compost • Vermicompost • Bio fertilizer	Improved germination percentage.	[47]
		Enhanced plant growth and improved yield attributes and yield.	[48,49]
		Improved chlorophyll content and photosynthesis rate, physiological growth parameters (RGR, CGR and NAR).	[50,51]
		Enhanced N, P, K and micronutrients content and uptake in seed.	[52,53]
		Enhanced oil, protein, linoleic acid, Linolenic acid and stearic acid percentage in seeds.	[54]
		Enhanced soil physical, chemical and biological properties	[49,55]
		Increase net returns and B:C ratio	[49]
Natural farming (NF)	• Jeevamritha • Beejamritha • Crop residue mulching	Stable yield of soybean but initial years less yield than conventional farming.	[6,56]
		Improved farm income as low inputs are used in soybean.	[57]

Conservation agriculture practices (CA)

CA represents the on farm improved package of agronomic technologies that permits minimum soil disturbance, soil cover with residue and crop diversification/ rotation spatially and temporally [11]. Minimum soil disturbance through reduced tillage, permanent soil-cover with residue retention and crop diversification are the integral part and main principles of CA, and has become a new paradigm for sustainable intensification of farming systems in 21st century. It has a potential to increase soybean productivity by enhancing resource use efficiency under different cropping systems [12]. The Broad Bed Furrow (BBF) machine sowing is one of the revolutionized climate smart technology in soybean under rainfed condition. BBF maintains optimum moisture in the beds by draining excess water in the deep furrow. BBF as crop establishment technique in soybean crop reduced runoff (10.6%), plant mortality (14–19%), enhanced yield (18.65%) and save 40 to 50% of water in comparison to traditional crop establishment techniques [13].

Integrated crop management practices (ICM)

ICM is a whole system approach based on knowledge and understanding the importance of local ecosystems and accordingly changing the management practices which are better suited to that particular ecosystem [14]. The several improved management practices are employed to sustain soybean production such as seed treatment (FIR, Fungicide, Insecticide and Rhizobium), application of organic (Farmyard manure, Rock phosphate) and inorganic fertilizers, use of plant growth promoting microorganisms, biocontrol agents for insect pests and disease control, selection of high yielding soybean genotypes, crop diversification to enhance crop productivity by maintain soil health.

Organic farming (OF)

OF concept relies on ecologically sound practices includes composting, biological pest and disease management that excludes synthetic chemicals, hormones and feed additives [15]. United State Department of agriculture (USDA) further extends organic farming reliability to crop rotation, crop residue, animal manures, off-farm organic waste, mineral grade rock additives, biological system for nutrient mobilization and plant protection in soybean.

Natural farming (NF)

Natural Farming is a chemical-free farming system rooted in Indian tradition enriched with modern understanding of ecology, resource recycling and on-farm resource optimization. It is considered as agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity. It is largely based on on-farm biomass recycling with major stress on biomass mulching, use of on-farm cow dung-urine formulations; maintaining soil aeration and exclusion of all synthetic chemical inputs [16]. In-addition, natural farming is a diversified farming system that integrates crops, trees and livestock, allowing the optimum use of functional biodiversity. Natural farming if done effectively enhances farmers' income while delivering many other benefits, such as restoration of soil fertility and environmental health, and mitigating and/ or reducing greenhouse gas emissions. Natural farming builds on natural or ecological processes that exist in or around farms [17].

Agri-horticultural system (AHS)

Soybean can be successfully being grown in any horticultural crops like mango, guava, anola, stone fruit (chiku), coconut, papaya oranges, particularly during their juvenile period depending on the sufficient availability of sunlight in the interspaces [18]. Soybean offer good scope to be grown in agri-horticultural system and can support farmers financially during the initial years of establishment of orchards. The tree based soybean intercropping can also help in breaking the compactions in the sub-soil [19] and may support rainwater conservation to a reasonable extent [20-57].

Conclusion

The sustainable management practices are current need to enhance soybean productivity under changing climate. Sustainable management practices (CA/ICM/OF) gaining momentum in soybean crop to enhance yield by maintaining soil health and environmental quality. The farmers are growing soybean with natural farming practices in some of the Indian states at small scale. However, needs sufficient scientific evidence to adopt on large scale. Therefore, sustainable management practices in rainfed soybean may bring economic benefits to farmers by birding yield gap with improved soil health and environmental protection.

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