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Study of selected lentil genotypes against drought

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ABSTRACT

Drought is one of the major abiotic stresses which, often inter-relatedly, adversely affect plant growth and productivity. Plant stress responses depend on the type of stress, on its intensity, on the species, and also on the genotype. An experiment was conducted in the experimental field of Plant Physiology Division of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during *rabi* season of 2014-15 to find out lentil genotypes for adoption in drought areas. Three previously selected genotypes BARI Masur-3, BLX-0104-9 and ILI-5143 were tested under no irrigation and irrigation (one irrigation at 30 DAS) condition. It was found that plant height, pod plant^{-1}, seed pod^{-1}; 1000-seed weight and seed yield were affected by with or without irrigation. Each parameter of all genotypes was decreased due to drought. The genotype BLX-010014-9 was found superior to others in respect of relative leaf area and relative yield.

Introduction

Drought, defined as the occurrence of a substantial water deficit in the soil or atmosphere. It increases an important constraint to crop productivity and yield stability worldwide. It is by far the leading environmental stress in agriculture and cause worldwide loss in crop yield (Shahram et al. 2009). The vast majority of the poor in dry lands depend on agriculture. And drought is the principal constraint of crop production in these areas. It may be defined as periods in the natural cycle of stress and renewal during which the amount of moisture in the soil no longer meets the needs of a particular crop. Drought occurs frequently in dry lands, partly because average rainfall is low, ranging across locations and years from an average of about 300 to 800 millimeters per annum, but also because it may be highly erratic, with torrential storms during the cropping season, followed by long dry spells. One of the most crucial functions of plant cells is their ability to respond to alterations in their environment. Understanding the connections between initial responses and the downstream events that constitute successful adjustment to its fluctuating environment is one of the challenges of plant biology research. Investigations on transcript level are the most common studies so far. Besides transcript analyses, new technologies based on mass spectrometry allow for the comprehensive study on metabolite and protein level. Past studies have focused on different stresses such as temperature, drought or salt using various plants and technologies. All these data have improved the understanding on the complexity of the plant response depending on the intensity and duration of homeostatic perturbation. However, due to the diversity of the research data and experimental conditions a comparison and integration is difficult or even impossible. Thus to gain better insights and to be able to visualize the complexity of the plant respond, integrative analyses combining different technologies and standardized cultivation conditions are becoming necessary.

Legumes are major sources of vegetable protein and indispensable for sustainable agriculture due to their ability to fix atmospheric nitrogen via their symbiosis with soil rhizobia. These bacteria colonize legume roots in specialized organs called nodules. Legumes are a vitally important source of protein in developing countries, where meat protein is consumed infrequently. They are also often grown in poor soils, because of their associated atmospheric N_2 fixation, and where water availability is low or unpredictable. Legumes are of considerable importance for providing food and feed world over. In comparison to cereal grains, legume seeds are rich in protein and thus provide highly nutritive food. Legumes are grown on a wide range of soils varying in texture and fertility. Most of the soils of arid and semi-arid regions, being low in soil moisture content, are also low in fertility. So to maximize plant productivity, proper supply of macro- and micro-nutrients to crops is essential. As a general practice, optimal supply of macronutrients to crops is usually ensured but that of micronutrients is ignored. In view of a plethora of literature, it is now well established that application of micronutrients is effective in alleviating the adverse effects of abiotic stresses such as salinity and drought. The involvement of micronutrients in different physiological and biochemical activities of the legume plants is well documented because correlations between micronutrient supply and crop growth and productivity have been often observed. Use of micronutrients like zinc (Zn), iron (Fe), boron (B), manganese (Mn), molybdenum (Mo), copper (Cu), cobalt (Co) and nickel (Ni) has now become a common practice to increase crop yield especially under adverse environmental conditions. Plants deficient in micronutrients may become susceptible to diseases and abiotic stresses. Rapid leaching of acids in sandy soils tends to produce a deficiency of tightly held nutrients such as Zn, Fe, Cu or B. Therefore, problem soils such as acid, alkaline or sandy soils are often deficient in one or more micronutrient elements.

Micronutrient application not only improves the stress tolerance potential indirectly (because micronutrients deficient plants exhibit an impaired defense response) but also results in improving a number of metabolic phenomena. Thus, application of micronutrients as foliar or soil amendment is recommended to achieve optimum crop productivity from the soils having inherent micronutrient deficiency and low moisture contents. In this chapter, the role of micronutrient management in improving the drought tolerance potential and productivity of legumes is reviewed and critically discussed (Ashraf et al. 2012). In Bangladesh, up to 60% of the land surface is subjected to continuous or frequent stress and drought occurs of about 3.5 million ha of land area causing a great damage to crop production. So, drought is a serious agronomic problem, being one of the most important factors contributing to crop yield loss in marginal lands and affecting yield stability (Sari-Gorla et al. 1999). Soil moisture deficiency can limit crop cover and decrease crop growth rate by negatively affecting various morpho-physiological process (Emam & Niknejhad, 2004). When a plant starts its reproductive growth and proceeds towards maturity, providing its required water through complementary irrigation increase its yield (Sarker et al. 2003). Plant growth consists of a series of biochemical and physiological process which are interacted and are affected by environmental factors. Produced dry matter of a plant can be studied by such indices as growth rate and relative growth rate, both are two most growth indices (Gordner et al. 1985; Karimi & Siddique, 1991). However, in many cases farmers in Bangladesh cannot irrigate timely in their crop and get low yield.

Lentil (*Lens culinaris* Medik.) is one of the most important food legume crops. It is a good source of high quality protein in human diets, (Mehta et al. 2005). In Bangladesh lentil is mainly grown in Rabi season. Usually it suffers from soil moisture stress during this growing period due to insufficient irrigation. Moreover, irrigation facilities are not available everywhere .Among the abiotic stresses, drought leads to a series of morphological, physiological, biochemical and molecular changes that adversely affect plant growth and productivity (Kafi et al. 2005). Like many other pulses, it is rich in cholesterol-lowering soluble fiber. Lentil has a wide range of variability in its gene pool for various qualitative and quantitative traits, including resistance to abiotic stresses and drought is a major constraint to lentil production all over the world (Barat et al. 2010). So, one of the major challenges of lentil production is to select drought resistant genotype(s) to reduce yield loss. So, it is necessary to find out suitable genotype(s) which could be grown in drought stress environment. Therefore, the present experiment was conducted for selecting suitable lentil genotype(s) for drought tolerance.

Materials and Methods

The experiment was conducted at Plant Physiology research field, BARI, Joydebpur, Gazipur during *rabi* season of 2014-15. The soil was silty clay loam in texture belonging Chhiata series under AEZ-28 having low organic matter (0.97%) and deficient in total nitrogen (0.056%), available phosphorus (12 ppm), exchangeable potassium (0.17 meq/100 g soil) and available sulpher (10 ppm).

Previously selected three genotypes (BLX –010014-9, ILI- 5143, and BARI Masur 3) were grown under no irrigation and with irrigation (one irrigation at 30 DAS) situation. The trial was non-replicated. The plot size was 1.5 m×1.5 m. Drought was imposed by withholding irrigation. The fertilizer dose was N_{23}, P_{18} and K_{20} Kg/ha and fertilizers were applied in the form of urea, triple super phosphate (TSP) and muriate of potash (MoP), respectively. All fertilizers were applied as basal during the time of land preparation. A light irrigation was given before sowing of seeds for uniform germination both for control and drought conditions. The seeds were sown on November 23, 2014 with line spacing of 25 cm. Ten plants were collected from each plot at flowering stage for leaf area measurement. The yield components data were taken from 10 randomly selected plants prior to harvest from each plot. Harvesting was done at maturity stage. At harvest, the yield data was recorded plot wise and yield was calculated. Relative yield (Fernandez, 1992) was calculated by using the following formula:

$$\text{Relative yield} = \frac{\text{Yield of drought stressed plot}}{\text{Yield of control plot}} \times 100$$

Results and Discussion

Drought escape was clearly the key response to drought. For severely drought-prone areas, selection for early flowering is therefore required. Variation in flowering time and seed yield under irrigated conditions accounted for 62% of seed yield variation under drought stress (Silim, 1993).

Significant genetic variability for traits in lentil germplasm adapted to rainfed conditions were shown to have longer roots and higher DRW (Kumar, 2012). Salisbury and Ross (1992) reported that low water availability adversely affects plant development and assimilate translocation. The applied drought susceptibility index (DSI) considered the relations between seed yield of plants under drought conditions (Y_D) and that under conditions of good soil watering (Y_{IR}) as well as their dependence on the drought severity index (D_S). The use of the index divided the cultivars into two groups of different drought tolerances.

The group of drought resistant cultivars characterized by mean values of the DSI index < 0.31 comprised field bean cultivars Bourdon, Gobo and Nadwislanski, soybean cultivars Aldana, Polan and Progres, field pea cultivars Miko and Solara and lupine cultivars Popiel and Bac. To the drought sensitive cultivars with DSI > 0.44 belonged Victor and Bronto of field bean species, Bareness and Mige of field pea species and Emir of lupine species. In general, the resistant cultivars when compared with the susceptible ones were characterized by lesser yield of seeds, which, however, was more stable both under conditions of drought and moistured plots. Any dependence of the degree of drought tolerance on the duration of the particular periods of plant growth was not observed in the experiments, however, both in' drought susceptible and drought resistant cultivars there appeared the tendency to shorten the development phases under drought and to prolong them under artificial irrigation (Grzsiak et al.1996)

Plant height, pod/plant, seed/pod, thousand seed weight and seed yield were varied under with or without irrigation situation (Table 1). The highest plant height was found in ILI-5143 followed by BARI Masur 3 and BLX-010014-9 under both the situation. Plant population m^{-2} was higher at irrigation treatment in all the genotypes over no irrigation. It may be due to more moisture. Leaf area index, pod/plant, seed/pod, 1000-seed weight and seed yield of all genotypes were more under irrigated situation over no irrigation. Among genotypes, higher values of all the parameters were recorded in BLX-010014-9 under both the situations.

Yield changes in non-irrigated and irrigated conditions for different genotypes, the primary selection of genotypes for relative drought tolerance or resistance and a comparison between new indices and previous ones were studied. Relative tolerance and resistance are used instead of tolerance and resistance because there are no complete tolerance and resistance to abiotic- stress. ATI and SSPI exhibited a positive significant simple correlation with TOL, Yp and SSI, but their correlations with RDI were significantly negative. ATI and SSPI differentiated between relative tolerant and intolerant genotypes better than TOL and SSI in some cases and were considered as a favorite index for the selection of relatively tolerant genotypes. ATI and SSPI are powerful to select extreme tolerant genotypes with yield stability and may be can use of them as parents in conformation to a QTL population for yield stability in two irrigated and non-irrigated conditions, because, both of them are related to relatively yield stability and may be state that a genotype with suitable yield stability carries drought tolerance or other related trait genes (Moosavi et al. 2007). The relative leaf area index was highest in BLX-010014-9 followed by BARI Masur-3 (Fig.1). The highest relative yield was also found in BLX-010014-9 followed by BARI Masur 3 (Fig. 2).

Conclusion

Survival of plants under adverse environmental conditions like drought relies on moisture existence in soil and cultivars. Genotypic characters bear a good significance to grow in drought conditions. It would to be concluded that BLX-010014-9 is more drought tolerant among the three genotypes.

Table 1. Effect of irrigation and variety on the yield and yield components of Lentil.

Irrigation	Variety	Plant ht. (cm)	Plant population m^{-2}	Leaf area Index	Pod/ plant	Seed / pod	1000-Seed wt.(g)	Yield (t/ha)
No irrigation	BLX-010014-9	32.93	110.3	3.65	39.93	1.76	21.7	1.65
No irrigation	ILI-5143	33.90	104.5	3.12	28.80	1.33	18.4	1.51
No irrigation	BARI Masur 3	34.90	100.2	3.24	30.36	1.50	19.3	1.58
One irrigation at 30 DAS	BLX-010014-9	34.20	112.5	3.79	42.13	1.90	23.8	1.73
One irrigation at 30 DAS	ILI-5143	35.66	106.2	3.49	31.20	1.73	19.0	1.67
One irrigation at 30 DAS	BARI Masur 3	35.36	104.2	3.44	32.53	1.76	20.2	1.69

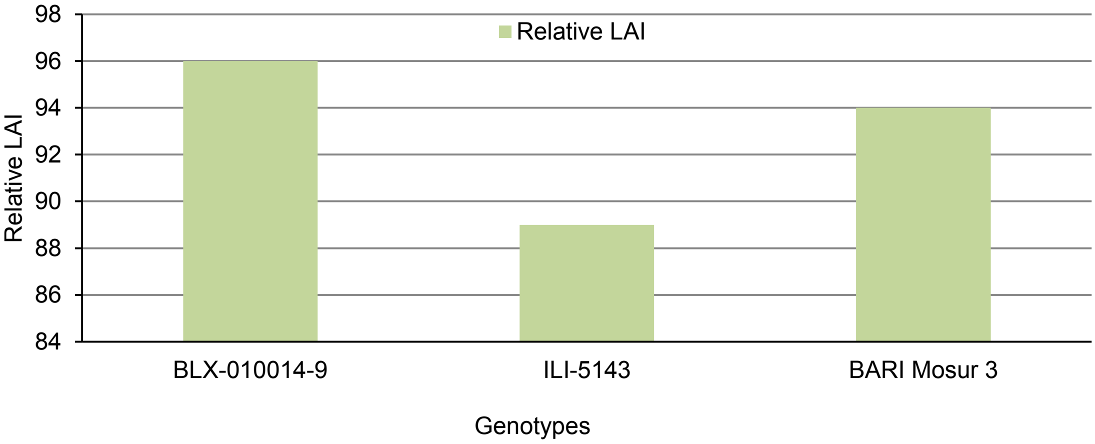

Fig. 1. Relative LAI of Different Genotypes

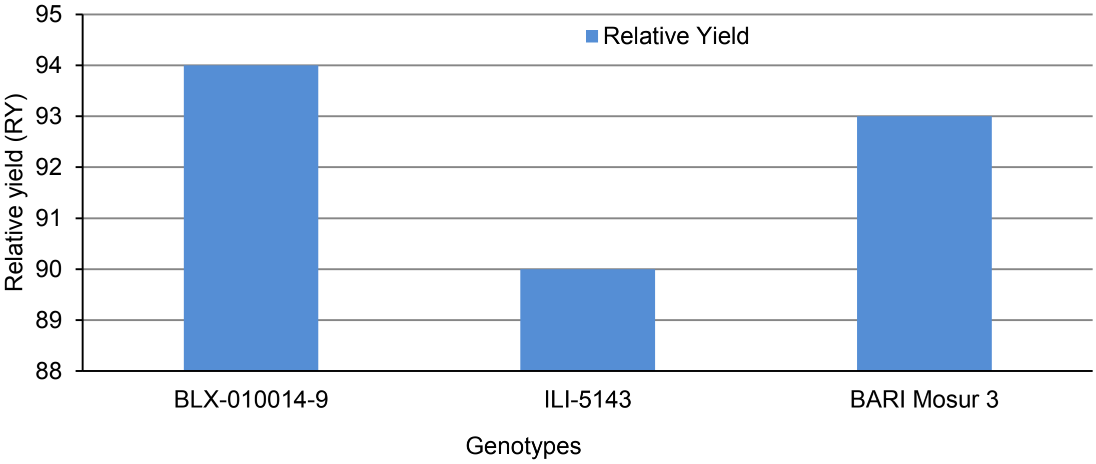

Fig. 2. Relative yield of different lentil genotypes

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