International Journal of Plant & Soil Science

26(6): 1-7, 2018; Article no.IJPSS.47764
ISSN: 2320-7035

Millet for Food and Nutritional Security in Drought Prone and Red Laterite Region of Eastern India

Koushik Brahmachari[1], Sukamal Sarkar[1*], Dipak K. Santra[2] and Sagar Maitra[3]

[1]Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur -741252, West Bengal, India.
[2]Department of Agronomy and Horticulture, Panhandle Research and Extension Center, University of Nebraska–Lincoln, Scottsbluff, NE 69361, USA.
[3]Department of Agronomy, MS Swaminathan School of Agriculture, Centurion University of Technology and Management, Gajapati – 761211 (Odisha), India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors KB and SS conceptualized the study. Authors KB, SS, DKS and SM wrote the first draft of the manuscript. Authors SS and SM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2018/v26i630062
Editor(s):
(1) Dr. Muhammad Shehzad, Department of Agronomy, Faculty of Agriculture, The University of Poonch Rawalakot AJK, Pakistan.
(2) Prof. Alejandro Hurtado Salazar, Departamento de Producción Agropecuaria, Fruit Improvement, Physiology of Production, Physiology of Plant Stress, Breeding of Fruits, Universidad de Caldas, Colombia.
Reviewers:
(1) Olubunmi Ayodele, Federal University of Technology, Nigeria.
(2) Toungos, Mohammed Dahiru, Adamawa State University Mubi, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47764

Opinion Article

Received 15 November 2018
Accepted 10 March 2019
Published 15 March 2019

ABSTRACT

The red and lateritic zone (RLZ) of Eastern India comprises of south-west part of West Bengal, a part of Odisha and Jahrkhand grimly a low position in respect of yield levels compared to many other parts of India. Soil of this area is poor in inherent fertility status with low to medium available nutrients of phosphorus, potassium and calcium. Most of the lands are located on higher elevation and erosion hazards and gully formation are very common. Monsoon rainfall is erratic or unevenly distributed in this region and, thus partial or even total failure of rainfed crops is very common. The major parts of this zone are rainfed, rice-fallow based mono-cropped and cropping intensity of the region is between 125-130%. This region of India is home of millions of resource-challenged small and marginal farmers having poor food and nutritional vis-à-vis economic security. To alleviate this grim situation of drought prone RLZ of Eastern India, intensification of Rice-fallow by inclusion of suitable crops was one the major challenges due to several bio-physical constraints. In this context,

**Corresponding author: E-mail: sukamalsarkarc@yahoo.com;*

being the climate resilient and drought tolerant crops, millets may be the best choice for the rice-based crop sequence, any fallow and marginal land, agro-forestry system or even for popularizing any millet-based crop sequence for escalating the level of livelihood of the small and marginal farmers of the dry tract of RLZ. The objective is to develop a model using implementing millet-based cropping system to address food and nutritional security for the regions like RLZ of eastern India. Available research data on millet production feasibility in the region was used. A multidisciplinary approach was used for value-addition and small-scale agri-industry. In this present paper, we conceptualized the current status, prospects and research strategies for augmenting the millet production system to improve the food and nutritional security across drought prone and red laterite region of Eastern India. We believe that same model can be applied elsewhere in the world with agro-climatic conditions like RLZ.

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

1. INTRODUCTION

Agriculture is undoubtedly the backbone of any developing country like India. It is the prime source of food-fodder-fibre-fuel-fruit-flower-fish and timber and provides raw materials to many large- and small-scale industries. A lion's share of the country's mammoth population depends directly or indirectly on agriculture. Being the largest private enterprise in India it contributes 17.4% of national GDP [1]. The green revolution in mid-sixties, steered by research based new technological development involving new materials, methods and ways of organizing farm inputs and the government policy, transformed the agriculture dramatically. As a result, the output exhibited manifold increase in production and productivity. But this development is not spread through-out the country in equal manner.

The red and lateritic zone (RLZ) of Eastern India comprised of South-west West Bengal, western Odisha and almost entire state of Jahrkhand. It occupies dismally a low position in respect of yield levels in comparison to many other parts of the country. The dismal situation regarding the low position in respect of yield levels is attributed to poor input use efficiency, soil degradation such as erosion, decline of soil organic carbon content [2], nitrate transfer to ground and surface water, biodiversity erosion [3] and above all, deceleration of total factor productivity. The RLZ of eastern India is also knows as The Chhota Nagpur Plateau. This area is surrounded by the Indo-Gangetic plain (EGP) to the north and east of the plateau, and the basin of the Mahanadi River to the south. The total area of the of this region is approximately 65,000 square kilometers [4]. Laterite, red gravelly, alluvial soil generally dominates the region. Soil of this area is poor in inherent fertility status with low to medium available nutrients of phosphorus, potassium and calcium. The nitrogen content generally varies from 0.03 percent to 0.06 percent. The pH ranges from 4.8 to 5.5 and cation exchange capacity (CEC) is also low [5]. Soils are highly course in texture and well aerated. Fe, Al content is generally high. Most of the lands are located on higher situation and erosion hazards and gully formation are very common. In some pocket areas micronutrient deficiency is found. Annual average rainfall varies from 1200-1600 mm most of which is precipitated between June and September. Even monsoon rainfall is erratic or unevenly distributed. And, thus partial or even total failure of rainfed crops is very common. The major parts of this zone are rainfed, mono-cropped and cropping intensity of the region is between 125-130%. Only 40% of the agricultural land is under irrigation. The landscape of this region is mostly undulating with drainage lines and land near streams comprising lowlands ('*bohal*') which rise to local uplands ('*tanr*') with relief typically <30 m. Hydrologically, uplands are recharge areas whereas lowlands are local discharge areas for seasonally recharged shallow ground-water. The narrow band of medium lowlands ('*kanali*') between them is a discharge area. The east India plateau is characterized by endemic poverty, food insecurity, comparatively low agricultural productivity and lack of irrigation infrastructure. Rice is the staple food crop and traditional cropping is typically mono-cropped rice production. *Bohal* is generally used for cultivation of rice. But with the increasing food demand, the medium uplands ('*baid*') of this region is now extensively used for rice cultivation. The region receives a high amount of rainfall with "low productivity" because soils are acid and infertile with low water holding capacity [6]. For this, cultivation of rice in medium uplands is risky job and poorly suited to traditional rice production systems of this RLZ. Intensification of Rice-fallow in red-laterite belt by inclusion of suitable crops was one the major challenges due to very limited options for introduction of new crops. But, in recent times, cropping system intensification by pulses is facing a bit impediment due to ill impacts of climate change like rising temperatures, unpredictable monsoons as well as severe disease pest infestation. Venture with vegetables has already shown the troubles related to availability of enough water during post monsoon seasons in RLZ.

West Bengal is known to be an advanced State of India in the context of physical, social and economic development, but it has within its territory a few backward regions, reflecting the problems of acute regional disparities. West Bengal is an intensely populated State having a population of 91.35 million and a density of 1029 people per square kilometer. Although West Bengal holds 12th position among the states of the country in total geographical area, it ranks fourth in population (nearly three times of the national average). Thus, with the 2.7% of the country's geographical area, it supports 7.55% of the country's total population. Majority of the people (70%) live in rural areas. About 23.01% of the population belong to the tribal communities and nearly 40% of the families live below the poverty line. One-fifth of the total area is covered by the forest. Marginal workers constitute about 35% of the total population of this area as against 8.05% for the state [1,7].

Intensification of existing cropping system of RLZ of eastern India needs a holistic approach from selection of land to value addition of final products. The existing cropping system in RLZ is mainly rice based where the farmer generally seeds rice at the onset of monsoon and reaps the harvest at the beginning of winter. Most of the land here remains fallow due to various bio-physical constraints like high evapotranspiration during summer and winter, meagre soil fertility and water holding capacity, erratic rainfall and less adoption of modern agro-techniques by the resource challenged peasants. Keeping all these facts at the background, for intensifying the cropping system of RLZ and improving food - nutritional - economic security, the inclusion of millet may be the most potential option. But for successful introduction of millets in this very zone, an all-round research intervention is highly required.

Millets comprise of a number of small-grained, annual cereal grasses, which include several distinct species: the pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracona*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*), barnyard millet (*Echinocloacrusgalli* (Japanese) and *E. colona* (Indian), kodo millet (*Paspalum scorbiculatum*), tef (*Eragrotis tef*), fonio [*Digitaria exilis* (white fonio) and *D. iburua* (black fonio)] and Job's tears (*Coix lacryma-jobi*). Millets are very hardy and climate-resilient crops suitable for environments prone to drought and extreme heat. This type of crops is adapted to a wide range of temperature, moisture-regime and input condition and can be a potential option for providing food and feed to millions of dryland farm families and their reared animals and birds. In addition, being the members of C4 group, millets sequester carbon, thereby adding to CO_2 abatement opportunities, contribute to improved agro-biodiversity by their rich varietal diversity and allow mutually beneficial intercropping with other vital crops. Small millets are the traditional crops and they are agronomically more adapted to impoverished soil and climatic conditions [8]. They can be cultivated where no other food crops can be profitably grown. Millets are obviously important food and fodder crops in semi-arid regions and are gaining more importance day by day in the world of escalating malnourished population [9]. About 500 million people in more than 30 countries depend on millets as staple diet, and more than 90 million people in Africa and Asia depend on millets as staple diet [10,11]. Choice of proper water saving options along with selection of suitable alternative crops vis-a-vis their varieties and application of suitable agro-techniques may decelerate the level of poverty generated due to non-judicious management in rainfed farming of the dry tract of RLZ of eastern India. In this context, the millets may be the best choice for the rice-based crop sequence, any fallow and marginal land, agro-forestry system; or even in popularizing any millet-based crop sequence for escalating the level of livelihood of the small and marginal farmers of the dry tract of eastern India.

2. RESEARCH OBJECTIVES

The objective is to develop a model using implementing millet-based cropping system to address food and nutritional security for the regions like RLZ of eastern India.

3. PRODUCTION SCENARIO OF MILLETS

Millet production systems in Asian countries are generally characterized by varying production practices and poor adoption of improved cultivars. Naturally, yield average is still ranging only in between 0.3–1.0 t/ha [11]. In recent past, area under millet cultivation has been drastically reduced over the years in India, although it is one of the major producers of millets in the world [12,13]. The millet growing region of India mainly concentrates across rainfed areas of Madhya Pradesh, Karnataka, Gujrat, Andhra Pradesh, Telangana and red lateritic tract of Eastern India. The total area under millet cultivation in India is about 25.17 million ha with a gross production of 42.86 million tons. Amongst different millets, finger millet yields 1706 kg ha^{-1}, but it occupied only 0.6 percent of gross cropped area of the country in 2014-15 [1]. In the western districts West Bengal, an agriculturally important eastern states of India, Sorghum, Pearl Millet and Finger Millet are mostly cultivated in the rainfed uplands of its red and lateritic belt (mostly in Ultisols with slightly acidic soil conditions). But, in recent past millets production scenario in West Bengal is showing a grim tinge (Fig. 1). Cultivation of millets in marginal lands with age old practices and very limited input supply is the prime cause behind such stagnant, rather decelerating productivity (Fig. 2).

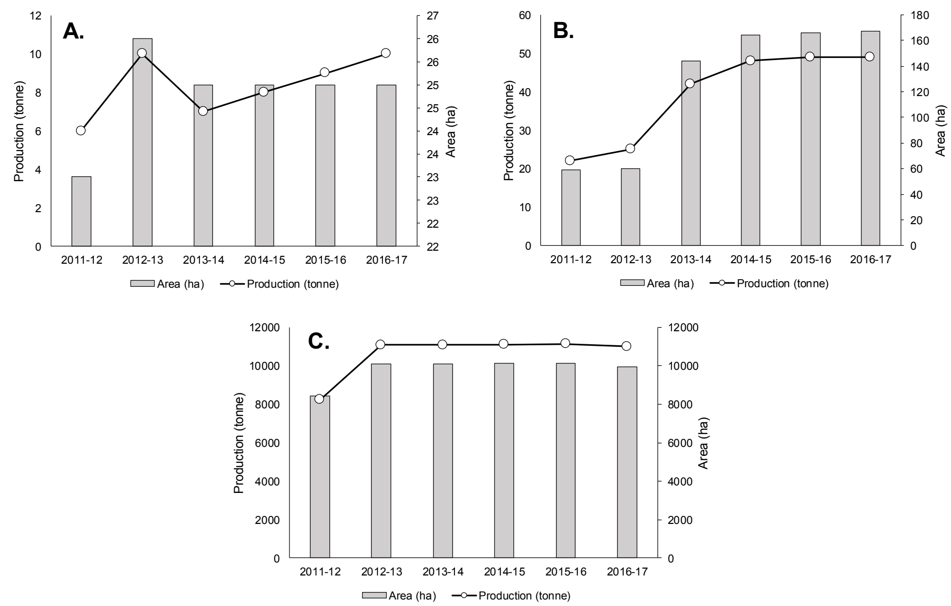

Fig. 1. Area (ha) and production (tonne) trend of major millets (A) sorghum; (B) pearl millet and (C) finger millet in West Bengal (Source: [7])

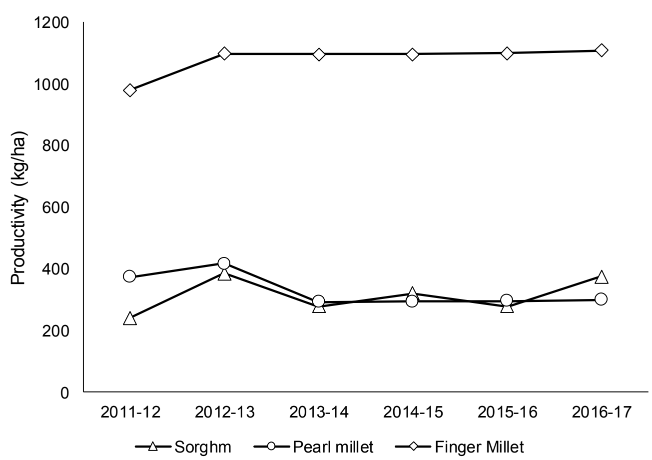

Fig. 2. Productivity trend (kg/ha) of major in West Bengal (Source: [7])

4. RESEARCH STRATEGY

Available research data on millet production feasibility in the region was used. A multidisciplinary approach was used for value-addition and small-scale agri-industry. Intensification of existing rice-based mono-cropping system though successful introduction of millets in this very zone, an all-round research intervention is highly required (Fig. 3). Some researches in the domain of crop improvement, crop production and crop protection aspects has already been carried out in the RLZ of Eastern India especially West Bengal (Table 1). Adoption of millets by the resource-challenged framers of this region is not an easy job. The successful introduction of millets requires scientific and step-wise intervention strategies from selection and development of location specific cultivars to adoption of best crop management practices like nutrient, water and weed management strategies. Weed management in millets requires serious research interventions as the millets are grown predominantly in the rainy season, weeds deprive these crops of vital nutrients and moisture and reduce the yield considerably. Because of wider row spacing and slow initial growth in millets, weeds are more problematic during initial crop growth period, and hence, early control is needed to optimize the yield [14]. Most of the minor millets are the improved species of most troublesome grassy weeds. Hence, it is very difficult to identify weeds in early stages and control them. Although, herbicides are very effective for controlling weed in minor millets, but under moisture stress at growing environment of millet the efficacy of pre-emergence herbicides like atrazine is reduced significantly. Hence, there is a need for exploring potentially effective broad-spectrum post-emergence herbicides for safe and effective weed control. Herbicide residues in soil and plant (grain and stover) need to be studied in different situations. Millets are generally less prone to disease-pest infestation. But some serious disease like Downey Mildew, Ergot, Blight etc. may cause serious damage in millet production. Thus, adoption of need based Integrated Plant Protection Management (IPM) strategy with scientific integration of both organic and inorganic plant protection agro-inputs should be formulated. Millets are course in nature, and they require series of post-harvest operations (cleaning, dehulling, milling etc.) before reaching to the end users. Millets have diversified high food value, but for wider consumption of these millets it is required to formulate the standard protocol for diversified millet based value-added products like Composite flour recipes (Breads, Baked bread, Steamed bread, Biscuits), Non-composite recipes (Boiled Products, Porridges etc.), Beverages (Non-fermented and fermented drinks, Malt Drinks) and Snacks (Pop sorghum, Pasta, Kurkure, Composite Flour Recipes, Breads etc.) [15]. Establishment of such cottage level small scale millet processing industries in this region not only improved the farm income but also improved the food and nutritional security. But to promote millet in drought prone and red laterite region of Eastern India in sustainable way, market and industry linkage with small and marginal farmers is essential. Formulation of such policies to establish the linkage between market and producer at national and regional level should be standardized.

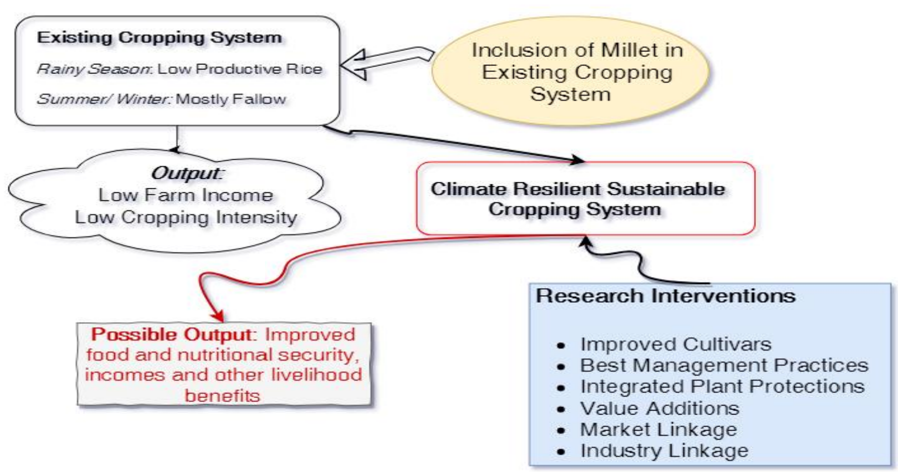

Fig. 3. Strategy to promote millet in existing cropping system in drought prone and red laterite region in Eastern India

Table 1. Some research advances of millets in in drought prone and red laterite region of Eastern India

Sl. no.	Technological Advancement	References
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	[16]
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.	[17]
2.	Seed soaking with water or 0.25% $CaCl_2$ has improved the growth and productivity of finger millet over un-soaked control.	[18]
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.	[19]
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	[20]
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.	[21]
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.	[22]

5. GLOBAL PERSPECTIVE

Internationally, the demand for millet based processed products is snowballing day by day. The economic gains through the adoption of millet-based cropping system may be augmented by addressing envisaged benchmarks resulting in significant improvement in productivity, profitability and even export earnings. Millets can be successfully grown in drought prone and unfertile soil where most other crops often failed to grow. Cultivated millets not only contribute to the economic efficiency of farming but also provide food and livelihood security to millions of downtrodden communities of the different parts of the world. Major millets producing counties concentrated in the pockets of southern and western Africa and Asia. Similar growth environment like drought prone and red laterite region of eastern India, predominates in different parts of the Globe like southern and western Africa and Asia west-central High Plains of the USA and western Australia. This millet-based crop production model possibly equally applicable to these regions.

6. CONCLUSION

Finger millet, pearl millet and sorghum have high likelihood of success in the millet-based crop production system of the proposed model in semi-arid drought prone areas in RLZ of eastern India and elsewhere in the globe with similar conditions. However, other short duration millets such foxtail millet, proso millet, little millet could be tested in case serious soil moisture shortage in the system although no research data has been reported for eastern Indian RLZ. We believe that our proposed model can be applied elsewhere in the world with agro-climatic conditions like RLZ of eastern India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Government of India, Ministry of Finance, Department of Economic Affairs, E.D. Economic Survey 2016-17; Delhi; 2016.
2. Khorsandi F, Yazdi FA. Estimation of saturated paste extracts' electrical conductivity from 1:5 soil/water suspension and gypsum. Commun. Soil Sci. Plant Anal. 2011;42:315–321.
3. Sau S, Ghosh SN, Sarkar S, Gantait S. Effect of rootstocks on growth, yield, quality, and leaf mineral composition of

Nagpur mandarin (*Citrus reticulata* Blanco.), grown in red lateritic soil of West Bengal, India. Sci. Hortic. (Amsterdam). 2018;237:142–147.
4. Gautam A. Chota Nagpur - An untold history: A socio-historical analysis. Anthropology. 2017;05:1–18.
5. Sarkar GK, Chattopadhyay AP, Sanyal SK. Release pattern of non-exchangeable potassium reserves in Alfisols, Inceptisols and Entisols of West Bengal, India. Geoderma. 2013;207–208:8–14.
6. Manivannan S, Thilagam VK, Khola OPS. Soil and water conservation in India: Strategies and research challenges. J. Soil Water Conserv. 2017;16:312.
7. Rudra K, Mukherjee S, Mukhopadhyaya U, Gupta D. State of environment report West Bengal, Kolkata; 2016.
8. Sharma S, Sharma N, Handa S, Pathania S. Evaluation of health potential of nutritionally enriched Kodo millet (*Eleusine coracana*) grown in Himachal Pradesh, India. Food Chem. 2017;214:162–168.
9. Affholder F, Poeydebat C, Corbeels M, Scopel E, Tittonell P. The yield gap of major food crops in family agriculture in the tropics: Assessment and analysis through field surveys and modelling. F. Crop. Res. 2013;143:106–118.
10. NAAS Role of Millets in Nutritional Security of India. Policy Paper No. 66. Natl. Acad. Agric. Sci.; 2013.
11. Patil JV. Millets and sorghum: Biology and Genetic improvement. 1st Ed.; John Wiley & Sons Ltd: West Sussex, United Kingdom; 2017. ISBN: 9781119123057.
12. Dayakar Rao B, Bhaskarachary K, Arlene Christina G. Nutritional and health benefits of millets. ICAR-Indian Institute of Millets Research: Hyderabad; 2017. ISBN: 81-89335-68-5.
13. Dayakar Rao, Sangappa Vishala GD, Arlene Christina VA, Tonapi BA. Technologies of millet value added products. Hyderabad; 2016.
14. Mishra JS. Weed management in millets: Retrospect and prospects. Indian J. Weed Sci. 2015;47:246–253.
15. Singh RB, Khan S, Chauhan AK, Singh M, Jaglan P, Yadav P, Takahashi T, Juneja LR. Millets as functional food, a gift from Asia to Western World; Elsevier Inc.; 2019. ISBN: 9780128131480.
16. Triveni U, Rani YS, Patro TSSK, Anuradha N, Divya M. Assessment of production potential of finger millet (*Eleusine coracana* (L.) Gaertn.) under rice-fallow conditions of North Coastal Zone of Andhra Pradesh, India. 2017;6:918–923.
17. Maitra S, Sounda G, Ghosh D, Jana P. Effect of seed treatment on finger millet (*Eleusine coracana*) varieties in rainfed upland. Indian J. Agric. Sci. 1997;67:478–480.
18. Maitra S, Ghosh DC, Sounda G, Jana PK, Roy DK. Productivity, competition and economics of intercropping legumes in finger millet (*Eleusine coracana*) at different fertility levels. Indian J. Agric. Sci. 2000;70:824–828.
19. Maitra S, Ghosh D, Sounda G, Jana PK. Effect of seed treatment on growth and productivity of finger millet under rained lateritic belt of West Bengal. Indian Agric. 1998;42:37–43.
20. Roy DK, Chakraborty T, Sounda G, Maitra S. Effect of fertility levels and plant population on yield and uptake of nitrogen, phosphorus and potassium in finger millet (*Eleusine coracana*) in lateritic soil of West Bengal. Indian J Agron. 2001;46:707–711.
21. Sun ZX, Yan CR, Zheng MZ, Zheng JM, Yang N, Bai W, Liu Y, Feng C. Effect of peanut and foxtail millet intercropping on crop photosynthetic response and fluorescence parameters. Res. Crop. 2014;15:461–466.
22. Kumar ACK, Nagaraja A, Raghavendra BT. Evaluation of genotypes of finger millet and foxtail millet against brown leaf spot disease. Environ. Ecol. 2015;33:136–139.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/47764