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ORIGINAL ARTICLE

Influence of Water deficit and Nitrogen supply on Grain yield and yield Components of Safflower

Kazem Ghassemi-Golezani, Raena Maghferati, Saeid Zehtab-Salmasi and Soheila Dastborhan
Department of Plant Eco-physiology, Faculty of Agriculture, University of Tabriz, Tabriz, Iran
E-mail: golezani@gmail.com

ABSTRACT
Water and nitrogen are essential requirements for crop growth and production. Thus, a field experiment was conducted in 2014, to evaluate the effects of nitrogen supply (N_1, N_2 and N_3: 0, 46 and 92kgN.ha^{-1}, respectively) on field performance and yield componentsof Safflower under different irrigation treatments (I_1, I_2, I_3 and I_4: irrigation after 60, 90, 120 and 150 mm evaporation, respectively). The experiment was arranged as split-plot based on randomized complete block (RCB) design with three replications. Irrigation treatments and nitrogen levels were located in the main and sub plots, respectively.The results indicated thatgrain yield of safflower was not significantly reduced by mild water deficit (I_2), but it was decreased under moderate (I_3) and severe (I_4) water stress mainly due to reduction in plant biomass and grains per plant. Moderate and severe water deficit led to 39.5-54.9% reduction in grain yield compared with well watering (I_1).Nitrogen fertilizer, particularly with a rate of 46 kgN.ha^{-1} improved plant biomass, grains per plant and consequently grain yield per unit area under all irrigation treatments. There was no significant difference among irrigation intervals and nitrogen levels in 1000 grains weight and harvest index.It was concluded that safflower is somehow tolerant to water stress and nitrogen supply with a rate of 46 kgN.ha^{-1}can improve field performance of this crop under a wide range of water availability.
Keywords: *Grain yield, Harvest index, Nitrogen supply, Safflower,Water deficit*

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INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an annual plant from the *Compositae* family that cultivated mainly for its seed, which is used as edible oil. Traditionally, the crop was grown for its flowers, used for coloring and flavoring foods and alsoas medicine [3].Environmental stresses such as drought may limit safflower performance in the field. Marita and Muldoon [17] reported that flowering phase in safflower is the most sensitive stage to drought stress.Drought is known as a major abiotic factor that limits plant growth and production in arid and semiarid regions more than other environmental stresses [23].CO_2 assimilation by leaves is reduced mainly by stomatal closure, membrane damage and disturbed activity of various enzymes, especially those of CO_2 fixation and ATP synthesis under drought stress [6]. Nitrogen supply is an important environmental factor affecting drought tolerance in plants. Drought stress indirectly affects crop growth through influencing nutrient absorption including nitrogen [22].Although nutrient and water absorption processes are independent processes, water requirement for absorption and transport makes them highly dependent on each other. Drought stress can decrease N availability, plant N uptake, leaf N, and activities of N assimilatory enzymes [21].

Nitrogen is an important element involved in the building of many compounds found in plant cells and levels such as protein, nucleic acid, photosynthetic pigments and enzymes structure [14]. Nitrogen can increase LAI, chlorophyll pigments [26], light interception, photosynthesis and accumulation of dry matter [2]. Nitrogen fertilization can also enhance the yield components and especially the number of capitols per plant and the seed weight per plant [4].Nitrogen absorption by crops is automatically reduced under dry conditions, even when mineral N is present in the soil colonized by roots [13].The effects of water and N deficit on plant production depend on their timing and intensity [19]. Positive effects of nitrogen supply on grain yield have been reported in some other crops [4,12,24]. However, nitrogen requirement of safflower at different levels of watering is poorly documented. Thus, the objective of this research is to investigate the effects of nitrogen supply on yield and yield component of safflower under different water availability.

MATERIALS AND METHODS

A field experiment was conducted in 2014 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (latitude 38°05′ N, longitude 46°17′ E, altitude 1360 m above sea level with the mean annual rainfall of 285 mm). The experiment was arranged as split plot on the basisof RCB design with three replications. The factors were four levels of irrigation (irrigation after 60 (I_1), 90 (I_2), 120 (I_3) and 150 (I_4) mm evaporation from class A pan) and three levels of nitrogen (0 (N_1), 46 (N_2) and 92 (N_3) kg $N.ha^{-1}$) which were allocated to main and sub plots, respectively.Each plot consisted of 6 rows with 4 m length, spaced 25 cm apart. Seeds were hand sown in about 3-4 cm depth with a density of 80 seeds m^{-2}on 30th April.All plots were irrigated immediately after sowing.After seedling establishment the plants in each plot were thinned and reduced to 50 plants m^{-2}. Subsequent irrigations were carried out on the basis of irrigation treatments.Nitrogen as urea was applied splitting the rate into 1/2 at 7-8 leaves stage and 1/2 just before flowering. Weeds were controlled by hand during crop growth and development.

At maturity, plants of $1m^2$ in the middle part of each plot were harvested and plant biomass, 1000 grains weight, grains per capitol, grains per plant, grain yield per unit area as well as harvest index were determined. The data were analyzed by MSTAT-Csoftware andDuncan's Multiple Range Test at $P \le 0.05$ was applied to compare means of traits.

RESULTS AND DISCUSSION

Analysis of variance of the data (Table 1) showed that water stress and nitrogen supply had significant effects on grains per plant, plant biomass and grain yield per unit area. Grains per capitol wasalso significantly influenced by nitrogen fertilizer.However, 1000 grains weight and harvest index were not significantly affected by theses factors and their interaction.

Table 1. Analysis of variance of yield and yield components of safflower under different irrigation and nitrogen levels

Source of variation	df	Mean Square					
		Grains per capitol	Grains per plant	1000 grains weight	Plant biomass	Grain yield	Harvest Index
Replication	2	10.59 ns	39.96 ns	58.85 ns	4826.1 ns	907.29 ns	8.586 ns
Irrigation (I)	3	23.96 ns	3244.78 **	12.92 ns	346116.7 **	22270.9 **	9.374 ns
E_a	6	17.92	222.69	51.85	10138.6	1021.0	4.778
Nitrogen (N)	2	22.93 **	320.34 **	5.071 ns	20920.5 **	1878.6 **	0.526 ns
I × N	6	4.009 ns	31.61 ns	14.21 ns	1083.9 ns	100.09 ns	1.456 ns
E_b	16	3.353	37.10	16.92	596.38	96.69	2.207
CV (%)	---	11.06	10.13	8.35	4.31	6.64	5.66

ns, **: No significant and significant at $p \le 0.01$, respectively

Grains per capitol and plant

Grain number per capitol under different irrigation intervals was similar. Nitrogen supply enhanced number of grains per capitol by 16%, compared withcontrol. There was no significant difference between N_2 (46 $kgN.ha^{-1}$) and N_3 (92 $kgN.ha^{-1}$) levels (Table 2). No significant interaction between watering and nitrogen supply suggest that improvement in grains per capitoldue to the nitrogen was occurred under all irrigation treatments.

Table 2. Means of grain yield and yield components of safflower in response to irrigation intervals and nitrogen fertilization

Treatments	Grains per capitol	Grains per plant	Plant biomass ($g.m^{-2}$)	Grain yield ($g.m^{-2}$)
Irrigation intervals				
60 mm (I_1)	17.6 a	81.4 a	771.5 a	205.3 a
90 mm (I_2)	14.6 a	69.4 a	685.6 a	170.3 a
120 mm (I_3)	15.9 a	51.0 b	459.7 b	124.1 b
150 mm (I_4)	18.1 a	38.7 b	348.0 b	92.6 b
Nitrogen fertilizer				
control (N_1)	15.0 b	55.2 b	524.1 c	135.5 c
46 $kgN.ha^{-1}$ (N_2)	17.3 a	65.5 a	607.6 a	160.5 a
92 $kgN.ha^{-1}$ (N_3)	17.4 a	59.7 b	567.0 b	148.3 b

Different letters at each column for each treatment indicate significant difference at $p \le 0.05$

In contrast, grains per plant decreased as water stress increased. Mean grains per plant under I_2, I_3 and I_4 treatments were 14.8, 37.4 and 52.5% less than that under I_1, respectively. This reduction was mainly associated with deduction in number of capitols per plant rather than with number of grains per capitol. Reducing effects of water stress on grains per plant have also been reported for sesame [5] and chickpea [10].

Nitrogen rate of 46 kg.ha^{-1} resulted in the highest number of grains per plant, followed by 92kg N.ha^{-1}, with no significant difference between the latter treatment and control. This improvement in grains per plant was likely the result of enhancing the number grains per capitol due to nitrogen application (Table 2). Photosynthesis and nitrogen metabolism are closely related to each other such that the functional activity of photosynthetic systems depends largely on the availability of nitrogen in plant [1], therefore nitrogen supply enhance photosynthesis rate, photosynthetic products and its translocation to the sinks.

1000 grains weight

The effects of water deficit and nitrogen fertilizer on 1000 grains weight werenot significant (Table 1).Nosignificant changes in grain weight under these conditions strongly related withdecreasinggrains per plantdue to water stress and increasing that trait as a result of nitrogen supply (Table 2). Similar grain weight under well and limited irrigation conditions was in agreement with the results of Eskandari *et al*. [5] for sesame and Ghassemi-Golezani and Mardfar [11] for common bean.

Plant biomass

Plant biomass was reduced by decreasing water availability. Increasing irrigation intervals led to the loss of 11.1% (I_2), 40.4% (I_3), and 54.9% (I_4) safflower plant biomass, compared with well watering (I_1). However, biomass production under I_1 and $I_2$and also under I_3 and $I_4$was statistically similar (Table 2). Drought stressdecreases water potential of plant at later stages of growth, leading to stomata closure and reduction inphotosynthesis rate and leaf growth [20], which ultimately decreases plant biomass. Decreasing plant biomass by water limitation has also been observed in other crops [5, 8,9].

Maximum biological yield was achieved with application of 46 kgN.ha^{-1}, which had significant difference with other nitrogen level and control (Table 2). Sumi and Katayama [25] reported that nitrogen promotes higher leaf area development and reduces rate of senescence.Nitrogen deficiency reduces radiation interception and radiation use efficiency due to reduction in leaf area index [18]. Latiri-Souki *et al.* [15] reported that nitrogen fertilizer increaseswater use efficiency and leaf area index which results in higher plant biomass and grain production in wheat.

Grain yield

The highest and the lowest grain yields per unit areawere obtained by irrigations after 60 and 150 mm evaporation, respectively(Table 2).Mean grain yield per unit area under mild (I_2), moderate (I_3) and severe water deficit (I_4) was respectively 17.1, 39.5 and 54.9% less than that under wellwatering (I_1). However, there was no significant difference between I_1 and I_2 and also between I_3 and I_4 treatments. Grain yield in safflower is the result of grains per plant and grain weight. Since 1000 grains weight under different irrigation treatments was similar, decreasing grain yield due to water deficit could be largely attributed to changes in grains per plant (Table 2). Drought mainly influences yield by limiting grain number by either influencing the amount of dry matter produced by the time of flowering (particularly in determinate plants) or by directly influencing pollen or ovule function, which leads to decreased grain-set [21].

Grain yield per unit area was improved with application of nitrogen fertilizer. The highest grain yield was recorded for 46 kgN.ha^{-1} (Table 2) .Increasing grain yields as a result of nitrogen supply may be the result of delayed leaf senescence and sustained leaf photosynthesis during the grain filling [7]. The beneficial effects of nitrogen fertilizeron grain yield have also been reported for safflower [4], maize [12] and soybean [24].

Harvest index

There were no significant difference amongirrigation intervals and nitrogen levels in harvest index (Table 1). No significant effect of water and nitrogen deficitson harvest index indicated that both total dry matter and grain yield similarly decreased with decreasing these resources (Table 2).Lovelli *et al*.[16] showed that the harvest index of safflower did not significantly change in 5 irrigation regimes with a restoration of 100, 75, 50, 25, and 0% of the maximum crop evapotranspiration.When harvest index is stable, the accuracy of yield predictions is entirely a function of the simulated rate of crop dry matter accumulation, and determination of grain sink size is not important. In contrast, the determination of grain number (seed-set) is important when harvest index declines below normal range, particularly under high-stress conditions [21].

CONCLUSION

Grain yield of safflower was not significantly reduced by mild water deficit, but it was decreasedunder moderate and severe water stress mainly due to reduction in plant biomassand grains per plant. Nitrogen fertilizer, particularly with a rate of46 $kgN.ha^{-1}$ improved plant biomass, grains per plant and consequently grain yield per unit area under all irrigation treatments.These results clearly indicate that safflower is somehow tolerant to water stress and nitrogen supply with a given rate can improve field performance of this crop.

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REFERENCES

1. Brennan, R.F. (1992). The role of manganese and nitrogen nutrition in the susceptibility of wheat plants to take-all in Western Australia. Fert. Res., 31: 35-41.
2. Caliskan, S., Ozkaya, I., Caliskan, M.E. & Arslan, M. (2008). The effects of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in Mediterranean-type soil. Field Crop Res., 108:126-132.
3. Dajue, L.& Mündel, H.H.(1996). Safflower. *Carthamus tinctorius* L. Promotingthe conservation and use of underutilized and neglected crops, Instituteof Plant Genetics and Crop Plant Research, Gatersleben/International Plant GeneticResources Institute, Rome, Italy, p. 1-83.
4. Dordas, C.A.& Sioulas, C. (2008). Safflower yield, chlorophyll content, photosynthesis and water use efficiency response to nitrogen fertilization under rainfed conditions. Ind. CropsProd., 27: 75-85.
5. Eskandari, H., Zehtab-Salmasi,S.,Ghassemi-Golezani, K.& Gharineh, M.H.(2009). Effects of water limitation on grain and oil yields of sesame cultivars. J. Food Agric. Environ., 7: 339-342.
6. Farooq, M., Wahid, A., Kobayashi,N., Fujita, D.& Basra, S.M.A. (2008). Plant drought stress: effects, mechanisms and management. Agron. Sustain. Dev., 29: 185-212.
7. Frederick, J.R. & Camberato, J.J.(1995). Water and nitrogen effects on winter wheat in the southeastern coastal plain: II. Physiological responses. Agron. J., 87: 527-533.
8. Ghassemi-Golezani, K., Dalil, B., Dabbagh-Muhammadi-Nasab, A.& Zehtab-Salmasi, S.(2008). The response of chickpea cultivars to field water deficit. Not. Bot. Horti Agrobot. Cluj-Napoca, 36: 25-28.
9. Ghassemi-Golezani, K., Dastborhan, S. & Zehtab-Salmasi, S. (2013). Seed priming and Field performance of borage (*Borago officinalis* L.) under different irrigation treatments. Int. J. Agron. Plant Prod., 4: 82-87.
10. Ghassemi-Golezani,K., Hosseinzadeh-Mahootchy,A., Zehtab-Salmasi, S. & Tourchi, M. (2012). Improving field performance of aged chickpea seeds by hydro-priming under water stress. Int. J. Plant Animal Environ. Sci., 2: 168-176.
11. Ghassemi-Golezani, K. & Mardfar, R.A. (2008). Effects of limited irrigation on growth and grain yield of common bean. J. Plant Sci., 3: 230-235.
12. Ghassemi-Golezani, K., Raei, N. & Raei, Y. (2015). Effects of water deficit and nitrogen levels on grain yield and oil and protein contents of maize. Azarian J. Agric., 2: 46-50.
13. Gonzalez-Dugo, V., Durand, J.L., Gastal, F. & Picon-Cochard, C. (2005). Short-term response of the nitrogen nutrition status of tall fescue and Italian ryegrass swards under water deficit. Aust. J.Agric. Res., 56: 1269-1276.
14. Herdrich, N. (2001). Safflower Production Tips. Washington State University Cooperative Extension, USA, 16p.
15. Latiri-Souki, K., Nortcliff, S. & Lawlor, D.W. (1998). Nitrogen fertilizer can increase dry matter, grain production and radiation and water use efficiencies for durum wheat under semi-arid conditions. Eur. J. Agron., 9: 21-34.
16. Lovelli, S., Perniola,M., Ferrara, A.& Di-Tommaso, T. (2007). Yield response factor to water and water use efficiency of *Carthamus tinctorius* L. and *Solanum melongena* L. Agric. Water Manage., 92: 73-80.
17. Marita, T.& Muldoon, D. (1995). Effect of irrigation schedules and new spacing on the yield of safflower (*Carthamus tinctorius* L.). J.Oilseed Res.,7: 307-308.
18. Marschner, H. 1995. Mineral Nutrition of Higher Plants. Academic Press, London, UK.
19. Nielsen, D.C.& Halvorson, A.D. (1991). Nitrogen fertility influence on water stress and yield of winter wheat. Agron. J., 83: 1065-1070.
20. Ozturk, A. (1999). The effect of drought on the growth and yield of winter wheat. Turk. J.Agric.For., 23: 531-540.
21. Prasad, P.V.V., Staggenborg, S.A.&Ristic, Z.(2008). Impacts of drought and/or heat stress on physiological, developmental, growth, and yield processes of crop plants. (Eds. Segoe, R.D. and Madison, W.I.). Response of crops to limited water: Understanding and modeling water stress effects on plant growth processes. USA, p. 301-355.
22. Pardos, J., Serrano, L. &Pugnaire, F.I. (1999). Constraints by water stress on plant growth. (Ed. Pessarakli, M.). Hand book of plant and crop stress. Second Edition, New York,p. 271-283.
23. Rodriguez, D. (2006). Drought and drought stress on south Texas landscape plants. San Antonio Express News, Gardening, ETC.
24. Shafii,F., Ebadi,A., Golloje, K.S.& Eshghi-Gharib, A. (2011). Soybean response to nitrogen fertilizer under water deficit conditions. Afr. J. Biotechnol., 10: 3112-3120.
25. Sumi, A.& Katayama, T.C. (2000). Effect of nitrogen fertilizer application and solar radiation on the growth response of sorghum seedlings to soil moisture. Japan.J.Crop Sci.,69: 513-519.

26. Werner, D.& Newton, W.E. (2005). Nitrogen fixation in agriculture, forestry, ecology and environment. Springer, Netherlands.