INTERNATIONAL JOURNAL OF APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY

www.ijabpt.com ISSN : 0976-4550

Volume-6, Issue-2, April-June-2015 Coden IJABFP-CAS-USA Copyrights@2015

Received: 10th Feb-2015 *Revised: 1st Mar-2015* *Accepted: 3rd Mar-2015*

Research article

EFFECT OF FOLIAR NUTRITION ON WATER POTENTIAL, PHOTOSYNTHETIC RATE, DRY MATTER PRODUCTION AND YIELD OF MUNG BEAN UNDER RECEDING SOIL MOISTURE CONDITION

D. Siva Nageswara Rao, Dr. T.C.M. Naidu, Dr. Y. AShoka Rani

Department of Crop Physiology, Agricultural College, Bapatla – 522 101, A.P.

ABSTRACT: A field experiment was conducted during *Rabi* season of 2012-13 at Regional Agricultural Research Station, Lam, Guntur, with an aim to find out the effect of foliar nutrition on water potential, photosynthetic rate, dry matter production and yield of mung bean under receding soil moisture conditions in split plot design with irrigation and no irrigation as main treatments and foliar sprays as sub treatments. Under receding soil moisture condition (moisture stress) KNO_3 @ 1% proved superior over other foliar sprays by recording more plant height, leaf area, shoot dry weight, and photosynthetic rate by maintaining high chlorophyll content, high proline and high leaf water potential. KNO_3 @ 1% gave higher yields under receding soil moisture condition compared to other foliar sprays. Under irrigated conditions urea @ 2% recorded higher yield. Among all treatments controlled (no spray) under unirrigated conditions recorded lower yields due to moisture stress and nutrient deficiency.
Key words: Receding soil moisture, Foliar spray, water potential, KNO_3, Black gram,

INTRODUCTION

Pulses provide rich and cheap source of protein, particularly to the vegetarians and the poor, who constitute the bulk population in India. They contain 30 per cent of proteins, which are nearly three times as much as cereals.

Black gram (*Vigna mungo* (L.) Hepper) is the fourth important pulse crop in India and second most important in Andhra Pradesh in terms of extent of cultivation. Seasonal variability in available moisture is the major constraint to production under rained farming. The erratic and low rainfall along with high temperature in the rainfed farming induces periods of water stress during crop growth. Thus the ability of the crop to grow and yield in such environments depends upon the relative performance of cultivars under drought. In A.P state black gram is grown during *rabi* under receding soil moisture conditions without any irrigation. As a result there was water deficit for the crop at critical stages, which affects the nutrient uptake, ultimately causing yield reduction. To increase the yield during drought conditions we have to take into consideration not only the normalization of plant water regime, but also the normalization of plant feeding and elimination of created deficiencies of some elements. A suitable way of plant feeding during and after drought is through foliar nutrition. Keeping this in view an investigation was carried to know the response of black gram to foliar nutrition under receding soil moisture condition.

MATERIAL AND METHODS

Black gram seeds of PU 31 variety were sown in black cotton soils on October 2012 at RARS, LAM, Guntur. The average temperature during the crop period varied from 31.7 ^{o}C and 18.9 ^{o}C. The total amount of rainfall received during the crop duration was 215.7mm. Average relative humidity was 94.2% to 57.2%. Sowing was done with a spacing of 30 cm x 10 cm in 3m x4m (12m^2) plot. The experiment was arranged as split plot design with three replications keeping irrigation (M_1) and unirrigation (M_2) as main plots and foliar spray of KNO_3 @ 1%, Urea @ 2%, DAP @ 2%, K_2SO_4 @ 1%, Triacontanol @ 1 ppm, water spray and control (no spray) as subplots. Nitrogen and phosphorus fertilizers were applied as per the recommendation (20 kg N and 50 kg P_2O_5 ha^{-1}) before sowing of the crop. Experimental plots were protected from pest and diseases by spraying of Monocrotophos @ 2 ml l^{-1} at the initial stage of the crop growth. Manual weeding was done at 15 days interval up to pod setting. Supplemental irrigation for irrigated main plot was given at 33 DAS and for unirrigated main plot was maintained without any irrigation. Soil moisture percent was measured in both irrigated and unirrigated main treatments. Foliar spray was done at flowering and pod initiation stages.

Leaf area and shoot dry weight ware measured by destructive growth analysis. Total leaf area per plant (cm^2) was measured at regular time intervals by using LI-COR LI-3100C leaf area meter. Water potential of leaves was measured by using WESCOR's water potential system (PSΨPRO). Photosynthetic rate of leaves was measured by using LI-COR LI-6400XT portable photosynthetic system. Soil moisture was measured at 10, 20 30 and 60 cm depth using profile probe type PR2 and soil moisture meter type HM2 of Delta-T devices at weekly intervals from 25 DAS to 61 DAS.

Total chlorophyll

The chlorophyll content in leaves was estimated after imposition of treatments for both irrigated and unirrigated conditions calorimetrically by DMSO method of Ronen and Galun (1984). The leaf samples were collected and surface was cleaned and made into small pieces. The sample weighing 500 mg was immersed in 5 ml of pure DMSO for 2 hours in room temperature. The optical densities were measured at 652 nm wavelengths by using UV-Vis spectrophotometer and total chlorophyll content were calculated according to following formula.

$$\text{Total chlorophyll} = \left(\frac{\text{D652 x 1000}}{34.5}\right) \text{x} \frac{V}{\text{1000 x W}} \text{mg g}^{-1}$$

Where V is volume of DMSO and W is weight of leaf material taken.

D652 = Absorbance of extract at 652 nm

Yield and its components such as number of pods per plant and test weight (100 seed weight) were measured at harvesting stage. The experimental data were analysed statistically by the method of analysis of variance procedure as suggested by Panse and sukhatme (1978). Statistical significance was tested by 'F' value at 5 per cent level of probability. Critical difference at 5 per cent was workedout.

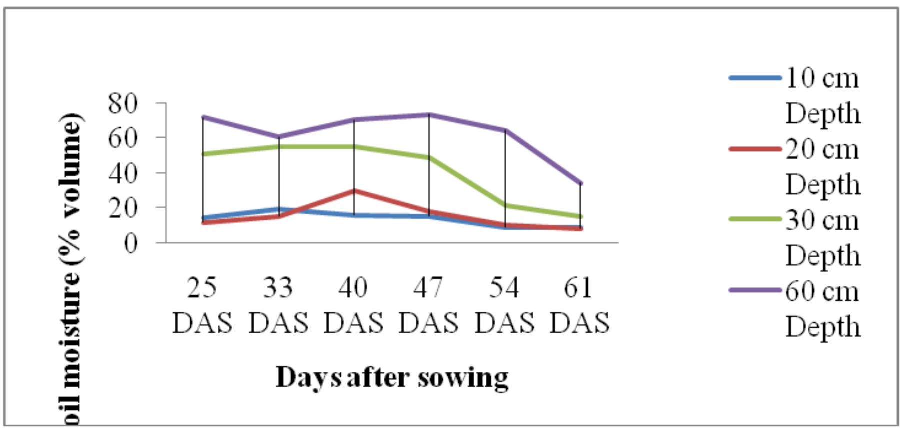

Figure-1: Soil moisture (% volume) under irrigated condition

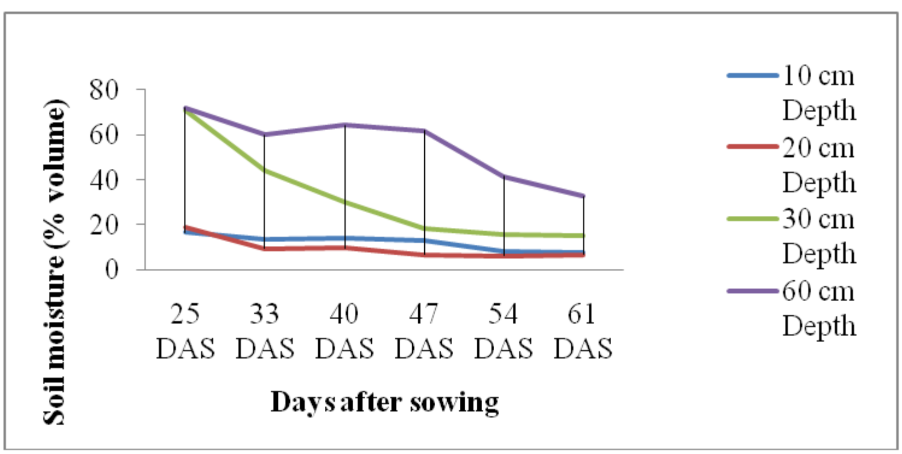

Figure-2: Soil moisture (% volume) under unirrigated condition

Under unirrigated condition lower soil moisture per cent was observed at 20 cm soil depth where maximum roots were located and it decreased gradually from 18.7 (% volume) to 6.8 (% volume). Under irrigated condition lower soil moisture per cent was observed at 10cm and 20 cm soil depth where maximum roots are present. But, soil moisture per cent at 10cm and 20 cm soil depth was more when compared with unirrigated conditions. The mean soil moisture per cent at 10cm and 20 cm soil depth under unirrigated condition was 12.38 (% volume) and 9.67 (% volume) respectively. Under irrigated condition mean soil moisture per cent at 10cm and 20 cm soil depth was 13.94 (% volume) and 15.45 (% volume) respectively (Figures-1 and 2).

RESULTS AND DISCUSSIONS

Plant height (cm), Leaf area (cm^2 plant^{-1}), Shoot dry weight (g pant^{-1})

The data on the influence of application of foliar chemicals on plant height, leaf area and shoot dry weight of black gram are presented in table number one. All these three parameters shows a significant difference among main plots and subplots.

Plant height after foliar spray under irrigated condition was 19.55 cm and under unirrigated condition it was 17.43 cm. Reduction in plant height due to drought after foliar spray was 10.84 %. Reduction in plant height was due to diversion of assimilates from stem and utilised them for increased root growth in order increase the water absorption. The results of reduction in plant height due to drought ware in conformity with Ali *et al*. (2011) in maize and Bardhan *et al*. (2007) in chickpea. Among interactions under irrigated conditions foliar spray of urea @ 2% recorded highest plant height (21.29 cm) and under unirrigated condition, foliar spray of KNO_3 @ 1% recorded significantly higher plant height (19.45 cm) which is on par with K_2SO_4 @ 1% and urea spray @ 2% . Increase in plant height was due to availability of Nitrogen and potassium to plants through foliar spray. Potassium regulates the osmotic turgor of cells and water balance which is driving force for cell division and elongation (Bardhan *et al*., 2007). Similar results of increase in plant height due to foliar nutrition of KNO_3 and potassium solution during drought was revealed by Bardhan *et al.* (2007) in chickpea and Besma *et al*. (2011) in potato respectively. Leaf area after foliar spray under irrigated condition was 441.03 cm^2 per plant and under unirrigated condition leaf area was 383.50 cm^2 per plant. The decrease in leaf area due to drought was 13.04 % after foliar spray because of drought stress. The results of reduced leaf area in water stressed plants was due to accelerated senescence and low turgor potentials which is driving force for cell division and cell elongation. Similar results of decrease in leaf area due to drought was revealed by Ali *et al.* (2011) in maize and Maiti *et al*. (2000) in various crops. Among interactions under irrigated condition urea spray @ 2% recorded highest leaf area (520.83 cm^2 plant^{-1}) and in unirrigated condition KNO_3 @ 1% recorded highest leaf area (412.5 cm^2 plant^{-1}). Lower leaf area was recorded by control (338.83 cm^2 plant^{-1}). Potassium is essential to obtain maximum leaf extension and stem elongation. Potassium regulates the osmotic turgor of cells and water balance which is driving force for cell division and elongation. A similar result of increase in leaf area due to foliar spray of potassium was reported by Besma *et al*. (2011) in potato. Regarding shoot dry weight under irrigated condition it was 3.86 g per plant and under unirrigated condition shoot dry weight was 3.39 g per plant. The decrease in shoot dry weight due to drought, after foliar spray was 12.18 %. Reduction in shoot dry weight under drought was due to reduced shoot growth, reduced leaf area, number of leaves, plant height and increased senescence. Similar results of decrease in shoot dry weight due to drought was revealed by Ali *et al.* (2011) in maize and Abdullahil *et al*. (2006) in wheat. Among interactions irrigated condition urea spray @ 2% recorded significantly higher shoot dry weight (4.83 g plant^{-1}) and under unirrigated condition KNO_3 @ 1% recorded higher shoot dry weight (3.77 g plant^{-1}) which is on par with K_2SO_4 @ 1% . Lower shoot dry weight was recorded by control (2.84 g plant^{-1}). KNO_3 marginally delayed the flowering. Delay in flowering would facilitate whole dry matter production. So foliar application of KNO_3 contribute in dry matter production (up to some extent) as indicated by delayed flowering (Bardhan *et al.*, 2007). Similar results of increase in shoot dry weight due to foliar spray of potassium under drought conditions was reported by Abdullahil *et al*. (2006) in wheat and Bardhan *et al.* (2007) in chickpea.

Water potential (Mpa)

Water potential was significantly decreased under unirrigated condition when compared with irrigated condition after foliar spray. After foliar spray under irrigated condition water potential was -1.56 MPa and under unirrigated condition it was -1.97 MPa. The reduction in water potential after foliar spray was 26.28 % because of drought. Decrease in water potential due to drought was due to excessive water loss through transpiration which is required to reduce leaf temperature Ali *et al.* (2011) in mungbean. Similar results of reduction in water potential due to drought was reported by Krouma (2010) in chickpea, Makbul *et al*. (2011) in soybean. Among interactions, under unirrigated condition KNO_3 spray @ 1% recorded significantly higher water potential (-1.81 MPa). Lower water potential was recorded by control (-2.34 MPa). Similar results of increase in water potential due to potassium spray under drought conditions was reported by sharma *et al*. (1993) in brassica and Sudam singh *et al*. (1998) in sugar cane. Among interactions, under irrigated condition KNO_3 @ 1% spray recorded significantly higher water potential (-1.29 MPa).

Table-1: Effect of foliar nutrition on plant height, leaf area and shoot dry weight under receding soil moisture conditions.

Treatments	Plant height (Cm)			Leaf area (cm^2 per plant)			Shoot dry weight (g per plant)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
KNO_3 @ 1%	20.97	19.45	20.21	486.10	412.50	449.30	4.13	3.77	3.95
Urea @ 2%	21.29	18.80	20.04	520.83	408.07	464.45	4.83	3.61	4.22
DAP@ 2%	19.70	17.44	18.57	473.19	387.57	430.38	4.00	3.40	3.70
K_2SO_4 @ 1%	20.46	19.14	19.80	437.60	390.93	414.27	4.07	3.65	3.86
Tricantanol @ 1 ppm	20.00	18.16	19.08	444.95	391.60	418.28	3.70	3.38	3.54
Water	17.87	15.27	16.57	378.53	354.97	366.75	3.35	3.10	3.23
No spray	16.54	13.71	15.13	345.97	338.83	342.40	2.93	2.84	2.89
Mean	19.55	17.43		441.03	383.50		3.86	3.39	
	SEM ±	CD	CV%	SEM±	CD	CV%	SEM ±	CD	CV%
Main plot	0.08	0.49	8.62	0.84	5.10	18.91	0.07	0.41	16.22
Sub plot	0.27	0.80	15.57	1.27	3.70	15.27	0.63	0.18	8.05
Interaction M x S	0.39	1.13		1.79	5.22		0.09	0.26	

M_1 = Irrigation M_2 = Unirrigation S x M = Sub plot means at fixed level of main plots

Table-2: Effect of foliar nutrition on water potential, Photosynthetic rate and Protein content under receding soil moisture conditions.

Treatments	Water potential (MPa)			Photosynthetic rate (µmol m^{-2} s^{-1} CO_2)			Total protein content (mg/g FW)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
KNO_3 @ 1%	-1.29	-1.81	-1.55	41.96	39.63	40.80	42.53	34.00	38.27
Urea @ 2%	-1.55	-1.91	-1.73	43.94	38.24	41.09	41.87	34.87	38.37
DAP@ 2%	-1.49	-1.94	-1.71	42.31	35.41	38.86	39.10	32.27	35.68
K_2SO_4 @ 1%	-1.33	-1.83	-1.58	41.28	39.22	40.25	39.43	31.37	35.40
Tricantanol @ 1 ppm	-1.68	-1.80	-1.74	40.88	35.75	38.32	40.97	33.30	37.13
Water	-1.72	-2.17	-1.94	35.76	34.43	35.10	38.33	28.30	33.32
No spray	-1.90	-2.34	-2.12	33.45	29.48	31.47	35.67	27.87	31.77
Mean	-1.56	-1.97		39.94	36.02		39.70	31.71	
	SEM ±	CD	CV%	SEM ±	CD	CV%	SEM ±	CD @5%	CV%
Main plot	0.03	0.15	8.48	0.14	0.84	10.27	0.06	0.36	4.50
Sub plot	0.02	0.06	3.82	0.32	0.94	12.86	0.13	0.37	5.18
Interaction M x S	0.03	0.09		0.46	1.34		0.18	0.52	

M_1 = Irrigation M_2 = Unirrigation S x M = Sub plot means at fixed level of main plots

Photosynthetic rate (µmol CO_2 m^{-2} s^{-1})

Photosynthetic rate under unirrigated conditions decreased significantly when compared with irrigated conditions. Under unirrigated condition photosynthetic rate was 36.02 µmol CO_2 m^{-2} s^{-1} and under irrigated condition it was 39.94 µmol CO_2 m^{-2} s^{-1}. The decrease in photosynthetic rate was 9.81 %. Reduction in photosynthetic rate by drought stress is due to stomatal (stomatal closure) and nonstomatal (impairments of metabolic processes) factors (Mafakheri *et al*., 2010). Photosynthesis can be inhibited even when the stomatal influence is eliminated (leaf discs without epidermis), suggesting that factors other than low CO_2 availability affect photosynthesis under drought conditions (Tang *et al*., 2002). Similar results of decrease in photosynthetic rate due to drought was reported in mungbean (Moradi *et al*., 2008), in tobacco (Rizhsky *et al*., 2002) and in chickpea (Krouma, 2010).

Table-3: Effect of foliar nutrition on proline content, total chlorophyll content and yield under receding soil moisture conditions.

Treatments	Total chlorophyll (mg/g FW)			Proline content (µg/g FW)			Grain yield (kg/ha)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
KNO_3 @ 1%	1.155	1.116	1.135	3.25	5.64	4.45	770.27	604.02	687.15
Urea @ 2%	1.183	0.964	1.074	2.90	4.51	3.71	792.17	585.30	688.73
DAP@ 2%	1.126	0.920	1.023	3.03	5.08	4.05	755.92	569.91	662.92
K_2SO_4 @ 1%	1.097	0.921	1.009	3.20	5.35	4.28	714.77	577.82	646.29
Tricantanol @ 1 ppm	1.052	0.888	0.970	2.45	5.26	3.86	663.87	518.27	591.07
Water	1.001	0.827	0.914	2.84	5.00	3.92	643.50	492.77	568.13
No spray	0.952	0.748	0.850	3.02	5.26	4.14	609.00	490.93	549.97
Mean	1.081	0.912		2.955	5.158		707.07	548.43	
	SEM ±	CD@5%	CV%	SEM ±	CD	CV%	SEM ±	CD	CV%
Main plot	0.008	0.046	3.49	0.01	0.07	2.53	1.22	7.45	22.39
Sub plot	0.025	0.074	6.18	0.04	0.11	4.45	1.54	4.50	15.07
Interaction M x S	0.036	NS		0.05	0.15		770.27	604.02	687.15

M_1 = Irrigation M_2 = Unirrigation S x M = Sub plot means at fixed level of main plots

Under unirrigated conditions all treatments showed significant increase in photosynthetic rate when compared with control. KNO_3 @ 1% spray recorded maximum photosynthetic rate (39.63 µmol CO_2 m^{-2} s^{-1}) and lower photosynthetic rate was recorded by control (29.48 µmol CO_2 m^{-2} s^{-1}). The reason for the enhanced need for K by plants suffering from environmental stress like drought appears to be related to the fact that K is required for maintenance of photosynthetic CO_2 fixation. Drought stress is associated with stomatal closure and thereby with decreased CO_2 fixation. Formation of ROS is intensified because of inhibited CO_2 reduction by drought stress. Obviously, formation of ROS under drought stress would be dramatic in plants exposed to high light intensity, with concomitant severe oxidative damage to chloroplasts. Increase in ROS production in drought-stressed plants is well known and related to impairment in photosynthesis and associated disturbances in carbohydrate metabolism (Cakmak, 2005). Under irrigated conditions all treatments showed significant increase in photosynthetic rate when compared with control. Urea @ 1% spray recorded maximum photosynthetic rate (43.94 µmol CO_2 m^{-2} s^{-1}).

Total chlorophyll content (mg g^{-1} FW)

Regarding total chlorophyll content there was no significant difference among the interactions. Total chlorophyll content showed a significant decrease under unirrigated condition when compared with irrigated condition. After foliar spray under irrigated condition total chlorophyll content was 1.081 mg g^{-1} FW and under unirrigated condition it was 0.912 mg g^{-1} FW. The decrease in total chlorophyll content due to drought after foliar spray was 15.63 %. Water deficit result in pigment damage in leaves. The decrease in chlorophyll content under water deficit is due to production of ROS such as 0_2^- and H_2O_2, which leads to lipid peroxidation and consequently result in chlorophyll destruction (Arjenaki *et al*., 2012). Similar results of decrease in total chlorophyll content during drought was reported by Suriyan *et al*. (2010) in rice, Mafakheri *et al*. (2010) in chickpea, Makbul *et al*. (2011) in soybean and Salekjalali *et al*. (2012) in barley.

Among interactions under unirrigated condition KNO_3 @ 1% recorded higher total chlorophyll content (1.116 mg g^{-1} FW) and lower total chlorophyll content was observed in control (0.742 mg g^{-1} FW). Under irrigated condition urea @ 2% recorded higher total chlorophyll content (1.183 mg g^{-1} FW) and lower total chlorophyll content was observed in control (0.952 mg g^{-1} FW). Addition of foliar spray like urea (or) KNO_3 increases the leaf nitrogen content. As 'N' is essential for chlorophyll synthesis, increase in leaf nitrogen content result in increase in chlorophyll content (Yildirim *et al*., 2007). Similar results of increase in total chlorophyll content due to foliar spray of KNO_3 or urea was reported by Sritharan *et al*. (2005) in mungbean, Kaur and Jagetiya (2005) in soybean and verma *et al*. (2009) in chickpea.

Proline content (µg g^{-1} FW)

Total proline content showed a significant increase under unirrigated condition when compared with irrigated condition. After foliar spray under irrigated condition total proline content was 2.96 µg g^{-1} FW and under unirrigated condition it was 5.16 µg g^{-1} FW.

The increase in total proline content due to drought after foliar spray was 74.32 %. Accumulation of proline in plants under stress is a result of the reciprocal regulation of two pathways i.e., increased expression of proline synthesis enzymes and repressed activity of proline degradation. This leads to a "proline cycle", the homeostasis of which depends on the physiological state of tissue (Mohammadkhani and Heidari, 2008) in maize. Proline accumulation is a mechanism for plants adaptation to abiotic stress conditions. Other roles for proline have been proposed, including stabilization of macromolecules, a sink for excess reductant and a store of carbon and nitrogen for use after relief of water deficit in mungbean (Thalooth *et al*., 2006). Similar results of increase in proline content during drought was reported by Mafakheri *et al*. (2010) in chickpea and Maiti *et al*. (2000) in various crops. Under unirrigated condition KNO_3 @ 1% recorded significantly higher total proline content (5.64 μg g^{-1} FW). Foliar spray of potassium induces proline synthesis during drought and this accumulation of proline might have served as a compatible solute (Besma *et al.,* 2011). Similar results of increase in proline content during drought due to foliar spray of KNO_3 was reported by Thalooth *et al*. (2006) in mungbean. Under irrigated condition foliar spray of KNO_3 @ 1% recorded significantly higher total proline content (3.25 μg g^{-1} FW) which is on par with K_2SO_4 @ 1% (3.20 μg g^{-1} FW).

Protein content (mg g^{-1} FW)

Regarding protein content there was a significant difference among the interactions. Total protein content showed a significant decrease under unirrigated condition when compared with irrigated condition. After foliar spray under irrigated condition total protein content was 39.70 mg g^{-1} FW and under unirrigated condition it was 31.71 mg g^{-1} FW. The decrease in total protein content due to drought after foliar spray was 20.13 %. This reduction in total protein content under drought was due to damage caused by reactive oxygen species (ROS) to proteins (Gabriala *et al.,* 2011). Similar results of decrease in total protein content due to drought was reported by Salekjalali *et al*. (2012) in barley. Among interactions under unirrigated condition, KNO_3 spray @ 1% recorded significantly higher total protein content (34.87 mg g^{-1} FW) followed by urea @ 2% (34.0 mg g^{-1} FW). Lower total protein content was recorded by control (27.87 mg g^{-1} FW). This may be due to presence of high leaf nitrogen content and potassium content by foliar spray. Nitrogen increases the protein synthesis as nitrogen is major element in protein and potassium maintains water balance. Similar results of increase in total protein content due to foliar spray of KNO_3 during drought was reported by Kaur and Jagetiya (2005) in soybean. Under irrigated condition urea spray @ 2%recorded significantly higher total protein content (42.53 mg g^{-1} FW) followed by KNO_3 @ 1% (41.87 mg g^{-1} FW).

Seed yield (kg ha^{-1})

Regarding seed yield there was a significant difference among the interactions. Seed yield showed a significant decrease under unirrigated condition when compared with irrigated condition. Under irrigated condition seed yield was 707.07 kg ha^{-1} and under unirrigated condition it was 548.43 kg ha^{-1}. The decrease in seed yield due to drought was 22.44 %. Similar results of decrease in seed yield due to drought were reported by Talooth *et al*. (2006) in mungbean and Mafakheri *et al*. (2010) in chickpea. Among interactions, under unirrigated condition KNO_3 @ 1% recorded significantly higher seed yield (604.02 kg ha^{-1}). Lower seed yield was observed in control (490.93 kg ha^{-1}). The increase in yield due to KNO_3 @ 1% spray under drought was 23.04 % when compared with control. Similar results of increase in seed yield due to foliar spray of KNO_3 or potassium spray under drought was reported by Jayarami reddy *et al.* (2004) in mungbean, Bardhan *et al*. (2007) in chickpea and Abdullahil *et al.* (2006) in wheat. Under irrigated condition foliar spray of urea @ 2% recorded significantly higher seed yield (792.17 kg ha^{-1}). Similar results of increase in seed yield due to foliar spray of urea under normal irrigated condition was reported by Rajavel *et al.* (2009) in mungbean, Sritharan *et al.* (2005) in mungbean and Bahr (2007) in chickpea.

REFERENCES

Abdullahil, B.Md, Abdul, K.Md., Abdul, H and Hidaka, T. (2006). Effect of fertilizer potassium on growth, yield and nutrient uptake of wheat (*Triticum aestivum*) under water stress conditions. South Pacific Studies. 27 (1): 25-35.

Ali, Z., Basra, S.M.A., Munir, H., Mahmood, A and Yousaf, S. (2011). Mitigation of drought stress in maize by natural and synthetic growth promoters. Journal of Agriculture and Social Sciences. 7(2): 56-62.

Arjenaki, G. F., Jabbari, R and Morshedi, A. (2012). Evaluation of drought stress on relative water content, chlorophyll content and mineral elements of wheat (Triticum aestivum L.) Varieties. International Journal of Agriculture and Crop Sciences. 4 (11): 726-729.

Bardhan, K., Kumar, V and Dhimmar, S.K. (2007). An evaluation of the potentiality of exogenous osmoprotectants mitigating water stress on chickpea. The Journal of Agricultural Sciences. 3(2): 67-74.

Besma, B.D., Denden, M and Aboud, S. (2011). Foliar potassium fertilization and its effects on growth, yield and quality of potato grown under loam-sandy soil and semi-arid conditions. International Journal of Agricultural Research. 6(7): 593-600.

Cakmak, I. (2005). The role of potassium in alleviating detrimental effects of abiotic stresses in plants. Journal of Plant Nutrition and Soil Science. 168: 521–530.

Jayaramireddy, P., Narasimha Rao, K.L., Narasimha Rao, C.L and Mahalaxmi, B.K. (2004). Effect of pre-sowing treatments with growth promoting chemicals and urea on seedling vigour, growth and yield of black gram in rice-fallow ecosystem. Annals of Plant Physiology. 18(2): 108-112.

Kaur, M.J and Jagetiya, B.L. (2005). Evaluation of yields by KNO_3 application in *Glycine max*. *B*ulletin of Pure and Applied Sciences. 24B (1): 51-56.

Khalilzadeh, R., Tajbakhsh, M and Jalilian, J. (2012). Growth characteristics of mung bean (*Vigna radiata* L.) affected by foliar application of urea and bio-organic fertilizers. International Journal of Agriculture and Crop Sciences. 4 (10): 637-642.

Krouma, A. (2010). Plant water relations and photosynthetic activity in three Tunisian chickpea (*Cicer arietinum* L.) genotypes subjected to drought. Turkey Journal of Agriculture. 34: 257-264.

Mafakheri, A., Siosemardeh, A., Bahramnejad, B., Struik, P.C and Sohrabi, Y. (2010). Effect of drought stress on yield, proline and chlorophyll contents in three chickpea cultivars. Australian Journal of Crop Science. 4(8): 580-585.

Maiti, R.K., Moreno-Limon, S and Wesche-Ebeling, P. (2000). Responses of some crops to various abiotic stress factors and its physiological and biochemical basis of resistances. *A*griculture Review. 21 (3): 155-167.

Makbul, S., Guler, N.S., Durmus, N and Guven, S. (2011). Changes in anatomical and physiological parameters of soybean under drought stress. Turkey Journal of Botany. 35: 369-377.

Mohammadkhani, N and Heidari, R. (2008). Drought induced accumulation of soluble sugars and proline in two maize varieties. World Applied Sciences Journal. 3 (3): 448-453.

Moradi, A., Ahmadia, A and Hossain, A.Z. (2008). The effects of different timings and severity of drought stress on gas exchange parameters of mungbean. Desert. 13: 59-66.

Panse, V.G and Sukhatme, P.V. (1978). *Statistical methods for agricultural workers*. Indian council of agricultural research, New Delhi. 187-202.

Rajavel, M and Vincent, S. (2009). Influence of nutrients and hormones on yield maximization of black gram. Journal of Ecobiology. 24(4): 387-394.

Rizhsky, L., Liang, H and Mittler, R. (2002). The combined effect of drought stress and heat shock on gene expression in tobacco. Plant Physiology. 130: 1143–1151.

Ronen, R and Galun, M. (1984). Pigment extraction from lichens with Dimethyl Sulfoxide (DMSO) and estimation of chlorophyll degradation. Environmental and Experimental Botany. 24: 239-245.

Salekjalali, M., Raheem, H and Behboud, J. (2012). Effects of soil water shortages on the activity of antioxidant enzymes and the contents of chlorophylls and proteins in barley. American-Eurasian Journal of Agriculture and Environmental Science. 12 (1): 57-63.

Sharma, K.D., Kuhad, N.S and Nandwal, A.S. (1993). Influence of K nutrition on Brassica genotypes in response to water stress. Plant Physiology and Biochemistry. 19(2): 110-115.

Sritharan, N., Anitha, A and Mallika, V. (2005). Effect of foliar spray of nutrients and plant growth regulators (PGRs) for yield maximization in black gram. Medras Agricultural Journal. 92 (4-6): 301-307.

Sudamasingh, Tiwari T. N., Srivastava, R. P and Singh, G. P. (1998). Effect of K on stomatal behaviour, yield and juice quality under moisture stress conditions. Indian Journal of Plant Physiology. 3(4): 303-305.

Suriyan, C., Suravoot, Y and Kanyaratt S. (2010). Water deficit stress in the reproductive stage of four indica rice (*Oryza* sativa L.) genotypes. Pakistan Journal of Botany. 42(5): 3387-3398.

Tang, A.C., Kawamitsu, Y., Kanechi, M and Boyer, J.S. (2002). Photosynthetic oxygen evolution at low water potential in leaf discs lacking an epidermis. Annals of Botany. 89: 861-870.

Thalooth, A.T., Tawfik, M.M and Magda Mohamed, H. (2006). A comparative study on the effect of foliar application of zinc, potassium and magnesium on growth, yield and some chemical constituents of mungbean plants grown under water stress conditions. World Journal of Agricultural Sciences 2 (1): 37-46.

Verma, C.B., Yadav, R.S., Singh, I. J and Singh, A. K. (2009). Physiological traits and productivity of rainfed chickpea in relation to urea spray and genotypes. Legume Research. 32 (1) : 103-107.

Yildirim, E., Guvenc, I., Turan, M and Karatas, A. (2007). Effect of foliar urea application on quality, growth, mineral uptake and yield of broccoli (*Brassica oleracea* L. var. *italica*). Plant Soil Environment. 53 (3): 120–128.

ISSN : 0976-4550

INTERNATIONAL JOURNAL OF APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY

Email : ijabpt@gmail.com

Website: www.ijabpt.com