Journal of Integrative Agriculture 2017, 16(4): 762–773

Available online at www.sciencedirect.com

ScienceDirect

ELSEVIER

REVIEW

Recognizing production options for pearl millet in Pakistan under changing climate scenarios

Asmat Ullah[1, 2], Ashfaq Ahmad[1], Tasneem Khaliq[1], Javaid Akhtar[3]

[1] *Agro-climatology Laboratory, Department of Agronomy, University of Agriculture, Faisalabad 38040, Pakistan*
[2] *Directorate of Agronomy, Ayub Agricultural Research Institute (AARI), Faisalabad 38850, Pakistan*
[3] *Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad 38040, Pakistan*

Abstract

Climate change is making the lands a harsher environment all over the world including Pakistan. It is expected to oppose us with three main challenges: increase in temperature up to 2–5°C (heat stress), increasing water stress and severe malnourishment due to climate change. It has been foreseen that there will be a 10% increase of dryland areas with climate change in the world, with more variability and incidences of short periods of extreme events (drought and heat stress). Pearl millet is a hardy, climate smart grain crop, idyllic for environments prone to drought and heat stresses. The crop continues to produce highly nutritious grain sustainably, thereby encouraging the fight against poverty and food insecurity due to its resilience. The crop is more responsive to good production options (planting time, planting density, inter/intra row spacing, nitrogen application and irrigation). It has high crop growth rate, large leaf area index and high radiation use efficiency that confers its high potential yield. In most of the cases, pearl millet is remained our agricultural answer to the climate calamity that we are facing, because it is selected as water saving, drought tolerant and climate change complaint crop. In view of circumstances, pearl millet cultivation must be retrieved by recognizing production options in context to changing climate scenarios of Pakistan using crop modeling techniques.

Keywords: pearl millet, production options, climate change, nitrogen use efficiency, radiation use efficiency

1. Introduction

Climate change includes extreme climatic events (drought, heat waves, flooding, etc.), variation in temperatures and un-even rainfall patterns. In view of current and future climate change, interest among researchers to assess climate resilience is increasing to strengthen the climate resilience in crops of hot and dry areas. Climate resilience is quite different to vulnerability and usually defined as "the ability to bounce back after an external shock or stress" (Dixon and Stringer 2015; Resilience Alliance 2015).

Climate change is equally affecting productivity and development of major and minor crops. Wheat, rice and maize are the most important major cereals bearing a huge population pressure, which is increasing at the rate of 1.59% with current population of 188 million in Pakistan (FAO 2015). The poultry industry also has huge demand for feed which is hardly compensated with maize grains. It is estimated that production of wheat and rice might be decreased to 15 and 17%, respectively, by midcentury (2040–2069) in Pakistan

Received 29 April, 2016 Accepted 25 July, 2016
Correspondence Asmat Ullah, Tel: +92-300-6762658, E-mail: aumalik.aari@gmail.com

doi: 10.1016/S2095-3119(16)61450-8

due to changes in temperature (Ahmad *et al.* 2015). On the other hand, low productivity of crops not only increases the cost per unit area but also is an extra burden on foreign exchange of the country. It has been reported that Pakistan will be the second largest importer of pearl millet, importing 61 000 tons' millet after China in 2030 (Nedumaran *et al.* 2013). In view of above scenarios, it is important to focus climate resilient and high productive cereals (pearl millet, sorghum, etc.) in agricultural production system to get good production by utilizing resources efficiently. Pearl millet is ecologically suitable, culturally appropriate, nutritionally efficacious and economically viable crop (Ndiku *et al.* 2014) under such circumstances.

Pearl millet is the sixth most important cereal crop after wheat, rice, maize, sorghum and barley (Singh *et al.* 2003). It is grown on an area of 31 million ha (ICRISAT 2016) in the world, while in Pakistan, pearl millet is cultivated on an area of about 0.50 million ha with production of 0.33 million tonnes (GOP 2015). It is categorized as coarse hardy cereal crop due to its versatile use in community. It is mostly grown on marginal soils and in areas with low rainfall (<350 mm) where other crops such as wheat, rice and maize fail to grow. Hence, this crop is considered as the main component of food security of rural poor people in hot and dry areas in the world including Pakistan (Vadez *et al.* 2012).

Being C_4 plant, it is efficient crop with large leaf area index (6.7) due to erect type of leave (Carberry *et al.* 1985) and ultimately high radiation use efficiency (RUE) that ranges between 2.5 g MJ^{-1} (Squire *et al.* 1986) to 4 g MJ^{-1} (Ram *et al.* 1999). In spite of its high efficiency, the yield of pearl millet is very low in Pakistan as compared to other countries (Ayub *et al.* 2007; ICRISAT 2016). The main reasons of low yield in Pakistan are lack of optimum production options (inadequate crop stand, planting time) under changing climate threats, competition with other cereals and unavailability of water that fulfill the demand of crop (Ayub *et al.* 2007; Sanon *et al.* 2014). The cultivation of pearl millet in marginal soils with exceptions of optimum management options, cannot fully capture soil-climate-crop interactions (Akponikpe *et al.* 2010). Among all, inappropriate management options and climate change are considered as the most important threats to pearl millet productivity.

In such scenarios, the endurance of the population depends on the suitable adaptation of agricultural production systems to climate change. A better understanding of the impacts of climate on crop productivity is a basic requirement to enhance climate resilience in crop varieties through breeding or for adapting current varieties more resilient to climate induced stress through management options *via* various strategies to respond the contrary impacts of climate change on crop economic part (Barnabas *et al.* 2008). Various tools can also be used in optimizing natural resources to assess the impacts of future impending climate on crop productivity (Yadav *et al.* 2014).

2. Area and production of pearl millet in Punjab, Pakistan

According to Directorate of Agriculture, Crop Reporting Services Lahore, Punjab, Pakistan, the final estimates of pearl millet crop in Punjab for year 2014 (423.20 thousand ha; 273.6 thousand tonnes production) showed 3.58% increase in acreage, however 3.29% decrease in produce over 2013 (408.6 thousand ha; 282.9 thousand tonnes production). The possible reasons for decrease in production in pearl millet are lack of optimized production options (planting time, planting density, fertilizer and irrigation management), seasonal variability (temperature variability, uneven rainfall pattern), unavailability of quality seed. GOP (2015) indicated that irrigated pearl millet crop was grown on 64% area as compared to 38% rain-fed/un-irrigated area in Punjab during summer season 2014 (Fig. 1). Among nine divisions of Punjab Province, the maximum area of 64 thousand ha was sown under irrigated conditions in Sargodha division followed by 58 thousand ha in Dera Ghazi Khan division (D.G. Khan). As for as rain-fed pearl millet cultivation is concerned, it can be depicted from Fig. 1 that 82 thousand ha area remained under un-irrigated pearl millet crop in Gujranwala division. It is pointed out that out of 440 thousand ha cultivated area of millet in Pakistan, 96% (423 thousand ha) were planted in Punjab Province during summer season 2014 which almost remained the same since decades (GOP 2015).

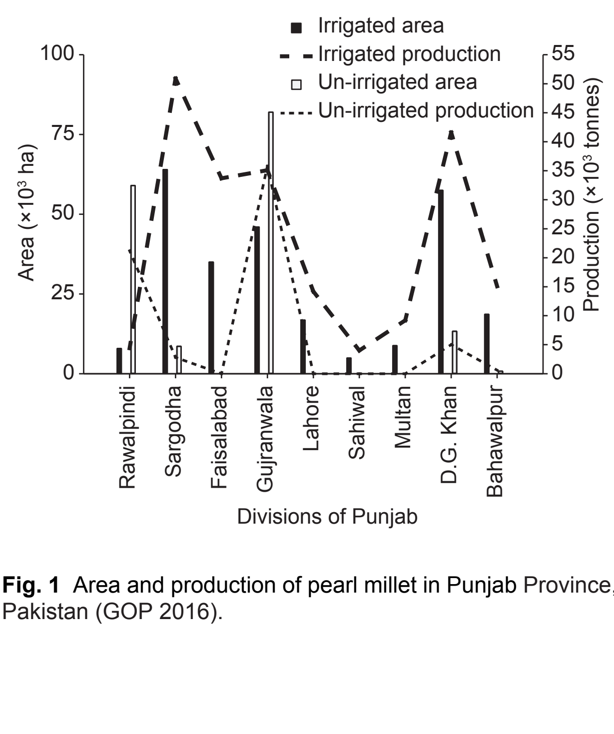

Fig. 1 Area and production of pearl millet in Punjab Province, Pakistan (GOP 2016).