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EFFECT OF DROUGHT STRESS ON SOME MORPHOLOGICAL TRAITS AND SEED YIELD OF INDIGO (*INDIGOFERA TINCTORIA* L.) UNDER DIFFERENT LEVELS OF NITROGEN

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ABSTRACT
Drought stress in arid and semi-arid regions of the world, including Iran, more than any other factors decline the plant growth and production. So selection the drought tolerant and resistant plants for arid and semi-arid areas is the major importance. Indigo (*Indigofera tinctoria* L.) is one of the resistant plants to drought which is suitable for sowing in dry and hot areas of the country. Therefore, considering the above mentioned, this study was carried out in order to effect of drought stress and nitrogen on yield and some physiological characteristics of Indigo in Jiroft area. The study consisted of experiments using randomized complete block design with three replications. The main factor was considered to be irrigation treatments including optimum irrigation and severe stress in which irrigation was done after depletion of 90% and 50% of field capacity, with three replications in Jiroft and Kahouj Agricultural Research Center during 2011. Results showed that no stress + 150 kg nitrogen ha^{-1} increased plant height, No. of Shoot/plant and No. Pod/plants of indigo as 70.98 cm, 8.73, 381.1. Levels of Water deficit stress had different effects on plant. Results showed that drought stress + 50 kg nitrogen ha^{-1} and no stress + 150 kg nitrogen ha^{-1} increased No. of Seed/pod of indigo as 3.47 kg/h. The most grain yield of about 224 kg ha^{-1} obtained from the highest density at optimum irrigation treatment.

KEY WORDS: *Indigo, Drought stress, Nitrogen, Yield seed*

Introduction

Indigo (*Indigofera tinctoria* L.) belongs to the Fabaceae family. It is mostly cultivated in tropical regions and today, it is produced in most hot regions of Asia, Central America and some parts of Africa for industrial uses. The plant is perennial, but it is cultivated as an annual plant (Shabani and Aein, 2008). A material called Indigo is extracted from the leaves of Indigo which is extensively used in industries for dying textile and objects. Indigo has a highly stable. It has various colors among which Indigotin is the most important one which is blue in color. It, also, has other dyes such as Indirubine, Indigorubine or red indigo, Indirenine, Indihumine or brown indigo.

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The roots and branches of indigo taste bitter. They are aperients and expectorant and are useful in healing stomach and bowel worms. They also pacify hair fall. All parts of the plant mitigate inflammation and useful in healing chronic bronchitis, asthma (particularly in children), hemorrhoid, insects bites, injury healing, skin disorders and their side-effects (Zargari, 1996). The main objective in agriculture production, so far, focused mostly on the increasing of yield and production (Ulusoy, 2001). Since Iran is located on a dry and semi-dry region and has different climates, the recognition of traits related to growth, yield as well as adaptation of sunflower, especially in relation to drought stress, can remarkably affect the development of planting area and its yield increase. Nezami *et al*., and Rahbarian *et al.,* indicated that plant height, plant dry matter and grain weight head^{-1} under dry and semi-dried conditions declined. Ahmad *et al.,*(Ahmad et al, 2006) and Rahbarian and Salehi Sardoei [2014a; b] reported that plant height and plant dry matter decreased with increasing water stress under controlled conditions. Chimenti et al.(2002); Erdem *et al*., indicated that grain yield decreased with increasing drought stress. Karam *et al*., (2007) showed that with increasing drought stress leaf area index, grain yield and its component decreased. Blum (1998) believes that environmental stresses in farm appear mainly in the form of such factors as water, nutrition and heat deficiency. Relative water content (RWC) of the leaves decreased under drought stress. Ali Meo (2000) conducted that plant height and number of grains head^{-1} decreased significantly by lowering the nitrogen level or increasing drought stress. Kalamian *et al.*, (2006) showed that drought stress decreased biologic yield. Furthermore, the results from Anwar *et al*., (1995), Anderia and Chiaranda (2002) showed a decrease in head diameter with increasing drought stress. Zubriski and Zimmerman (1991), Singh *et al., (*1996), Mathers and Stewart (1982) showed that increase in use of nitrogen caused an increase in grain yield. Therefore the aim of this study was to evaluate the effect of different levels of nitrogen application in different moisture conditions on yield and yield components of Indigo in order to achieve the optimum use of resources.

Materials and Methods

This experiment was conducted in order to investigate the effects of water deficit stress, different levels of nitrogen and drought stress on grain yield and yield components and harvest index in indigo. It was performed during 2011 at the research farm of the Centre of Agriculture and Natural Resources in jiroft, kerman, Iran. The experiment was implemented using randomized complete block design with three replications. The main factor was irrigation treatments including optimum irrigation and severe stress. Irrigation was done after reduced of 90 and 50 percent of field capacity, respectively. four levels nitrogen consisting of 50, 100, 150 and 200 kg N ha^{-1}. Each sub-plot consisted of 7 plant line. Each plant line was 4 meter long. The distance between two sub-plots and two main plots were 1m and 1.5m, respectively. Thus main plot area was 51.6 m^2 with total area of 2500 m^2. The operations of plough and preparation of farm included a deep plough, two vertical disks, leveling, furrow, mound and plot making. The soil texture was loamy silt. The amount of fertilizer added to farm was determined by soil analysis. The planting was done manually after irrigation in 27 may 2011. The grains used in this study were indigo. The first irrigation was done in 5 June. The thinning conducted in 4-5 leaf stage. The weeding conducted in

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2 stages of 20 and 40 days after planting. Nitrogen fertilizer applied in the form of surplus in 2 stages of 7-8 leafage and flowering time. When downside of head turned to brownish yellow the final harvest was performed. In this stage seeds had 20 percent of moisture. In order to remove the edge effect, the sampling was not conducted from lateral rows. For determining soil moisture samples were taken from 2 depths of soil 0-30 and 30-60 cm in each (Tab. 1.).

Tabale 1. Chemical and physical properties of farm soil at depth of 0-30 and 30-60 cm

Depth (cm)	PH	EC ($ds.m^{-1}$)	Total P_2O_5 (ppm)	Total N (%)	Total K_2O (ppm)	Organic carbon (%)	Texture soil
0-30	7.9	1.05	7.9	0.03	160	0.26	Sandy-loamy
30-60	8.1	0.98	4.5	0.02	150	0.19	Sandy-loamy

Analysis of variance was performed using standard techniques and differences between the means were compared through duncan significant difference test [$P < 0.05$] using MSTAT-C software package.

Results and Discussion

Results showed that no stress + 150 kg nitrogen ha^{-1} increased plant height, No. of Shoot/plant, No. Pod/plants and seed yield of indigo as 70.98 cm, 8.73, 381.1 and 22.4 kg/h (Table 2). This situation probably was the result of a disorder in nitrogen absorption process by plant under severe drought stress. deficit in soil caused a limitation in plant ability to absorb nitrate from soil. More nitrogen consumption resulted in increasing plant height and its preservation until the end of growth period. The results of this study about the effect of applying different amounts of nitrogen on plant height and leaf area agree well with Allison and Haslam (1993). This is because of ability of the plant to access to more nitrogen and increasing reproductive and productive parts. Fathi *et al*., (1997) reported that with increasing nitrogen consumption plant height increased due to more access to absorbing nutrients. This is, in turn, a function of the durability of No. of Shoot/plant after growth stage as well as the sink-source relationship (1994). Decreasing seed yield at severe drought stress can be related to the lack of stored carbohydrates before pollination stage at productive parts and to decreasing durability of growth at plants of under treatment that resulted in a short period of grain filling. Westgate (1994) reported that the main reason of grain weight reduction is decrease in grain filling period due to stress. With increasing severe drought stress, grain yield decreased. Increasing nitrogen application caused grain yield to increase. The consumption of more quantities of fertilizer at optimum irrigation condition caused considerable increase in grain yield whereas at no stress drought condition

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using more quantities of nitrogen did not increased grain yield. It seems that this situation results from absorption reduction and increasing nitrogen waste due to water deficit in soil. The most grain yield of about 224 kg ha^{-1} obtained from the highest density at optimum irrigation treatment. Liang *et al.*, (1992) reported that maximum grain yield in maize need high irrigation, use of plenty of fertilizer and meeting temperature requirements. Results showed that drought stress + 50 kg nitrogen ha^{-1} and no stress + 150 kg nitrogen ha^{-1} increased No. of Seed/pod of indigo as 3.47 kg/h (Table 2). The results showed that with increasing intensity of drought stress there was a significant decrease in biological yield. These results confirmed results of Radford 91986), Kalamian *et al.*, [14], Jasso *et al.*, (2002) who also showed decreasing biological yield because of drought stress. In this study, increasing the use of nitrogen increased No. of seed/pod (Tab 1). Results showed that drought stress + 50 kg nitrogen ha^{-1} increased leaf dry weight of indigo as 5.12 (Table 1). The reason for increase in total dry matter production in plants under optimum irrigation was the extension of leaf area and its higher durability that provided enough physiological resource to take advantageof received light and therefore produce more dry matter.
Results showed that no stress + 50 kg nitrogen ha^{-1} increased shoot dry weight, total dry weight and total fresh weight of indigo as 5.27 kg/h, 7.99 and 18.60 ton/h (Table 1). The results of Martin *et al.*, (1992) confirm obtained results in this survey on nitrogen use efficiency at drought stress condition. Levels of Water deficit stress had different effects on plant.

Table 2 - Effect of Concentration of Drought Stress and Nitrogen on Some Morphological Traits and Seed Yield of Indigo (*Indigofera tinctoria* L.)

Drought Stress (fc)	Nitrogen (kg/h)	Plant Height (cm)	No. of Shoot/plant	No. of Seed/pod	No. Pod/plants	Seed Yield (kg/h)	Shoot Dry weight (kg/h)	Leaf Dry weight (kg/h)	Total Dry Weight (ton/h)	Total Fresh Weight (ton/h)
No stress	50	66.02a	6.90bcd	4.83cd	180.2cd	196.1cde	5.27a	2.74b	7.99a	18.60a
	100	69.70a	7.32abc	4.93abc	196.6cd	203.3bc	3.94b	2.72b	5.45c	17.40ab
	150	70.98a	8.73a	5.12a	381.1a	224a	3.72b	2.39b	6.31b	15.25b
	200	67.18a	7.40ab	5.10abc	283.5b	217.9b	4.16b	2.68ab	6.96b	12.48c
Drought stress (50 Fc)	50	48.10b	7.40ab	5.99d	209.1c	197.2cd	1.93c	3.47a	5.27c	8.55d
	100	48.02b	5.25d	5.25ab	110.7e	172f	2.09c	0.95c	2.95d	7.33d
	150	50.97b	5.72cd	4.62bcd	214.6c	185.2def	2.37c	2.13b	3.31d	9.77d
	200	52.05b	6.23cd	4.73bc	152.4dc	179.4ef	2.51c	1.87b	4.75b	9.67d

Means followed by same letter are not significantly different at $P< 0.05$ probability using Duncan's test.

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Conclusions

Among the most important results obtained about application of water deficit stress, significant reduction of Plant height, No. of shoot/plant, No. pod/plants, seed yield, shoot dry weight, total dry weight and total fresh weight at severe stress in comparison with optimum irrigation can be pointed out. By increasing nitrogen fertilizer from 50 to 150 kg nitrogen ha^{-1} all the aforementioned traits increased significantly.

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