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Full Length Research Paper

Millet for Food and Nutrition Security in Eastern India's Red Laterite and Drought-Prone Areas

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In comparison to many other regions of India, the red and lateritic zone (RLZ) in Eastern India, which includes a portion of Odisha, Jahrkhand, and the southwest region of West Bengal, has a dreadfully low yield level. This region's soil has low to medium levels of phosphorus, potassium, and calcium available, making it naturally unfertile. The majority of the holdings are situated at higher elevations, where gully development and erosion threats are prevalent. Due to the unpredictable or unequal distribution of monsoon rainfall in this area, rainfed crops frequently fail partially or completely. The majority of this zone is rainfed, monocropped with rice and fodder, and has a cropping intensity of 125–130%. Millions of small and marginal farmers in this area of India struggle with limited resources and provide inadequate food and nutrition in relation to their economic security. Due to a number of biophysical limitations, one of the main obstacles to improving the dire situation in the drought-prone RLZ of Eastern India was intensifying rice-fallow by adding appropriate crops. Since millets are drought-tolerant and climate resilient, they might be the best option for the rice-based crop sequence, any fallow or marginal land, an agro-forestry system, or even for popularizing any millet-based crop sequence to raise the standard of living for small and marginal farmers in the RLZ's arid tract. The goal is to create a paradigm that addresses food and nutritional security for areas such as the RLZ in eastern India by implementing a millet-based cropping system. The feasibility of millet production in the area was assessed using the research data that was available. Value-addition and small-scale agribusiness were approached from a multidisciplinary perspective. In order to increase food and nutritional security in the drought-prone and red-laterite regions of Eastern India, we conceptualized the existing state, future possibilities, and research plans for enhancing the millet production system in this work. We think the same methodology can be used in other parts of the world with agroclimatic circumstances similar to those in the RLZ.

Key words: Millet; drought; red laterite; Eastern India; socio-economy.

INTRODUCTION

Without a doubt, the foundation of any developing nation like India is agriculture. It is the primary source of timber, fruit, flowers, fish, fiber, fuel, food, and fodder. It also supplies raw materials to several small and large-scale companies. The vast majority of the nation's people is either directly or indirectly dependent on agriculture. It is India's biggest private company and accounts for 17.4% of the country's GDP [1]. Agriculture was drastically changed by the green revolution in the middle of the 1960s, which was driven by government policy and research-based new technical development incorporating new materials, techniques, and ways to organize farm inputs. Consequently, the output showed a multiplication in both production and productivity. However, this development is not equally distributed across the nation.

South-west West Bengal, western Odisha, and nearly the whole state of Jahrkhand are all included in the red and lateritic zone (RLZ) of Eastern India. Comparing its yield levels to those of many other regions of the nation, it is in a pitifully low position. Poor input utilization efficiency, soil degradation (e.g., erosion, decline in soil organic carbon content [2], nitrate transfer to ground and surface water, biodiversity erosion [3], and, most importantly, a slowdown in total factor productivity are all blamed for the depressing state of low yield levels. The Chhota Nagpur Plateau is another name for the RLZ in eastern India. The Mahanadi River basin to the south and the Indo-Gangetic plain (EGP) to the north and east of the plateau encircle this region. This region has a total area of roughly 65,000 square kilometers [4]. In general, the area is dominated by laterite, red gravelly, and alluvial soil. This region's soil has low to medium levels of phosphorus, potassium, and calcium available, making it naturally unfertile. In general, the nitrogen level ranges between 0.03 and 0.06 percent. In addition to having a poor cation exchange capacity (CEC), the pH fluctuates from 4.8 to 5.5 [5]. Soils are well-aerated and have a very coarse texture. In general, the content of Fe and Al is high. The majority of the holdings are situated on higher terrain, where gully development and erosion threats are frequent occurrences. Micronutrient deficiencies are found in certain localized locations. The majority of the 1200–1600 mm of annual average rainfall falls between June and September. The distribution of monsoon rainfall is also irregular. As a result, rainfed crops frequently experience partial or even complete failure. The region's cropping intensity ranges from 125 to 130 percent, and the majority of this zone is rainfed and monoculture. Irrigation covers just 40% of the agricultural land. This region's terrain is primarily undulating, with drainage lines and land close to streams. It consists of lowlands called "bohal" that ascend to local uplands called "tanr," with relief usually less than 30 meters. In terms of hydrology, lowlands are local discharge zones for seasonally replenished shallow groundwater, while uplands are recharge areas. The discharge area is the "kanali," or narrow strip of medium lowlands, that separates them. Food insecurity, endemic poverty, relatively low agricultural production, and a lack of irrigation infrastructure are the hallmarks of the east India plateau. The major food crop is rice, and monoculture is the norm in traditional farming. In general, bohal is used to grow rice. However, due to the growing demand for food, rice is now widely grown in this region's medium uplands, or "baid." Due to the acidic, infertile, and limited water-holding capacity of the soils, the area has high rainfall but "low productivity" [6]. Because of this, growing rice in medium-upland areas is a dangerous endeavor that is not well suited to the RLZ's conventional rice production systems. One of the main obstacles to intensifying rice-fallow in the red-laterite region by adding appropriate crops was the scarcity of choices for new crop introduction. But in recent years, the negative effects of climate change, such as rising temperatures, erratic monsoons, and a serious disease pest invasion, have made it rather difficult to intensify cropping systems using pulses. Vegetable ventures have previously demonstrated the issues with adequate water supply in RLZ during post-monsoon seasons.

In terms of physical, social, and economic development, West Bengal is regarded as an evolved Indian state; nonetheless, it contains a few underdeveloped areas that highlight the issues of stark regional differences. With 91.35 million residents and a population density of 1029 persons per square kilometer, West Bengal is a densely populated state. West Bengal is the fourth most populous state in the nation, with roughly three times the national average, while having the 12th largest geographical area. Therefore, it sustains 7.55% of the nation's total population despite making up only 2.7% of its land area. 70% of the population resides in rural areas. Tribal communities make up about 23.01% of the population, and about 40% of families are below the poverty level. The forest covers one-fifth of the entire area. Approximately 35% of the population in this area is made up of marginal laborers, compared to 8.05% throughout the state [1,7].

A comprehensive strategy is required for the intensification of the current cropping system in the RLZ of eastern India, from land selection to the value addition of finished goods. The current agriculture system in RLZ is mostly focused on rice, which is typically planted by farmers at the start of the monsoon season and harvested at the start of the winter. Due to a number of biophysical limitations, including high summer and winter evapotranspiration, low soil fertility and water-holding capacity, irregular rainfall, and a lower uptake of contemporary agro-techniques by resource-constrained peasants, the majority of the land here remains fallow. Considering all of these factors, adding millet could be the most viable way to enhance the RLZ agricultural system and increase food, nutritional, and economic security. However, an all-encompassing scientific intervention is crucial for the successful introduction of millets in this particular zone.

Millets are a group of small-grained, annual cereal grasses that include a number of different species, such as foxtail millet (Setaria italica), finger millet (Eleusine coracona), little millet (Panicum sumatrense), barnyard millet (Echinocloacrusgalli (Japanese) and E. colona (Indian), tef (Eragrotis tef), fonio [Digitaria exilis (white fonio) and D. iburua (black fonio)], and Job's tears (Coix lacryma-jobi). Millets are incredibly durable and climate-resilient crops that thrive in areas that frequently experience drought and intense heat. Millions of dryland farm families, together with the animals and birds they raise, may be able to rely on this type of crop for food and feed since it can adapt to a wide range of temperature, moisture, and input conditions. As members of the C4 group, millets also enhance agro-biodiversity through their wide varietal diversity, enable mutually beneficial intercropping with other essential crops, and trap carbon, increasing potential for CO2 abatement. The traditional crops are little millets, which are better suited agronomically to poor soil and climate [8]. They can be grown in areas where it is not profitable to grow other food crops. Given the growing number of undernourished people worldwide, millets are becoming increasingly significant as food and fodder crops in semi-arid areas [9]. More than 90 million people in Asia and Africa rely on millet as a staple food, and 500 million people in more than 30 nations do the same [10,11]. The degree of poverty brought on by careless management in rainfed farming of the arid region of the RLZ of eastern India may be reduced by choosing appropriate water-saving choices, choosing appropriate alternative crops in relation to their types, and applying appropriate agro-techniques. In this situation, millets might be the best option for any fallow and marginal land, agro-forestry systems, or rice-based crop sequences. They could also be used to popularize any millet-based crop sequence that would raise the standard of living for small and marginal farmers in the arid eastern Indian region.

2. RESEARCH OBJECTIVES

The goal is to create a paradigm that addresses food and nutritional security for areas such as the RLZ in eastern India by implementing a millet-based cropping system.

3. PRODUCTION SCENARIO OF MILLETS

In general, different production methods and a lack of acceptance of improved cultivars are characteristics of millet production systems in Asian nations. The yield average, of course, still only ranges between 0.3 and 1.0 t/ha [11]. Even though India is one of the world's largest producers of millets, the amount of land used for millet farming has substantially decreased in recent years [12,13]. The rainfed regions of Madhya Pradesh, Karnataka, Gujrat, Andhra Pradesh, Telangana, and the red lateritic tract of Eastern India comprise the majority of India's millet-growing region. With a gross yield of 42.86 million tons, millet is grown on around 25.17 million hectares of land in India. Even though finger millet produces 1706 kg ha-1, it only made up 0.6% of the nation's gross cultivated area in 2014–15 [1]. Sorghum, Pearl Millet, and Finger Millet are mostly grown in the rainfed uplands of the red and lateritic belt of West Bengal, an agriculturally significant eastern state in India (mainly in Ultisols with slightly acidic soil conditions). However, the current state of West Bengal's millets output has a somber undertone (Fig. 1). The main reason for this flat or even declining production is the cultivation of millets on marginal lands using antiquated methods and a very small supply of inputs (Fig. 2). .

4. RESEARCH STRATEGY

like atrazine is reduced significantly. Hence, there is a need for exploring potentially effective Research data on millet production that is currently available wide-ranging post-emergence herbicides for to be investigated in many contexts.

The region's viability was used.For value, a multidisciplinary approach was employed. Secure and efficient weed management. Herbicide residues in plants (grain and stover) and soil require as well as small-scale agricultural sector.

An all-encompassing research intervention is crucial to intensifying the current rice-based monocropping system through the successful introduction of millets in this exact zone (Fig. 3). In the RLZ of Eastern India, particularly West Bengal, certain studies have previously been conducted in the areas of crop protection, crop production, and crop development (Table 1). It is not an easy task for the resource-constrained framers of this region to adopt millets. For millets to be successfully introduced, scientific and step-generally less vulnerable to infestations of diseases and pests. However, several severe diseases, such as blight, ergot, and downey mildew, can seriously harm millet productivity. Therefore, it is necessary to develop a need-based Integrated Plant Protection Management (IPM) strategy that incorporates both organic and inorganic plant protection agro-inputs in a scientific manner. Because of their coarse texture, millets need to go through a number of post-harvest processes (such as washing, dehulling, and milling) before they can be consumed by final consumers. Millets feature a wide range of sensible intervention techniques from choice and food value, but to increase the amount of these creation of location-specific cultivars to It is necessary to formulate millets.

the norm use of optimum crop management techniques, such as the millet-based value-added diversified protocol Water, nutrients, and weeds administration goods like recipes for composite flour (Breads, tactics. To control weeds in millets, you need Steam-cooked bread, baked bread, biscuits), non-significant research initiatives Since the wet season is when millets are primarily grown, weeds beverages (both fermented and non-fermented), and composite recipes (such as boiled products and porridges) diminish the yield by depriving these crops of essential moisture. nutrients as well as a significant amount. beverages, malt beverages), and snacks (pop sorghum, pasta, kurkure, recipes for composite flour,

Weeds are more problematic during the initial crop growth period because to millets' slower beginning growth and broader row spacing, which results in early breads, etc.) [15]. In addition to increasing agricultural revenue, the establishment of such cottage level small-scale millet processing companies in this area To maximize the yield, control is required [14]. The majority of but also made the food better.

The enhanced species of security are the minor millets. However, in drought-prone areas, to encourage millet most annoying grassy weeds.

Therefore, it is & Eastern India's red laterite region in extremely challenging to detect and manage weeds in their early stages. However, herbicides are extremely

Linking together with small and marginal farmers in a sustainable manner is crucial. useful for weed control in small millets, however creation of such regulations to determine the

The effectiveness of pre-emergence herbicides in the millet growing environment under moisture stress

At the national and regional levels, the relationship between the producer and the market should be standardized.

A. Crop Improvement

1. Finger millet varieties A 404, WR 5 and EC 50-90 performed well in rainfed upland of red and lateritic belt of West Bengal

B. Crop Production

1. Pre-sowing seed treatment with 100 ppm Na_2HPO_4 or KH_2PO_4 was found beneficial to maximize growth and productivity of finger millet.

2. Seed soaking with water or 0.25% $CaCl_2$ has improved the growth and productivity of finger millet over un-soaked control.

3. Application of 60 kg N + 30 kg P_2O_5 + 30 kg K_2O + 30 kg S/ha has recorded the maximum grain and straw yield of finger millet in RLZ of West Bengal.

4. Seed inoculation with biofertilizer Rhizobium alone or in combination with 30 kg N per ha has reported to enhance the growth and yield of finger millet in RLZ of West Bengal

6. Intercropping of Groundnut and foxtail millet produced a better production increase and synergy. In the intercropping system the apparent quantum efficiency and light saturation point increased. Thus, the groundnut and foxtail millet intercropping reported to be improved the light energy utilization efficiency.

C. Crop Protection

1. About 65 finger millet genotypes and 15 foxtail millet genotypes were evaluated in field against brown spot disease causing pathogen. Amongst them 24 finger millet genotypes and 7 foxtail millet genotypes were highly resistant against the brown spot disease. Thus, genotypes of finger millet and foxtail millet which can be utilized as a source of resistance for breeding disease resistant lines against brown spot disease.[16],[17],[18],[19],[20],[21],[22]

5. GLOBAL PERSPECTIVE

The demand for processed goods made from millet is growing daily on a global scale. By meeting the intended benchmarks, the economic benefits of adopting a millet-based cropping system may be increased, leading to a notable increase in productivity, profitability, and even export revenue. Most other crops frequently failed to grow on unfertile, drought-prone soil, but millets can thrive there. In addition to increasing farming's economic efficiency, farmed millets give millions of impoverished communities across the world fod and a stable source of income. Large millet-producing nations are primarily found in isolated regions of Asia and southern and western Africa. Similar growing conditions, such as the red laterite and drought-prone eastern Indian region, are found in other places of the world, such as the west-central High Plains of the USA and western Australia, as well as southern and western Africa and Asia. This millet-based crop production plan might work just as well in these areas.

6. CONCLUSION

Sorghum, finger millet, and pearl millet have a strong chance of succeeding in the millet-based crop production system of the suggested model in semi-arid, drought-prone regions of eastern India's RLZ and other places with comparable circumstances. Although no research data has been recorded for the eastern Indian RLZ, alternative short-duration millets, such as foxtail, proso, and small millet, might be studied in the event of a severe soil moisture scarcity in the system. We think that other agroclimatic regions, such as the RLZ in eastern India, can use our suggested approach.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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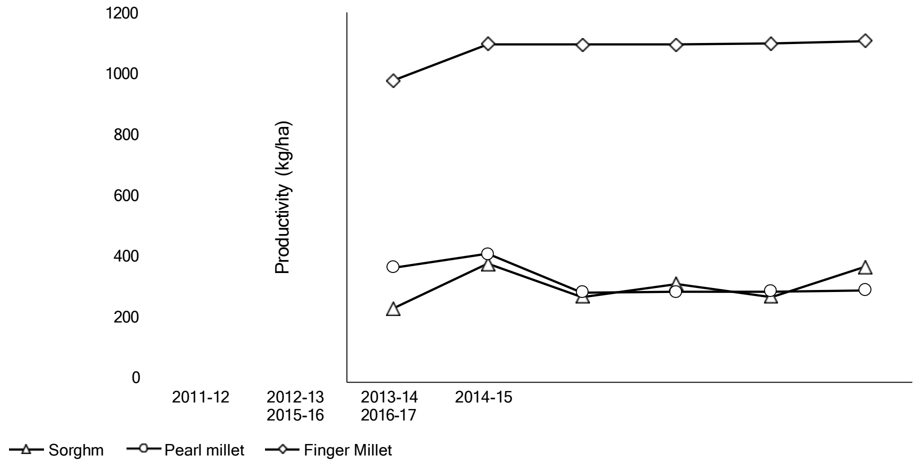

Fig. 2. Productivity trend (kg/ha) of major in West Bengal (Source: [7])

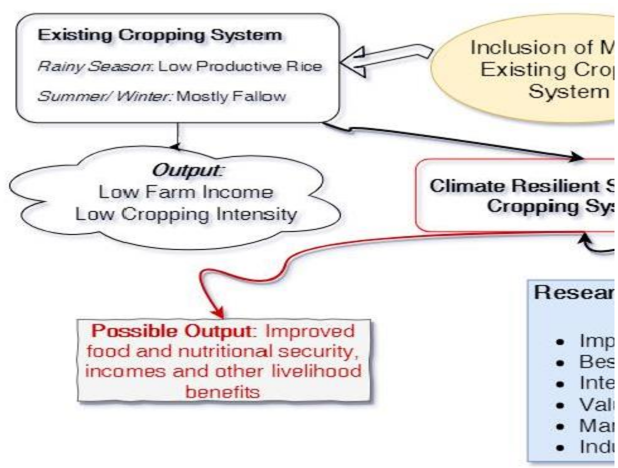

Fig. 3. Strategy to promote millet in existing cropping system in drought prone and red laterite region in Eastern India