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Influence of Zinc Nutrition on Total Dry Matter, Yield Parammeters and Yield of Chickpea (*Cicer arietinum* L.)

M Karthik, K Jayalalitha, B Sreekanth and Ch Sujani Rao
Department of Crop Physiology, Agricultural College, Bapatla, A. P.

ABSTRACT

A field experiment was conducted during *rabi* season of 2020-21 at Agricultural College Farm, Bapatla to study influence of zinc nutrition on total dry matter, yield and yield attributes of chickpea under heat stress. The experiment was laid out in split plot design with three main treatments *i.e.*, three dates of chickpea sowing *viz.*, normal sowing (sown on November 10^{th} - (M_1)), moderately delayed sowing (sown on November 30^{th} - (M_2)) and late sowing (December 20^{th} - (M_3)) to expose the crop to late sowing induced heat stress during flowering and pod formation stages and four sub treatments *viz.*, no zinc application (control – S_0), foliar spray of $ZnSO_4$. H_2O @ 0.2 % (S_1), Zn-EDTA @ 0.3 % (S_2) and $ZnSO_4$. $7H_2O$ @ 0.5 % (S_3) at pre flowering and pod formation stages in three replications. The results showed that late sown chickpea crop decreased total dry matter, number of pods plant^{-1}, test weight and seed yield by 26.5, 14.1, 12.6, 5.5 and 17.6 per cent, respectively, over normal sown crop. Foliar spray of $ZnSO_4$. $7H_2O$ @ 0.5 % at pre flowering and pod formation stages increased the total dry matter, the number of pods plant^{-1}, test weight and seed yield by 21.8, 17.3, 26.0, 3.4 and 42.6 per cent, over the untreated plants. Normal sown crop sprayed with $ZnSO_4$. $7H_2O$ @ 0.5 % at pre flowering and pod formation stages (M_1S_3) recorded the highest mean values above parameters and the lowest mean values were recorded by the late sown crop with no zinc application (M_3S_0).

Keywords: *Chickpea, Dry matter, Yield and Zinc Nutrition.*

Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and ranks 3rd in production globally, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). It is grown in more than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in America and 0.4% in Europe). India is the largest chickpea producing country accounting for 64% of the global chickpea production. The other major chickpea producing countries include Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico and Iraq. India tops the chickpea production with 11.38 million tonnes in the world followed by Australia (0.99 million tonnes) (FAOSTAT, 2018). In India, chickpea is grown in an area of 1.056 million hectares with a production of 11.379 million tonnes and a productivity of 1,078 kg ha^{-1}. In Andhra Pradesh, it is cultivated in an area of 0.52 million hectares with a production of 0.59 million tonne and productivity of 1,132 g ha^{-1} (Ministry of Agriculture, 2017-18).

Most of the chickpea growing regions experiences ≥ 30°C during the reproductive period. Flowering and pod formation stages in chickpea are known to be very sensitive to changes in external environment, and exposure to heat stress at this stage leads to reduction in seed yield (Summerfield *et al.*, 1984). Seed yield is reduced by high temperature ($\geq$ 30°C) during flowering and pod development. Major reduction in the seed yield after brief episodes of high temperature (30-35°C) during seed filling can diminish seed set, seed weight and accelerates senescence and reduces the yield (Siddique and Loss, 1999).

Zinc is involved in a wide range of physiological processes within the plant cell and several of these are also associated with tolerance to high temperature stress. Zinc nutrition activates the enzymes involved in carbohydrate metabolism, maintenance of integrity of cellular membranes and protein synthesis as well as being an important factor in a plant's defense against reactive oxygen species which proliferate under various stress conditions, including heat stress (Cakmak *et al*., 1997). This suggests that adequate zinc nutrition may be important for maintaining plant productivity in high temperature environments. The present study was taken up to investigate the influence of zinc nutrition on total dry matter, yield parameters and yield of chickpea (*Cicer arietinum* L.) under heat stress.

MATERIAL AND METHODS

The experiment was conducted during *Rabi*, 2020-21 at Agricultural college farm, Bapatla. The soil of the experimental field was clay in texture, acidic in reaction (7.42) with organic carbon (0.2 %), available nitrogen (210.6 kg ha^{-1}), phosphorus (49.7 kg ha^{-1}), available potassium (310.4 kg ha^{-1}) and zinc (1.80 ppm). The experiment was laid out in a Split Plot Design, replicated thrice with a plot size of 4 m x 3 m and the row spacing of 30 cm and intra row spacing of 10 cm. Sowing was done by dibbling and recommended dose of fertilizers were applied and manual weeding was done to raise a healthy crop. the main plots (Treatments) received three dates of sowing *viz.,* November 10th (normal sowing) (M_1), November 30th (moderately sowing) (M_2) and December 20th (delayed sowing) (M_3) and sub treatments consisted of foliar application of different zinc sources *i.e.,* foliar spray of $ZnSO_4$. H_2O @ 0.2 % (S_3), Zn-EDTA @ 0.3 % (S_2) and $ZnSO_4$. $7H_2O$ @ 0.5 % (S_1) at pre flowering and pod formation stages, with no zinc application as control (S_0). The data on total dry matter accumulation in plants were recorded at 20, 40, 60, 80 days after sowing (DAS) and at harvest. Five adjacent plants sampled from each treatment in three replications and then separated into leaves, stems and pods. The plant parts were dried to a constant weight in hot-air oven at 80^{0}C for two days and the dry weights were recorded and expressed in g plant^{-1}. Number of pods per plant was recorded at harvesting time. A lot of seeds was drawn at random from each treatment plot in 3 replications and weighed. Number of seeds constituting the sample was counted and from these values 100 seed weight was computed. Five plants in each replication were harvested and the seed was separated, cleaned, dried and weighed to the nearest gram to obtain the average grain yield per plant. Stastical significance was tested at 5 per cent level of probability and critical differences were calculated for those parameters which were found significant (p d" 0.05) to compare the effects of different treatments by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Total dry matter (g plant^{-1})

The data pertaining to the effect of heat stress and zinc treatments on total dry matter aree presented in Table 1. At 20 and 40 DAS, among the main treatments, the maximum total dry matter was obtained with the normal sown crop *i.e.,* November 10th (M_1- 0.48 and 1.94 g plant^{-1}, respectively) and the lowest total dry matter was recorded in the late sown crop (M_3 - 0.40 and 1.63 g plant^{-1}, respectively). Moderately delayed sown crop recorded significantly lesser total dry matter (M_2-0.44 and 1.79 g plant^{-1}, respectively) than the normal sown crop (M_1) and higher than the late sown crop (M_3). At 60 and 80 DAS, the highest total dry matter was obtained with the normal sown crop (M_1-8.30 and 10.76 g plant^{-1}, respectively), whereas the lowest total dry matter was recorded by the late sown crop (M_3-6.53 and 9.02 g plant^{-1}, respectively). Moderately delayed sown crop recorded significantly lesser total dry matter (M_2-7.40 and 9.84 g plant^{-1}, respectively) than the normal sown crop (M_1) and higher total dry matter than the late sown crop (M_3). At harvest, higher total dry matter was recorded by the normal sown crop (M_1-12.25 g plant^{-1}). Lesser total dry matter was recorded by the late sown crop (M_3-9.00 g plant^{-1}) which was statistically at par with the moderately delayed sown crop (M_2-10.00 g plant^{-1}). In the present study, late sown and moderately late sown chickpea crops decreased the total dry matter by 26.5 and 18.4 per cent, respectively, at harvest. Heat stress is one of the most important causes of reduced yield and dry matter production in many crops, including maize and wheat (Giaveno and Ferrero, 2003).

At 60 and 80 DAS, among the sub treatments, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages recorded the highest total dry matter (S_3-8.13 and 10.74 g plant^{-1}, respectively), whereas the lowest total dry matter was recorded by the control plants (S_0-6.72 and 8.99 g plant^{-1}, respectively). The remaining treatments (S_2 and S_1) were significantly differed with each other and recorded significantly higher total dry matter than S_0 treatment and lesser than S_3 treatment. At harvest, among the sub treatments, significantly higher total dry matter was recorded by the foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages (S_3-11.41 g plant^{-1}) which was at par with the foliar spray of Zn-EDTA @ 0.3 % at pre flowering and pod formation stages (S_2-10.71 g plant^{-1}). Lesser total dry matter was recorded without application of zinc (S_0-9.37 g plant^{-1}). In the current study, foliar application of $ZnSO_4.7H_2O$ @ 0.5 % and Zn-EDTA @ 0.3 % at pre flowering and pod formation stages increased the total dry matter by 21.8 and 14.3 per cent, respectively, at harvest. Kashem *et al.* (2000) reported that drought and heat stress decreased the dry-matter accumulation and grain yield of winter wheat both under field and greenhouse conditions, which could be alleviated by the foliar application of $ZnSO_4.7H_2O$ @ 0.5 %.

Among the interactions, at 80 DAS and at harvest, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages to the normal sown chickpea crop recorded the highest total dry matter (M_1S_3-11.72 and 13.43 g plant^{-1}, respectively) and the lowest was recorded with the late sown crop with no application of zinc (M_3S_0-8.27 and 8.20 g plant^{-1}, respectively) illustrated in Tabel 1. The results are in accordance with the findings of Peck *et al.* (2019) who stated that heat stress significantly reduced the total dry matter in Halberd by 15% and application of zinc up to 2 mg kg$^{"1}$ increased the total dry matter production and growth rates in wheat.

Number of Pods Per Plant

Normal sown chickpea crop recorded the maximum number of pods per plant (M_1-50.77), whereas the minimum number of pods per plant was recorded in the late sown crop (M_3-43.62). Moderately delayed sown crop recorded significantly less number of pods per plant (M_2-47.06) than the normal sown crop (M_1) and more number of pods than the late sown crop (M_3). Late sown crops i.e., M_3 and M_2 decreased the number of pods per plant by 14.1 and 7.3 per cent, respectively, over M_1 (normal sown crop) in the present study. The results are in aggrement with Basu *et al.*, (2009) who reported that temperature stress during reproductive development can cause significant pod abortion and decreased seed filling and the chickpea genotypes do not set pods when temperatures reach 32 to 35°C.

Among the sub treatments, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages recorded higher number of pods per plant (S_3-51.48) compared to other treatments, and it was at par with the foliar spray of Zn-EDTA @ 0.3 % at pre flowering and pod formation stages (S_2-49.04). Lesser number of pods per plant was obtained with control (S_0-43.88) which was on a par with the foliar spray of $ZnSO_4.H_2O$ @ 0.2 % (S_1-44.20). In the present study, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % (S_3) and Zn-EDTA @ 0.3 % (S_2) increased the number of pods per plant by 17.3 and 11.8 per cent, respectively, over control plants (S_0) (Table.2). Khan *et al.* (2000) reported that soil application of zinc (5.0 kg ha^{-1}) recorded the highest plant height, number of pods $plant^{-1}$ and number of seeds pod^{-1} in chickpea. This enhancement might be due to the crucial role of zinc in the synthesis of proteins and carbohydrate metabolism and the results are supporting the findings of present investigation.

In the present study, among the interactions, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages to the normal sown chickpea crop recorded higher number of pods per plant (M_1S_3-56.44) compared to all other treatments, and lesser number of pods per plant was obtained in the late sown crop with no application of zinc (M_3S_0-38.83. In the present study, late sown chickpea crop sprayed with $ZnSO_4.7H_2O$ @ 0.5 % increased the number of pods per plant by 22.9 per cent, over the late sown crop without zinc application (M_3S_0). The increase in pod and seed yield might be due to higher availability of zinc during development as reflected by increased zinc concentration in leaves and seeds after resupply of zinc to deficient plants is well documented with the findings of (Neena and Chatterjee, 2002).

Test Weight (g)

In the current study, significant differences were observed among the main treatments and sub treatments. Normal sown chickpea crop recorded higher test weight (M_1-21.55 g), whereas lower test weight was recorded in the late sown crop (M_3-20.37 g), which was on a par with the moderately delayed sown crop (M_2-20.75 g) (Tabel.3). In the present study, late sown chickpea crop (M_3) and moderately delayed sown crop (M_2) decreased the test weight by 5.5 and 3.7 per cent respectively, than the normal sown crop (M_1). Heat stress during grain development can affect the availability and translocation of assimilates to the grain thus reducing starch synthesis and deposition resulting in lower grain weight (Wiegand and Cuellar, 1981).

Among the sub treatments, the highest test weight was obtained by the foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages (S_3-21.33 g). The lowest test weight was recorded with no application of zinc (S_0-20.63 g) which was at par with the foliar spray of Zn-EDTA @ 0.3 % (S_2-20.83 g) and foliar spray of $ZnSO_4.H_2O$ @ 0.2 % at pre flowering and pod formation stages (S_1-20.76 g). Foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages exhibited superior performance by increasing the test weight by 3.4 per cent over control (no application of zinc). This response can be related to key role of zinc in biosynthesis of IAA, regulating the auxin concentration in plant and other biochemical, physiological activities like photosynthesis, respiration, nitrogen metabolism and initiation of primordia for reproductive parts facilitating better translocation of desired metabolites to the yield contributing parts of plant like seeds and leads to increase in seed weight. These results are in agreement with (Firdous *et al.*, 2018).

Table 1. Influence of zinc nutrition on total dry matter (g plant^{-1}) at 20, 40, 60, 80 DAS and at harvest in chickpea under heat stress

Treatments	20DAS				40DAS			
	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	Mean	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	Mean
Control(no application of zinc)	0.47	0.42	0.35	0.41	1.73	1.56	1.41	1.56
Spray of $ZnSO_4$. H_2O @ 0.2 %	0.5	0.39	0.4	0.43	1.81	1.6	1.5	1.63
Spray of Zn-EDTA @ 0.3 %	0.47	0.53	0.43	0.47	2.02	1.91	1.69	1.87
Spray of $ZnSO_4.7H_2O$ @ 0.5%	0.48	0.43	0.43	0.44	2.22	2.09	1.94	2.08
Mean	0.48	0.44	0.4		1.94	1.79	1.63	

	20DAS			40 DAS		
	Main Plots	Sub Plots	Interaction	Main Plots	Sub Plots	Interaction
S.E m±	0.003	0.002	0.003	0.01	0.02	0.03
CD @ = 0.05	0.01	NS	NS	0.07	NS	NS
CV (%)	5.89	4.27		8.87	7.27	

Treatments	60DAS				80DAS				At Harvest			
	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	Mean	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	Mean	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	Mean
Control(no application of zinc)	7.48	6.70	5.99	6.72	9.78	8.92	8.27	8.99	10.76	9.16	8.20	9.37
Spray of $ZnSO_4$. H_2O @ 0.2 %	8.20	7.22	6.25	7.22	10.49	9.51	8.80	9.60	12.21	9.67	8.65	10.17
Spray of Zn-EDTA @ 0.3 %	8.55	7.56	6.63	7.58	11.08	10.21	9.26	10.18	12.61	10.31	9.21	10.71
Spray of $ZnSO_4.7H_2O$ @ 0.5%	9.00	8.14	7.25	8.13	11.72	10.74	9.76	10.74	13.43	10.86	9.96	11.41
Mean	8.30	7.40	6.53		10.76	9.84	9.02		12.25	10.00	9.00	

	60DAS			80DAS			At Harvest		
	Main Plots	Sub Plots	Interaction	Main Plots	Sub Plots	Interaction	Main Plots	Sub Plots	Interaction
S.E m±	0.04	0.02	0.06	0.04	0.02	0.06	0.35	0.25	0.36
CD @ = 0.05	0.11	0.1	NS	0.13	0.12	0.17	1.07	0.86	0.98
CV (%)	8.28	7.14		8.94	7.23		8.87	7.27	

Table 2. Influence of zinc on no of pods per plant in chickpea under heat stress

Treatments	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	Mean
Control (no application of zinc)	45.44	39.11	38.83	43.88
Spray of $ZnSO_4$. H_2O @ 0.2 %	48.00	45.49	43.84	44.20
Spray of Zn-EDTA @ 0.3%	50.55	49.22	44.86	49.04
Spray of $ZnSO_4.7H_2O$ @ 0.5%	56.44	51.33	47.74	51.48
Mean	50.77	47.06	43.62	

	Main Plots	Sub Plots	Interaction
S.E m±	0.83	0.73	1.52
CD (p = 0.05)	3.26	2.51	4.56
CV (%)	6.15	4.68	

Table 3. Influence of zinc nutrition on test weight (g) in chickpea under heat stress

Treatments	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	MEAN
Control (no application of zinc)	21.26	20.54	20.21	20.63
Spray of $ZnSO_4$. H_2O @ 0.2 %	21.42	20.68	20.36	20.76
Spray of Zn-EDTA @ 0.3%	21.53	20.64	20.47	20.83
Spray of $ZnSO_4.7H_2O$ @ 0.5%	22.14	21.39	20.68	21.33
Mean	21.55	20.75	20.37	

	Main Plots	Sub Plots	Interaction
S.E m±	0.15	0.08	0.44
CD (p = 0.05)	0.64	0.23	NS
CV (%)	2.31	1.28	

Table 4. Influence of zinc nutrition on seed yield (Kg ha^{-1}) in chickpea under heat stress

Treatments	M_1 (NOV 10th)	M_2 (NOV 30th)	M_3 (DEC 20th)	Mean
Control (no application of zinc)	633.7	566.6	508.4	569.5
Spray of $ZnSO_4$. H_2O @ 0.2 %	766.9	678.9	658.4	701.4
Spray of Zn-EDTA @ 0.3%	885.3	751.7	715.7	784.2
Spray of $ZnSO_4.7H_2O$ @ 0.5%	906.4	781.1	748.2	811.9
Mean	798.1	694.5	657.6	

	Main Plots	Sub Plots	Interaction
S.E m±	21.5	14.9	20.4
CD (p = 0.05)	62.1	46.8	58.5
CV (%)	8.2	6.3	

Seed Yield (Kg ha^{-1})

Significant differences were observed among the main treatments, sub treatments and their interactions. Normal sown chickpea crop recorded the highest seed yield (M_1-798.1 Kg ha^{-1}) and the lowest seed yield was recorded in the late sown crop (M_3-657.6 Kg ha^{-1}), which was on a par with the moderately delayed sown crop (M_2-694.5 Kg ha^{-1}) (Tabel.4). In the present study, late sown chickpea crop (M_3) and moderately delayed sown crop (M_2) decreased the seed yield by 17.6 and 13.0 per cent respectively, than the normal sown crop (M_1). The results are in aggerement with Prasad *et al* (2012) who reported that high temperature stress directly influences seed fill duration by decreasing the grain fill duration, leading to smaller seed size and lower yields.

Among the sub treatments, significantly higher seed yield was obtained by the foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages (S_3-811.9 Kg ha^{-1}) which was at par with the foliar spray of Zn-EDTA @ 0.3 % at pre flowering and pod formation stages (S_2-784.2 Kg ha^{-1}), whereas lesser seed yield was recorded with no application of zinc (S_0-569.5 Kg ha^{-1}). Foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages exhibited superior performance and improved the seed yield by 42.6 per cent, over control (no application of zinc). Prasad *et al.,* 2011 reported that in chickpea the foliar application of $ZnSO_4$ @ 0.5 % recorded highest yield (2902 Kg ha^{-1}).

Among the interactions, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages to the normal sown chickpea crop recorded higher seed yield (M_1S_3-906.4 Kg ha^{-1}) compared to all other treatments, whereas lesser seed yield was obtained in the late sown crop with no application of zinc (M_3S_0-508.4 Kg ha^{-1}). Under late sown conditions, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages (M_3S_3) increased the seed yield by 47.2 per cent over the late sown crop without zinc application (M_3S_0). The increase in grain yield due to zinc application might be due to the higher efficiency of enzymatic activities which ultimately influence the plant growth, as Zn is an important component of all classes of enzymes that encourage growth and yield components. (Gupta and Pandey 2012).

CONCLUSION

Foliar spray of $ZnSO_4$. $7H_2O$ @ 0.5 % at pre flowering and pod formation stages increased the total dry matter, number of pods plant^{-1}, test weight and seed yield by 26.5, 14.1, 12.6, 5.5 and 17.6 per cent, foliar spray of $ZnSO_4.7H_2O$ @ 0.5 % at pre flowering and pod formation stages increased the total dry matter, number of pods plant^{-1}, test weight and seed yield of chickpea both under normal sown as well as late sown (heat stress) conditions.

Hence, the use of zinc spray in chickpea plants grown under late sown conditions during flowering and pod formation stages counteracted the deleterious effects of heat stress on total dry matter, seed yield and its components.

LITERATURE CITED

Basu P S, Ali M and Chaturvedi S K 2009 Terminal heat stress adversely affects chickpea productivity in Northern India–strategies to improve thermotolerance in the crop under climate change. In *W3 Workshop Proceedings: Impact of Climate Change on Agriculture*. 23: 189-193.

Cakmak I, Ozturk L, Eker S E L I M, Torun B, Kalfa H I and Yilmaz A 1997 Concentration of zinc and activity of copper/zinc-superoxide dismutase in leaves of rye and wheat cultivars differing in sensitivity to zinc deficiency. *Journal of Plant Physiology*. 151 (1): 91-95.

Firdous S, Agarwal B K and Chhabra V 2018 Zinc-fertilization effects on wheat yield and yield components. *Journal of Pharmacognosy and Phytochemistry*. 7 (2): 3497-3499.

Giaveno C and Ferrero J 2003 Introduction of tropical maize genotypes to increase silage production in the central area of Santa Fe, Argentina. *Crop Breeding and Applied Biotechnology*. 3 (2).

Gomez Kwanchai A and Arturo A 1984 *Statistical procedures for agricultural research*. John Wiley & Sons.

Gupta B and Pandey N 2012 Improving reproductive efficiency of chickpea by foliar application of zinc. *Brazilian Journal of Plant Physiology*. 24: 173-180.

Kashem M A, Singh B R, Kubota H, Sugawara R, Kitajima N, Kondo T and Kawai S 2000 Zinc tolerance and uptake by *Arabidopsis halleri* ssp. gemmifera grown in nutrient solution. *Environmental Science and Pollution Research*. 17 (5): 1174-1176.

Khan H R, G K McDonald and Rangel Z 2003 Zn fertilization improves water use efficiency, grain yield and seed Zn content in chickpea. *Plant and Soil*. 249 (2): 389-400.

Neena M and Chatterjee C 2002 Yield, physiology and productivity of rice under manganese stress. *Indian Journal of Plant Physiology*. 7 (4): 392-395.

Peck A W and McDonald G K 2010 Adequate zinc nutrition alleviates the adverse effects of heat stress in bread wheat. *Plant and soil*. 337 (1): 355-374.

Prasad M B K, Sapiano M R, Anderson C R, Long W and Murtugudde R 2012 Long-term variability of nutrients and chlorophyll in the Chesapeake Bay: A retrospective analysis, 1985–2008. *Estuaries and Coasts*. 33 (5): 1128-1143.

Prasad R P D, Pulla Rao, Ch Srinivasulu K and Veeraraghavaiah, R. 2011. Zinc Management Strategy to Increase Growth and Seed Yeild of Kabuli Chickpea (Cicer kabulium L.). *The Andhra Agricultural Jornal* 58(4): 405-407.

Shiraiwa T and Hashikawa U 1995 Accumulation and partitioning of nitrogen during seed filling in old and modern soyabean cultivars in relation to seed production. Jpn. J. Crop Sci. 64 : 754-759.

Siddique K H M, Loss S P, Regan K L and Jettner R L 1999 Adaptation and seed yield of cool season grain legumes in Mediterranean environments of south-western Australia. *Australian Journal of Agricultural Research*. 50 (3): 375-388.

Summer field R J, Hadley P, Roberts E H, Minchin F R and Rawsthrone S 1984 Sensitivity of chickpea (*Cicer arietinum* L.) to hot temperatures during the reproductive period. *Experimental Agriculture*. 20: 77–93.

Valenciano J B, Boto J A, and Marcelo V 2011 Chickpea (Cicer arietinum L.) response to zinc, boron and molybdenum application under field conditions. *New Zealand Journal of Crop and Horticultural Science, 39*(4), 217-229.

Wang J, Gan Y T, Clarke F and McDonald C L 2006 Response of chickpea yield to high temperature stress during reproductive development. *Crop Science*. 46 (5): 2171-2178.

Wiegand C L and Cuellar J A 1981 Duration of grain filling and kernel weight of wheat as affected by temperature.

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