Soil & Tillage Research 170 (2017) 18–26

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Influence of varying tillage systems and nitrogen application on crop allometry, chlorophyll contents, biomass production and net returns of maize (*Zea mays* L.)

Allah Wasaya[a,b,*], Muhammad Tahir[c], Hakoomat Ali[d], Mubshar Hussain[a,d,*], Tauqeer Ahmad Yasir[a], Ahmad Sher[a], Muhammad Ijaz[a], Abdul sattar[a]

[a] College of Agriculture, Bahauddin Zakariya University, Bahadur Sub-Campus Layyah, Pakistan
[b] Key Laboratory of Agricultural Water Resources, The Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, The Chinese Academy of Sciences,286 Huaizhong Road, Shijiazhuang 050021, Hebei, China
[c] Department of Agronomy, University of Agriculture Faisalabad, Pakistan
[d] Department of Agronomy, Bahauddin Zakariya University Multan, Pakistan

ARTICLE INFO

Article history:
Received 1 September 2016
Received in revised form 14 February 2017
Accepted 15 February 2017
Available online 7 March 2017

Keywords:
Chlorophyll contents
Dry matter yield
Maize
Nitrogen levels
Tillage systems

ABSTRACT

Subsoil compaction and injudicious use of nitrogenous fertilizers are key factors for lowering maize yield. Maize yield can be improved by minimizing subsoil compaction through deep ploughing, and using required amount of nitrogen fertilizer. Therefore, this two-year field experiment was conducted to evaluate the effects of varying tillage systems and nitrogen application on leaf chlorophyll contents, allometric traits, grain yield and net returns of maize (*Zea mays* L.). The study consisted of i) three tillage systems viz. conventional tillage (using cultivator), deep tillage with moldboard plough + 2-cultivations, and deep tillage with chisel plough + 2-cultivations; and ii) three nitrogen levels viz. 100, 150 and 200 kg ha^{-1}. Tillage systems and nitrogen levels improved allometric traits, grain and dry matter yield, and net returns of maize in both years. Chisel tilled plots observed more leaf area index and duration, and crop growth rate which ultimately resulted in 23 and 8% more grain and dry matter yield, respectively compared with moldboard tilled plots. Similarly, nitrogen application at 200 kg ha^{-1} recorded higher leaf area index and duration, crop growth rate, chlorophyll contents, and 21% and 8% higher grain and dry matter yield respectively, compared with control. Maximum net return and benefit-cost ratio was recorded from maize grown under chisel ploughed plots by applying 200 kg ha^{-1} nitrogen. Therefore, maize should be grown with 200 kg ha^{-1} nitrogen application by preparing the field with chisel plough followed by cultivator to obtain higher grain yield and net returns under semi-arid conditions of Pakistan.

1. Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops throughout the world and ranked as 3rd major cereal after wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) in Pakistan. In Pakistan, its yield is low compared with developed countries which may be due to improper management practices such as tillage and nitrogen (N) application (Wasaya et al., 2012). Among major crop production factors, tillage is also an important factor which contributes about 20% of yield increment in crops (Ahmad et al., 1996). Continuous cultivation of fields with same tillage implement (cultivator) creates a plough/hard pan in the subsoil layers which adversely affects crop productivity in semi-arid regions (Wasaya et al., 2011; Shahzad et al., 2016a). This rise in plough pan gradually prevents roots from penetrating into deep soil layers and also decreases the root proliferation (Whitmore et al., 2011), and yield of crops (Mao, 2009). The subsoil compaction characterized by higher bulk density reduces the root length of crops up to 40% (Coelho et al., 2000), hence leads to less nutrient and water uptake (Ishaq et al., 2001; Motavalli et al., 2003) and ultimately, cuts the crop yield (Coelho et al., 2000). Subsoil compaction can be managed by deep tillage, which improves root proliferation and leads to higher maize yield (Varsa et al., 1997). Deep tillage may improve N recovery efficiency (NRE) and greater NRE has been observed under deep tilled compared with compacted soil

* Corresponding authors at: College of Agriculture, Bahauddin Zakariya University, Bahadur Sub-Campus Layyah, Pakistan
E-mail addresses: allah.wasaya@bzu.edu.pk, wasayauaf@gmail.com (A. Wasaya), mubashiragr@gmail.com (M. Hussain).

http://dx.doi.org/10.1016/j.still.2017.02.006

(Motavalli et al., 2003). It breaks soil layers having high bulk density and improves water movement in the soil, root development and growth, and increases the potential for crop production (Bennie and Botha, 1986). In addition to breaking plough pan in the subsoil, deep tillage also reduces the growth of weeds and improves plant performance in terms of higher yield and dry matter production (Wang et al., 2009; Shahzad et al., 2016b,c).

Nitrogen plays a significant role in chlorophyll synthesis and is an integral part of chlorophyll. The chlorophyll acts as photosynthetic machinery in plants and convert light energy into chemical energy (Hak et al., 1993). Nitrogen deficiency adversely affects photosynthetic capacity, radiation use efficiency (RUE) and leaf N content in crops (Uhart and Andrade, 1995; Vos et al., 2005). However, the increase in the photosynthesis rate, dry matter production and grain yield was found in maize hybrids grown with higher N supply (Uribelarrea et al., 2009). More chlorophyll resulted in increased photosynthetic active leaf area, hence produces more assimilates and leads to better growth and development (Amaliotis et al., 2004; Vanyine et al., 2012). Application of N had a strong and significant impact on different growth and yield traits (Sanjeev et al., 1997; Fedotkin and Kravtsov, 2001; Mahmood et al., 2001). Various N levels also had substantial effect on biomass production, grain yield, harvest index (H.I.) and N use efficiency of crops (Paolo and Rinaldi, 2008; Rafiq et al., 2010). Higher N application improved grains per spike, 1000-grains weight and yield in wheat due to delay in leaf senescence and higher photosynthesis (Bavec et al., 2007; Namakka et al., 2008). Although several studies pointed out the benefits of deep tillage and N application on different cereals, but most of the work has been done on tillage and N as individual factors and little information is available on their interactive effects especially on maize in semi-arid region of Pakistan. Therefore, the present study was designed with the objective to find out an economic and better tillage practice and N level for higher maize yield under semi-arid conditions.

2. Materials and methods

2.1. Site description

A two-year field experiment was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan (31.25° N, 73.09° E and 135 m above sea level) during summer (locally called *kharif*) season 2008 and 2009 in order to establish a proper tillage and N management strategies in maize crop. The experimental site is located in semi-arid region, where crop was irrigated with canal water. Previously this area was under wheat-crop cropping system before the start of current study. Conventional tillage i.e. two cultivations with tractor mounted cultivator followed by planking was practiced for both crops. The soil of the site was sandy clay loam that contains 58, 20.2 and 21.8% of sand, silt and clay, respectively with 0.72% organic matter and 0.04% of total nitrogen contents. The study was conducted in semi-arid climate, and climatic data for both years during whole crop season is presented in Fig. 1.

2.2. Experimentation

Maize was sown under three tillage systems viz. conventional tillage (two cultivations with tractor mounted cultivator followed by planking), tillage with moldboard plough up to 30 cm depth followed by 2-cultivations with cultivator and one planking, and tillage with chisel plough up to 40 cm depth followed by 2-cultivations with cultivator and one planking with three N levels viz. 100, 150 and 200 kg ha^{-1} taking 100 kg ha^{-1} as control because it is a common practice of farmers of the country The experiment was carried out in a split plot design by keeping tillage systems and N levels in main and sub plots, respectively. The whole experiment was replicated thrice in a net plot size of 4.5 m × 10 m. The total experimental area used for the current study was about 1215 m^2 (0.122 ha).

2.3. Crop husbandry

A presoaking irrigation of 10 cm was applied to experimental field before maize sowing and final seedbed was prepared after six days of irrigation when field reached at workable moisture level. Seedbed was prepared according to treatments needs and maize hybrid pioneer-31R88 was sown with the help of dibbler on August 07, 2008 and August 01, 2009 by using 25 kg ha^{-1} seed rate, maintaining row–row distance of 75 cm and a plant–plant distance of 20 cm. Two seeds per hill were planted and then one plant per hill was maintained by thinning at three leaf stage. Phosphorous (P) and potassium (K) were applied at the rate of 100 kg ha^{-1} each along with N as mentioned in treatments. Whole P and K were applied at the time of sowing while N was applied in three splits i.e.

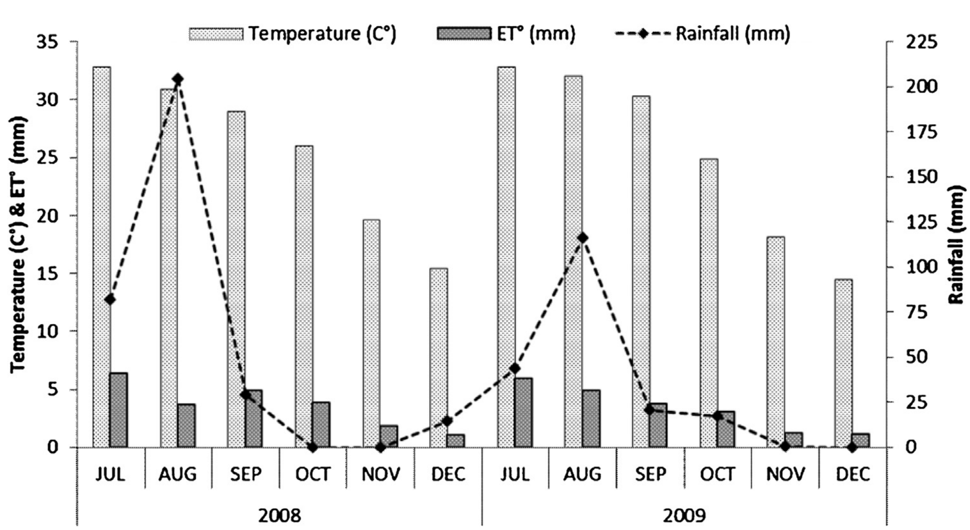

Fig. 1. Climatic data for growing season of crop during 2008 and 2009.