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Original article

Effect of tillage, irrigation and nitrogen fertilizer on crop yield of forage maize (*Zea mays* L.)

E. Afshoon[1*], H. Moghadam[2], M.R. Jahansooz[3], M. Oveisi[4]

1. Ph.D. Student, Department of Agronomy and Plant Breeding, Crop Ecology, University of Tehran, Karaj, Iran
2. Assistant Professor, Department of Agronomy and Plant Breeding, University of Tehran, Karaj, Iran
3. Professor, Department of Agronomy and Plant Breeding, University of Tehran, Karaj, Iran
4. Associate Professor, Department of Agronomy and Plant Breeding, University of Tehran, Karaj, Iran

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Extended abstract

Introduction

Corn (*Zea mays* L.) for its high potential in the production of yield is critical. Given Iran's position in the arid and semiarid belt of the world, the issue of drought, salinity, and their effects on crops should be considered more than any other non-biological stress. Drought stress is a global problem that threatens the growth of crops and food security (Jaleel et al., 2009). Drought stress affects biomass and eventually, yield losses by affecting physiological processes, growth and development of plant tissues (Orfanou et al., 2019). Irrigation and nitrogen mismanagement have been considered as the most critical factors in reducing maize yield (Norwood, 2000). Although nitrogen is critical for the growth of plants, the negative growth response to the excess of nitrogen fertilizer under drought stress (Cabrera, 2004) must be considered. Conservation tillage due to improved water, carbon and nitrogen resources in the soil has the remarkable ability to optimize crop production in arid and semiarid regions of the world (Husnjak et al., 2002). Optimal leaf aria deployment is crucial for photosynthesis performance and dry matter production (Aslam et al., 2013). Decrease in leaf area index following drought stress (Karam, 2005) and a decrease in plant height and grain weight following reduction of nitrogen levels and increase in drought intensity (Kalamian et al., 2006) have been reported previously. It has been suggested that no-3tillage under drought stress and conventional tillage under normal water demand, will cause increased yield (Ruisi et al., 2014). The results of different researches on the application of tillage methods on maize crop varied, with no significant differences in plant traits (height, leaf area index and dry weight) as a result of long-term application of different tillage methods (Ram et al., 2010), no significant effect of tillage on plant growth and yield (Jat et al., 2006) and improved growth and yield enhancement in non-tillage under compacted soils due to improved aeration And increased seedling emergence (Morrison et al., 1990). This study was conducted to study the effects of different tillage methods, different nitrogen fertilizer levels and drought stress on forage maize yield.

Materials and methods

This study was carried out to study the effect of irrigation and nitrogen fertilizer on crop yield of forage maize cultivated under conventional and conservation tillage systems, an experiment was conducted in 2018 and 2019 in split -split plots on randomized complete block design with three replications in farm

*Correspondent author Esmaeil Afshoon; E-Mail: Esmaeilafshoon@ut.ac.ir

of University of Tehran. Tillage systems as the main -plot in two factors was including conversation and conventional tillage, Water stress as the subplot in three levels by 30, 60 and 90 Percent of moisture requirement and nitrogen urea as the sub-sub plot at three levels by 0, 50 and 100 Percent of the recommended rate.

Results

The combined variance analyses indicated that the highest stem diameter (19.8 mm) was obtained from the interaction of water slightly stress and conventional tillage. the highest leaf aria index (6.08), leaf dry weight (441.58 g m^{-2}), stem dry weight (1478.2 g m^{-2}), total dry weight (1919.93 g m^{-2}) and total fresh weight (6732.6 g m^{-2}) was obtained from the interaction of conventional tillage, 90 and 100 percent water and nitrogen demand, respectively. The effect of drought stress on stem diameter reduction in conservation tillage compared to conventional tillage can be due to decreased root penetration and consequently reduced nutrient uptake by the plant. Decrease of leaf area index due to drought stress (Ur-Rahman et al., 2004) and increase of leaf area index with increased irrigation levels and supply of required amounts of nitrogen fertilizer (Lack et al., 2008), previously has been reported. Loss of leaf dry weight following water stress can be attributed to decreased water uptake and, most likely disruption of plant photosynthetic processes and sap production.

Conclusions

According to the results of two years of study, it is concluded that the interaction between drought stress and nitrogen fertilizer in conventional tillage with severe drought stress will decrease yield. Nitrogen fertilizer management is critical under these conditions.

Keywords: Leaf aria index, Nitrogen fertilizer, Tillage, Total dry weight, Water stress

Table 1. Physical and chemical soil properties of the experimental site

Depth (cm)	Available K (mg kg^{-1})	Available P (mg kg^{-1})	pH	EC (dS m^{-1})	Soil texture	Sand (%)	Silt (%)	Clay (%)	OC (%)	Total N (%)	Year
0-30	125	8.3	8.4	0.97	Clay loam	25	44	31	0.76	0.09	**2018**
0-30	120	9.1	8.2	1	Clay loam	25	44	31	0.76	0.09	**2019**

Table 2. Total and frequency irrigation of forage maize in the examined treatments.

	Irrigation frequency			**Water consumption (m^3)**	
Year	**No tillage**	**Conventional tillage**	**Water deficiency stress**	**No tillage**	**Conventional tillage**
			Slight water stress	6210	5372
2018	26	30	**Moderate water stress**	3726	3223
			Severe water stress	1863	1611.6
			Slight water stress	6000	5175
2019	25	29	**Moderate water stress**	3600	3105
			Severe water stress	1800	1552.5

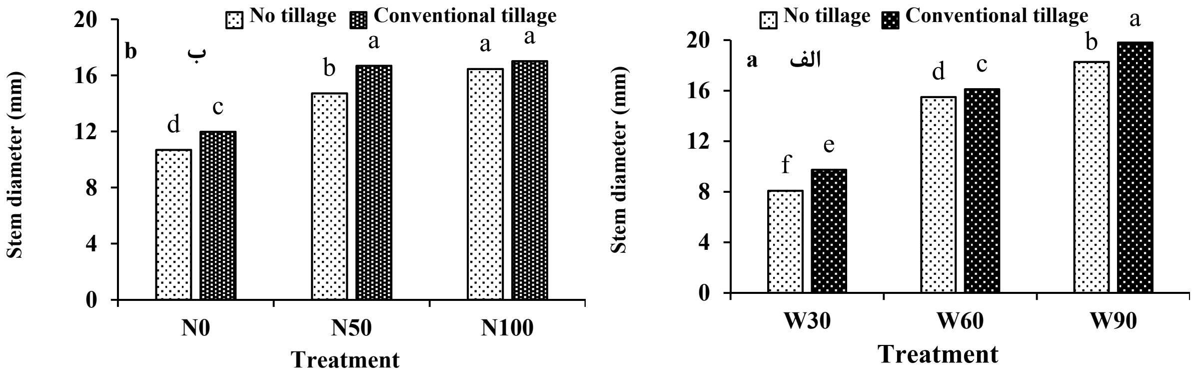

Fig. 1. Stem diameter of forage maize affected by water shortage stress (a), and nitrogen levels (b) under tillage systems. N0, N50 and N100 are 0, 50 and 100 percent of nitrogen demand, respectively and W30, W60 and W90 are water stress in 30, 60 and 90 percent of water requirement. The numbers with the same letters are not statistically significant.

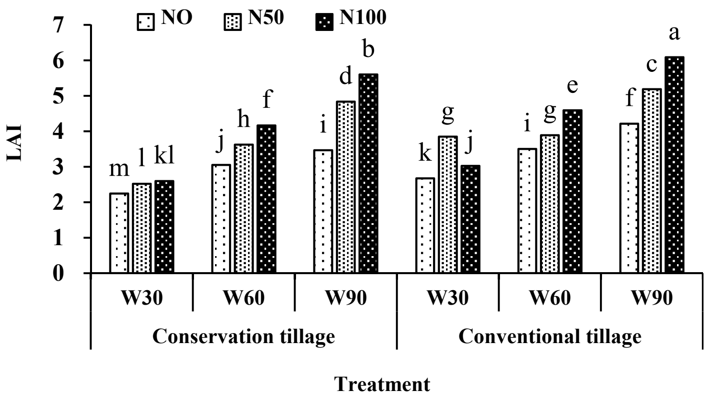

Fig. 2. Leaf aria index of forage maize affected by nitrogen levels,and water shortage stress under tillage systems. N0, N50 and N100 are 0, 50 and 100 percent of nitrogen demand, respectively and W30, W60 and W90 are water stress in 30, 60 and 90 percent of water requirement. The numbers with the same letters are not statistically significant.

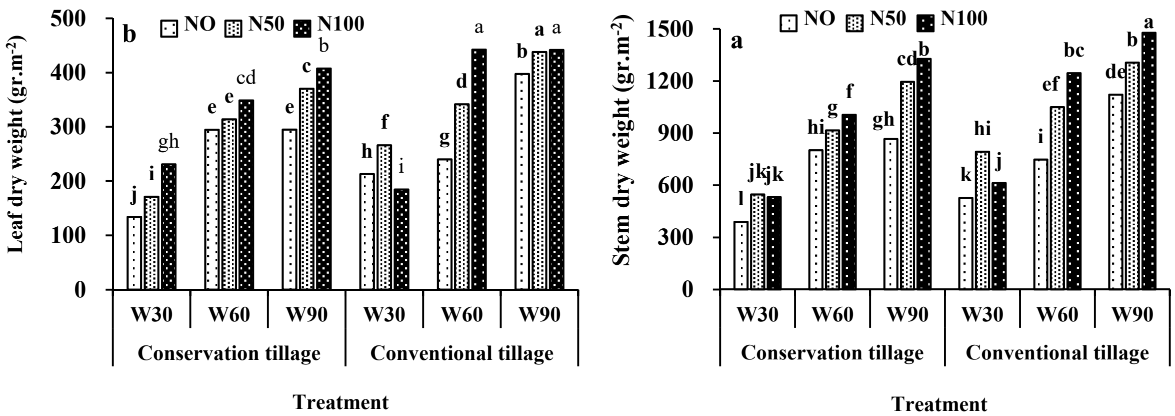

Fig. 3. Stem (a) and laf (b) dry weight of forage maize affected by nitrogen levels,and water shortage stress under tillage systems. N0, N50 and N100 are 0, 50 and 100 percent of nitrogen demand, respectively and W30, W60 and W90 are water stress in 30, 60 and 90 percent of water requirement. The numbers with the same letters are not statistically significant.

Table 3. Analysis of variance for stem diameter, leaf area index, leaf dry weight, stem dry weight, total fresh weight, total dry weight, nitrogen use efficiency,and water productivity of forage maize affected by tillage type, water shortage stress,and nitrogen fertilizer

S.O.V	df	Stem diameter	Leaf area index	Total fresh weight	Leaf dry weight
Year (Y)	1	0.10^{ns}	0.0333 ^{ns}	28158.29^{ns}	60.29 ^{ns}
E_y	4	0.68	3.8102	585646.8	421.44
Tillage (T)	1	43.54**	8.0545*	3084664.25 ^{ns}	52684.91*
T ×Y	1	0.00022 ^{ns}	0.0232 ^{ns}	33843.26 ^{ns}	136.33 ^{ns}
E_a	4	0.05	0.1981	168485.16 ^{ns}	588.53
Water stress (W)	2	963.51**	38.9918**	94480563.2**	344873.99**
W ×Y	2	0.06 ^{ns}	0.0169 ^{ns}	20011.6 ^{ns}	30.17 ^{ns}
T × W	2	2.97**	0.2753 ^{ns}	806766.48 ^{ns}	4747.22*
T × W × Y	2	0.03	0.03	0.0161 ^{ns}	37865.88n
E_b	16	0.11	0.2748	89717.4	1501.85
Nitrofen (N)	2	296.69**	12.4999**	21288102.9**	60288.60**
N ×Y	2	0.08 ^{ns}	0.0013 ^{ns}	9683.3 ^{ns}	28.59 ^{ns}
N × T	2	4.47*	0.0898*	514417.22*	2980.72*
N × T ×Y	2	0.22 ^{ns}	0.22 ^{ns}	0.0016 ^{ns}	19324.2 ^{ns}
N× W	4	66.54**	2.4450**	2073107.98**	7674.57**
N × W × Y	4	0.06 ^{ns}	0.06 ^{ns}	0.0125 ^{ns}	3492.3^{ns}
N × T × W	4	0.51 ^{ns}	0.51 ^{ns}	0.4369**	846998.34**
N × T × W × Y	4	0.24 ^{ns}	0.24 ^{ns}	0.0032 ^{ns}	18847.8 ^{ns}
E_c	48	0.19	0.2121	199410.10	1361.56
C.V. (%)	-	*2.96*	*11.99*	*10.52*	*12.01*

Table 3. Continued

S.O.V	df	Steam dry weight	Total dry weight	Nitrogen use efficiency	Water productivityt
Year (Y)	1	121443.14 ^{ns}	116090.37 ^{ns}	8.09 ^{ns}	0.83 ^{ns}
E_y	4	57056.48	60160.57	704.82	6.64
Tillage (T)	1	563719.44*	961069.89*	5275.21 ^{ns}	13.41*
T ×Y	1	476.11 ^{ns}	1122.30 ^{ns}	102.39 ^{ns}	0.02 ^{ns}
E_a	4	5832.60	9911.21	310.74	1.85
Water stress (W)	2	3846945.75**	6487918.77**	115254.74**	202.27**
W ×Y	2	8615.90 ^{ns}	8958.67 ^{ns}	26.20 ^{ns}	0.76 ^{ns}
T × W	2	10509.24 ^{ns}	28612.63 ^{ns}	137.54 ^{ns}	7.37 ^{ns}
T × W × Y	2	1392.94 ^{ns}	2627.58 ^{ns}	98.92 ^{ns}	0.57 ^{ns}
E_b	16	14684.48	16105.44	204.31	1.03
Nitrofen (N)	2	839311.97**	1347096.36**	793369.29**	173.18**
N ×Y	2	712.63 ^{ns}	455.87 ^{ns}	5.42 ^{ns}	0.16^{ns}
N × T	2	6744.38 ^{ns}	11627.30 ^{ns}	4111.22**	9.66**
N × T ×Y	2	2237.51 ^{ns}	1571.84 ^{ns}	28.34 ^{ns}	0.08 ^{ns}
N× W	4	90404.41**	137385.29**	32785.39**	12.17**
N × W × Y	4	3389.37 ^{ns}	4573.12 ^{ns}	13.50 ^{ns}	0.06 ^{ns}
N × T × W	4	48796.63**	119857.42**	549.30**	8.89**
N × T × W × Y	4	2759.16 ^{ns}	3515.76 ^{ns}	28.13	0.21 ^{ns}
E_c	48	12261.30	14573.64	20.24	1.84
C.V. (%)	-	12.10	9.88	13.22	10.87

^{ns},* and ** are indicating non-significance and significance of mean square at the probability level of 5% and 1%, respectively.

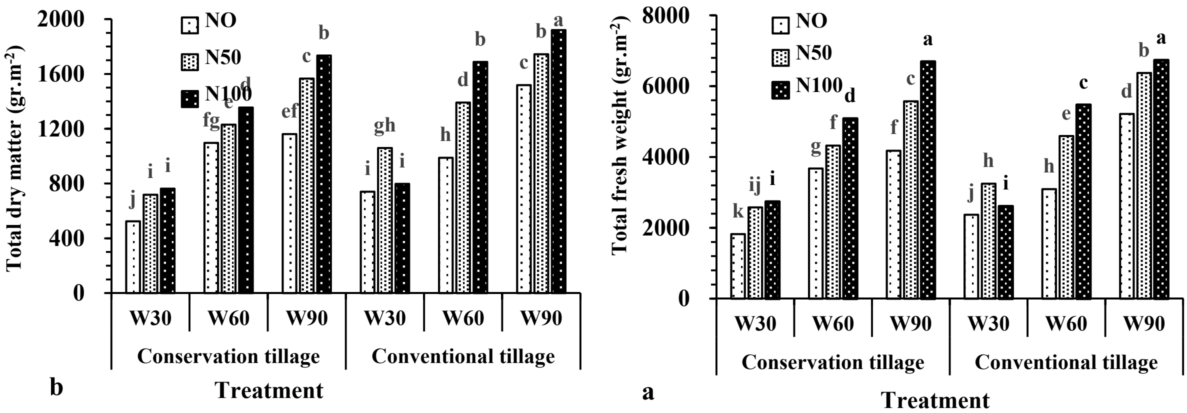

Fig. 4. Total fresh (A) and dry weight (B) of forage maize affected by nitrogen levels,and water shortage stress under tillage systems. N0, N50 and N100 are 0, 50 and 100 percent of nitrogen demand, respectively and W30, W60 and W90 are water stress in 30, 60 and 90 percent of water requirement. The numbers with the same letters are not statistically significant.

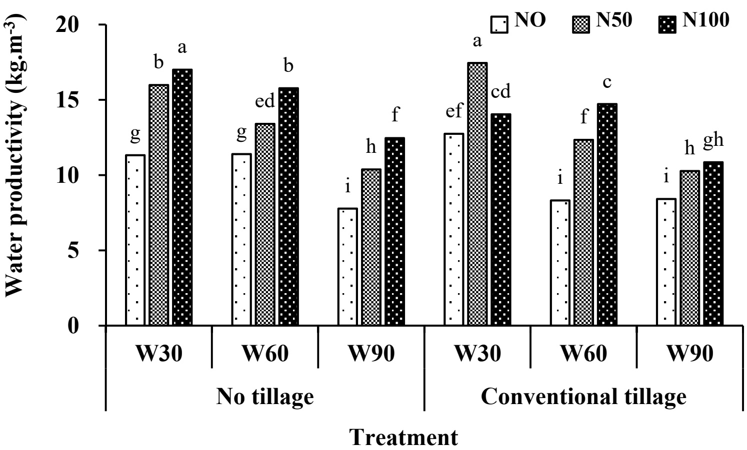

Fig. 5. Water productivity of forage maize affected by nitrogen levels,and water shortage stress under tillage systems. N0, N50 and N100 are 0, 50 and 100 percent of nitrogen demand, respectively and W30, W60 and W90 are water stress in 30, 60 and 90 percent of water requirement. The numbers with the same letters are not statistically significant.

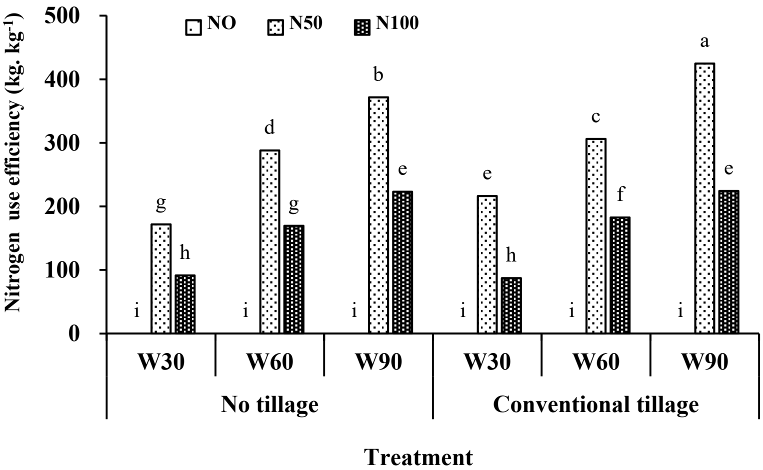

Fig. 6. Nitrogen use efficiency of forage maize affected by nitrogen levels,and water shortage stress under tillage systems. N0, N50 and N100 are 0, 50 and 100 percent of nitrogen demand, respectively and W30, W60 and W90 are water stress in 30, 60 and 90 percent of water requirement. The numbers with the same letters are not statistically significant.