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Research article

STUDIES ON MORPHOLOGICAL AND PHYSIOLOGICAL TRAITS ON MINERAL COMPOSITION IN CLUSTER BEAN GENOTYPES UNDER DROUGHT STRESS

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ABSTRACT: Drought is a major factor limiting the growth of all crops in pod-filling stages. The functional relationship of drought stress and accumulation of various ions in cluster bean is to be studied properly. The objective of this study was to investigate the effects of drought on morphological and physiological effect on root growth, shoot growth, leaf area, relative water content(R.W.C) and Chlorophyll SPAD reading values variations. Accumulation of several major nutrients in six cluster bean genotypes RGC-936, RGC-1025, HG-365, GC-1031, JG-1 and JG-2 genotypes have varying in drought tolerance. RGC-1025, RGC-936, HG365, GC-1031, JG-2, JG-1 were grown in departmental Botanical garden with Randomized block designed plot maintained under optimum temp for 39-48 days in field condition. Total root length was greater in RGC1025 and RGC-936 followed by JG-1 and JG-2. High decrease observed in N, P, K, Ca, Mg and Zn nutrient content and less decrease was observed in Fe and, Cu. It is found that the shoot root ratio, leaf area, RWC were high and chlorophyll SPAD reading values were less in water stressed conditions in the cluster bean genotypes RGC-1025, RGC-936 and HG365 when compared to JG-2, JG-1 and GC-1031.

Key words: Cluster bean, Major nutrients leaf area, R.W.C., SPAD readings.

INTRODUCTION

Cluster bean is generally considered as a drought tolerant crop; few studies have shown that water stress experienced during critical growth stages can lead to substantial reduction of seed yield. Boutra and Sanders in 2001 reported that water stress during both flowering and pod-filling stages decreased seed yield. It was also found that moisture stress at flowering stages was more detrimental for obtaining higher pod yield. The average yield of this crop is very low in India (418.49 kg ha-1) and in Rajasthan (874.35 kg ha-1) as well. Poor and imbalance nutrient management is one of the important factors for low yield of this crop [1]. As India lies in semiarid zone soil mineral deficiency is a major problem around various areas which causes considerable negative impact on crop production. Hence, the present investigation was designed and conducted to investigate their impact of drought and minerals content and uptake by Cluster-Bean from soil. The interactions between drought and other nutrients led to changes in nutrient content and physiological disorders with reduction of plant growth and yield. Plants are constantly exposed during their life cycle to adverse environmental conditions that negatively affect growth, development, or productivity.

Minerals are good source such as Fe, Zn, P, Ca, Cu, K, Mn and Mg, and are excellent sources of complex carbohydrates. Different physiological, biochemical process altered by drought, such as RWC, gas exchange photosynthesis and metabolism of carbohydrates, proteins, amino acids and organic compounds. Mineral nutrients are influences different plant growth and developmental stages and reproductive and grain filling stages and an important role in drought and disease control.

Most of the Microelements can affect resistance indirectly, and deficient Plants become more suitable substrates for pests acquired in the form of inorganic ions from soil. Drought stress reduced accumulation of seed reserves between 8% and 12%. For example, there was a general decreasing trend in total soluble proteins in all plant tissues due to water deficit [2]. Few differentiate genotypes into efficient and inefficient nutrients (N, P, K, micronutrients) utilizations in rice [3, 4]. For importance of mineral nutrients gained by grain crops accumulation of Zn, Fe, P, and N in the seeds of three common bean groups (Chitti, red, and white) under contrasting moisture regimes, and the classification of genotypes based on grain yield and irrigation efficiency.

MATERIALS AND METHODS

Plant Growth Conditions and drought Stress Treatments

Cluster bean seeds were procured from Regional Agricultural Research Station, Rekulakunta Agricultural University (ANGRAU), Ananthapuramu, India, grown in field condition Dept of Botanical garden Sri krishna devaraya university Ananthapuramu in earthen pots containing air dried red soil and farmyard manure in 3:1 proportion. The field condition under natural photoperiod (12-14 hours and temperature 30 ± 4 °C) in the botanical garden and were irrigated once 4 days with water. After germination, seedlings were thinned to 15 cm in between plant to plant and rows 30cm maintained for 39 days. 39-day-old plants were subjected to drought stress. Only control plants irrigated 0nce 4 days and treated plants without water up to 39-48 days. After 10 days of 3rd leaf collected from control and treated plants.

Determination of Growth Parameters

The plants were carefully uprooted from pots and washed thoroughly with running tap water. Plant growth was determined by measuring the length of the root and shoot system. The dry weight (DW) was measured after the shoots and roots were dried at 80 ºC to constant weight. Leaf area was measured by using leaf area meter (Li-Cor, Li3100 USA).

Determination of Nutrient Elements

Leaves were separated from Plants. These were thoroughly washed with tap water and distilled water the sample surface. These samples were dried at 70ºC in a hot air oven for 24 hours and powdered using mortar and pestle Samples in powder form were used for atomic absorption Spectrophotometer (AAS). Each plant material (0.25 g) was taken in 50 ml flask and add 6.5 ml of mixed acid solution that is, Nitric acid (HNO_3), Sulfuric acid (H_2SO_4) and Perchloric acid ($HClO_4$) (5:1:0.5) Load the sample in the digestion system unit with manifold and KEL FLOW setup, temperature up to 42^0C, 1.30 hour and will cooling take half an hour. Thereafter, few drops of distilled water have been added after the completion of digestion. Then these digested samples were transferred in 50 ml volumetric flasks and the volume was made up raised to 50 ml by adding distilled water in them. Then the extract was filtered with filter paper (Whatmann No. 42) and filtrate was collected in labeled plastic bottles. The solutions were analyzed for the elements of interest utilizing atomic absorption spectrometer (Shimadzu AA-670) with suitable hollow cathode lamps. The percentages of different elements in these samples were determined by the corresponding standard calibration curves obtained by using standard AR grade solutions of the elements, for Mg2+, Ca2+, Fe2+, , Mn2+, Cu2+, , Zn2+, and K+, Na+, for using flame photometer, nitrogen estimation by using with kelplus system , 10ml 0.1 ml Sodium Carbonate , 3 drop Methyl indicator, 0.1N H_2SO_4.

Determination of Chlorophyll Content with SPAD (SCMR) Meter

SCMR (Minolta SPAD-502, Konica, Japan) was measured during 9.00-11.00 am using the second fully expanded leaf from the top of the main stem care was taken to ensure that the SPAD meter sensor fully covered the leaf lamina and that interference from veins and midribs was avoided, totally five leaves for three plant and then single value was obtained for plant by averaging the data.

RESULTS AND DISCUSSION

Drought is a common response to the growth inhibitions of morphological and physiological, biochemical changes. Drought effects especially mineral content decrease in accumulation and effect on critical growth Pod-filling stage of crops. In our present investigation in Six cluster bean genotypes were studied their root, shoot length and leaf area was increased. And the pod-filling stage the mineral content were decreased in shoot and increased in root and leaf area of the genotypes of RGC-1025, RGC-936, and HG-365 when compared to control JG-2, JG-1, and GC-1031. Then the Relative water content (RWC) has been increased and Chlorophyll SPAD value was decreased accordingly (Table 1) under drought condition.

The Nitrogen status has been influenced the growth of plants of which root, shoot and leaf area, physiologically Relative water content, Photosynthesis and pigments of chlorophyll, and increasing of soil moisture for mineralization process. A significant increase in plant height with nitrogen availability (Table 1) in general under drought condition cluster bean genotypes, the nitrogen supply insufficient consequent the photosynthetic rate were reduced by reducing leaf area as result of that it accelerate leaf senescence finally leads stunted growth. It is observed that the absorption of phosphate from soil and transport into plants was decreased in stem i.e. available P is increased. In the soil reduces P uptake and consequently induces lower foliar P content the accumulated P also increased in leave under drought condition when compared to sensitive genotypes.

In sufficient phosphorous supply along with nitrogen is frequent limiting factor to plant development. Plants show retarded growth and reddish coloration due to increased Anthocynin formation. The deficiency of phosphorus in legumes depressed the activity of nitrogen fixing bacteria [5] for which the availability of nitrogen in root zone is also reduced [6]. In our present investigation it is found that the drought resistant cluster bean genotypes contain high phosphate ability of P can increased the height of the plant and leaf area. The results are in consistent with reports in wheat [7, 8] Pearl millet [9].

Table-1: Morphological and physiological characters under controlled and drought conditions

Variety Name	Treatment	Shoot length in cm	Root length in cm	Leaf area in cm^2	Relative water in (RWC) %	Chlorophyll SPAD nm/cm^2
RGC-1025	**control**	**65.2±0.74**	**20.6±0.4**	**34.84±0.64**	**85.05±0.28**	**53.77±0.43**
	stress	57.3±1.11	18.6±0.3	26.57±0.69	71.32±0.02	56.77±0.43
RGC-936	control	64.6±0.33	20.2±0.16	29.58±0.38	82.20±0.93	45.36±0.41
	stress	58.7±0.37	19.2±0.07	22.13±0.12	71.8±0.53	48.3±0.53
HG-365	control	65.6±0.20	18.3±0.24	33.59±0.47	79.25±0.77	48.61±0.55
	stress	55.8±0.535	16.3±0.24	25.35±0.43	67.59±4.08	55.64±0.53
Gc-1031	control	58±0.816	18.1±0.18	33.74±0.61	83.44±0.22	56.14±0.21
	stress	51.3±0.73	15.2±0.10	25.07±0.68	67.70±0.71	62.80±0.75
JG-1	control	62.3±0.326	19.16±0.60	36.08±0.60	76.44±1.14	48.38±0.59
	stress	51.5±1.69	15.5±1.04	24.08±0.74	68.14±0.62	56.383±1.04
JG-2	control	62.5±0.56	22.6±1.52	37.71±0.78	82.70±0.52	46.51±1.35
	stress	50.3±393	17.8±0.64	23.04±0.21	67.36±0.89	52.51±0.67

The data represent the mean ±SD (n=10) of three replicates and the same letters after averages are not significantly different at $p<0.05$ (DMR test).

Table-2: Elemental profile drought stress and controlled condition in six cluster bean genotype leaves

Varity name	Treatment	Nitrogen mg/g	Phosphorus mg/g	K mg/g	Sodium mg/g	Ca µg/g	Mg µg/g	Cu µg/g	µg/g	Fe µg/g	Zn µg/g
RGC-1025	control	174±2	80.1±0.08	28.2±0.2	5.9±0.20	19.1±0.1	18.1±0.1	23.2±0.2	7.7±0.04	63.22±0.22	52.2±0.127
	stress	154±1	80.7±0.53	9.3±0.26	21.9±0.4	17.4±0.5	17±0.55	21.3±0.16	6.5±0.29	54.14±0.78	42.2±0.16
RGC-936	control	174.6±0.3	96.9±0.19	27.5±1	5.9±0.15	18.2±0.15	14.6±0.2	22.2±0.2	7.5±0.06	55.12±0.11	49.3±0.31
	stress	154.3±0.9	90.9±1.02	9.2±0.3	26.5±0.7	16.4±0.16	12.6±0.32	20.6±0.56	6.4±0.02	45.53±0.473	38.9±0.20
HG-365	control	193.6±1.5	76.2±0.43	21.6±0.	5.9±0.4	17.5±0.3	17.5±0.3	37.6±0.60	7.8±0.425	78.29±1.6	52.7±1.43
	stress	194.6±1.2	75.6±0.43	9.5±0.4	17.3±0.4	14.4±0.04	13.93±0.40	25.7±0.46	5.7±0.26	69.36±0.90	46.1±1.46
GLC-1031	control	190±0.5	81.4±0.2	20.3±0..5	5.7±0.05	18.8±0.2	18.3±0.15	24.4±0.11	7.6±0.37	65.88±0.83	54.1±0.43
	stress	173.3±1.2	80.8±0.4	9.6±0.04	18.6±0.4	16.5±0.2	14.51±0.43	22.6±0.30	6.07±0.1	57.33±0.54	46.3±0.04
JG-1	control	164±1	82.4±0.4	21.6±0.5	6.4±0.1	16.2±0.2	18.63±0.61	23.6±0.61	6.02±0.2	73.62±0.54	49.6±0.54
	stress	146.5±0.5	82.7±0.35	9±2.1	17.7±0.3	16.3±0.6	15.9±0.49	21.7±0.47	4.77±0.11	64.80±0.51	39.4±0.67
JG-2	control	150.3±1.0	79.2±0.23	22.5±0.1	6.5±0.1	17.8±0.1	17.66±0.15	20.6±0.595	8.3±0.15	74.28±0.27	48.4±0.4
	stress	134±2.9	78.8±0.50	10.3±0.08	18.6±0.45	16.8±0.98	13.7±0.20	19.6±0.20	6.5±0.131	64.81±0.87	36.6±0.41

The data represent the mean ±SD (n=10) of three replicates and the same letters after averages are not significantly different at $p<0.05$ (DMR test).

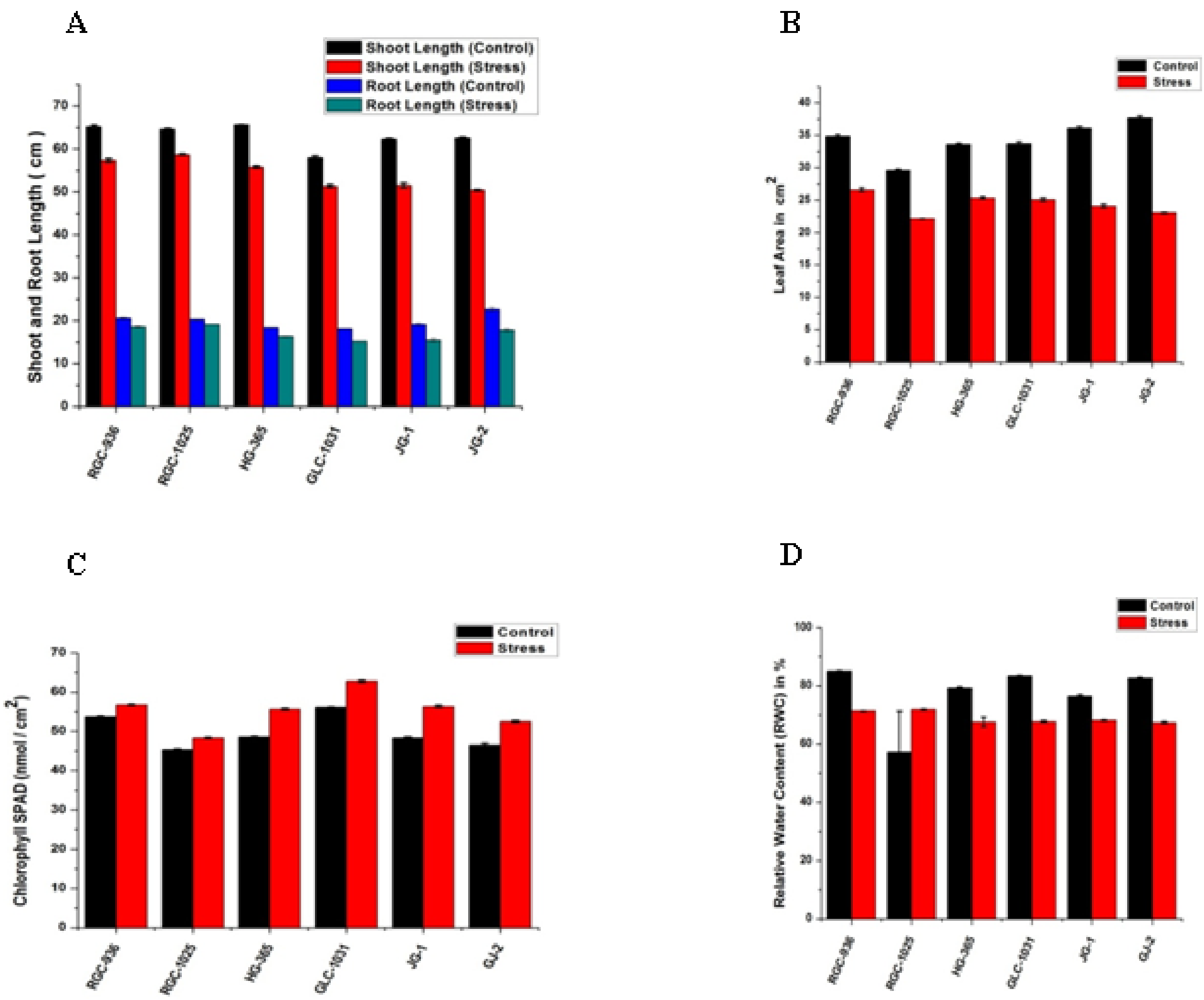

Fig. 1: Effect of drought stress on morphological and physiological Parameters in six cluster bean genotype at pod-filling stage along with their respective controls; A) Shoot and root growth in cm, B) Leaf area in cm C) Relative water content (R.W.C) in%, D) Chlorophyll content with SPAD Meter reading in nmol/cm^2

In our present study RWC was decreased under lower condition of soil moisture, but in high P uptake will be enhanced the RWC in drought resistant cluster bean genotype of RGC-936 (table 2) was reported in cluster bean [10], pigeon pea and chickpea. Phosphorus increased RWC under stress in wheat and cherry. Phosphorus increased RWC under stress in wheat and cherry.

Drought affects plant growth through water deficit, K+ is important for maintaining the turgor pressure in plants under water stress. In plants coping with drought stress, the accumulation of K+ may be more important adjustment phase, because osmotic adjustment through ion uptake like K+ is more energy efficient. In our present study potassium levels are high in controlled plants than in treated plants [11]. In our results it is observed that in water stressed plants generally the potassium levels are low. These results in confirmation with reduced levels of potassium in banana under drought condition, in olive. But when it is compared the potassium levels in the susceptible genotypes (Table 1) and drought resistant genotypes (Table 2) the high potassium levels are observed in drought genotypes (Table 1). The results are agreement with studies of potassium application in Maize and Potato to with stand water stress the underlying mechanism for maintaining adequate tissue K+ levels under draught stress seems to be dependent upon selective K+ uptake and selective cellular and distribution of potassium in the shoots [12].

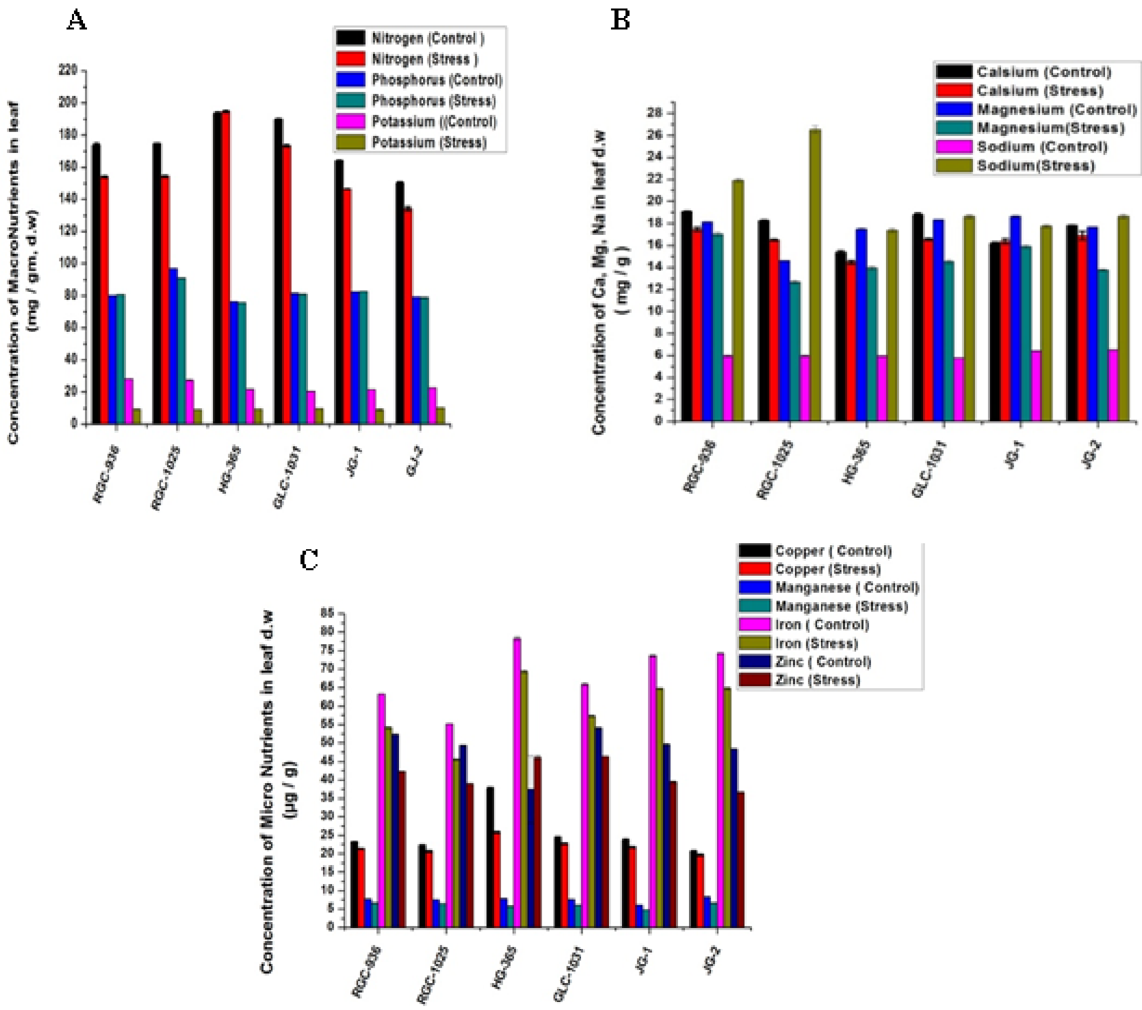

Fig. 2: Effect of drought stress Elemental profile in six cluster bean genotype leaves at pod-filling stage along with their respective controls A) Nitrogen (N),Phosphorous (P) , Potassium (K) B) Calcium Ca, Magnesium (Mg), Sodium

The distribution of Ca2+ in the roots and shoots decreased in the drought-sensitive cluster bean genotypes i.e. JG-2 than the drought resistant genotype i.e. RGC-936, RGC-1025 (Table 1) suggesting that the ability of plants to retain Ca2+ is associated with their drought resistance. The major function of magnesium is the role of as the central atom of chlorophyll molecules; it is also involved conservation and conversion [13]. In our study as like that of calcium, magnesium in roots and shoots decreased slightly in the drought-sensitive cluster bean genotypes i.e.JG-1 than the drought resistant genotypes i.e. RGC 936 and RGC 1025.

Thus, more research should focus on alternative strategies of increasing plant resistance to drought including the use of the genetic potential for conventional breeding and/or molecular technologies to introduce appropriate genes and regulatory systems. In our study Mn deficiency is high in susceptible cluster bean genotypes (Table 1). Low moisture in the soil can induce Mn deficiency. The conversion of Mn to reduce and more soluble forms is increased in moist soil conditions.

Availability of zinc might have stimulated the metabolic and enzymes activity thereby increasing the plant growth parameters. Zinc involved in much metabolic process carbohydrate protein synthesis, auxins synthesis impact on water relation and stomata conductance. Zinc (Zn) and iron (Fe) accumulation rate and deficiency depend on factors plant species, genotype high soil PH, low organic matter, climate and agronomic practice these are influence factors on crop yield in semi arid regions and arid regions. Our experimental study Zinc deficiency is high in susceptible genotypes.

Iron accumulation or deficiency influences on crop yield. In Drought conditions, increase in Fe reduction because of anaerobic conditions oxygen is depleted in a saturated soil, Fe3+ is reduced to the most available Fe2+ form for the plant. As the soil dries and the oxygen concentration increases, Fe is oxidized to the insoluble ferric form [14]. In our experiment copper content in aerial port is reduced in susceptible genotype s than in the resistant genotypes. There is evidence that Cu is reduced during plant uptake during drought [15]. Although micro nutrient deviancies are very common in aired regions scanty information is available to the effect of drought on copper uptake and distribution. In our study the sodium content high in drought induced cluster bean genotype than the controlled plants. In JG-2, Jg-1 are the sodium levels are high when comparing to other varieties such as RGC-1025, RGC-936 and HG-365. In JG-2 and JG-1the sodium levels are attributed that sodium stimulates growth by enhanced cell expansion and a substitute role for potassium as on osmolitically solute and in Chromium induced plants an increase in sodium content in leaves, stem and root of cluster [16].

CONCLUSION

Mineral nutrients play a vital role in the synthesis of essential organic molecule such amino acids. Nutrient imbalance effect many metabolic functions. Drought disturbs mineral nutrient content in plants their by inhibits plant growth and development such as leaf area, root and shoot lengths which altimetry effect at pod-filling stage in cluster bean. In the present study drought reduces mass flow mineral nutrient uptake and trans location from root to the shoot which altimetry affect the metabolic process in physiology. More attention needs to given for the studies addressing the effect of drought in macro nutrient and micro nutrients at gene level and by plant breeding pogrom.

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REFERENCES

[1] Sundara Rao, V.V.B. 1973. A field experiment on nitrogen fixation by modulated legumes. Plant and Soil, Special volume. 287-291.

[2] Castaneda-Saucedo MC, Crdova-Tellez L, GonzalezHernandez VA, Delgado-Alvarado A, Santacruz-Varela A, Garcia-de los Santos G (2009) Physiological performance, yield, and quality of dry bean seeds under drought stress. Interciencia. 34:748-754.

[3] Fageria NK, Barbosa Filho MP, Moreira A 2008. Screening upland rice genotypes for manganese-use efficiency. Commun Soil Sci Plant. 39:2873-2882.

[4] Fageria NK, Baligar VC, Moreira A, Portes TA 2010. Dry bean genotypes evaluation for growth, yield components and phosphorus use efficiency. J Plant Nutr. 33:2167-2181.

[5] Rahman, M. M., M. M. H. Bhuiyan, G. N. C. Sutradhar, M.M. Rahman and A.K. Paul 2008. Effect of phosphorus, molybdenum and rhizobium inoculation on yield and yield attributes of mungbean. Int. J. Sustain. Crop Prod. 3:26-3.

[6] Champagnol F 1979. Relationships between phosphate nutrition of plants and salt toxicity, Phosphorus Agri. C. 76: 35-43.

[7] Gutiérrez-boem, F.H. and G.W. Thomas. 1998. Phosphorus nutrition affects wheat response to water deficit. Agron. J. 90:166–171.

[8] Gutiérrez-boem, F.H. and G.W. Thomas. 1999. Phosphorus nutrition and water deficits in field grown soybean. Plant Soil 207:87–92.

[9] Faye, I., Diouf, O., Guissé, A., Sene, M., Diallo, N., 2006. Characterizing root responses to low phosphorus in pearl millet [Pennisetum glaucum (L.) R. Br. Agron. J. 98, 1187–1194.

[10] Kuhad, M.S. and I.S. Sheoran. 1986. Physiological and biochemical changes in cluster bean (Cyamopsis tetragonoloba L) genotypes under water stress. Ind. J. Plant Physiol., 29, 46-52.

[11] Reager, M.L., Choudhary, G.R. and Dahama, A.K. 2003. Effect of weed control and phosphorus on growth and quality of cluster bean [Cyamopsis tetragonoloba (L.) Taub. Ann. Agric. Res. New Series, 24 (3): 563-566.

[12] Giller, K. E. and G. Cadisch 1995. Future benefits from biological nitrogen fixation: An ecological approach to agriculture. Plant Soil. 174: 255- 277.

[13] Shivran, A.C, Khangarot, S.S, Shivran, P.L. and Gora, D.R. 1996. Response of cluster bean [Cyamopsis tetragonoloba (L.) Taub] varieties to sulphur and phosphorus. Indian Journal of Agronomy, 41 (2): 340-342.
[14] Tripathi, H.C., Singh, R.S. and Mishra, V.K. 1997. Effect of S and zinc nutrition on yield and quality of chickpea (Cicer arietinum L.). Journal Indian Society of Soil Science, 45 (1): 123-12.
[15] Yruela, I. (2005) Copper in Plants. Brazilian Journal of Plant Physiology, 17, 145-156.
[16] Blair MW, Gonzalez LF, Kiwanis PM, Butare L 2010. Genetic diversity, inter-gene pool introgression and nutritional quality of common beans (Phaseolus vulgaris L.) from central Africa. Theor Appl Genet. 121:237-248.

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