

IMPACT OF SUPPLEMENTAL UV-B RADIATION ON FLOWER AND POD FORMATION IN CHICKPEA (*CICER ARIETINUM* L).

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Abstract: Surface level ultraviolet radiation (280-320nm) and ozone are components of the global climate and any increase in their levels can lead to adverse effects on crop growth and productivity on a broad geographic scale. The object of this study was to determine the effect of season long exposure of supplemental UV-B on flower and pod formation in *Cicer arietinum* L. The study revealed that supplemental UV-B radiation promoted the number, fresh weight and dry weight of flower and pod if it was given for 1 hr and 2 hr however 3 hr supplemental UV-B radiation inhibited number, fresh weight and dry weight of flower and pod in *Cicer arietinum* L.

Keywords: *Cicer arietinum*, Supplemental UV-B radiation, Flower, Pod

INTRODUCTION

Sensitivity to increased UV-B radiation varies significantly among plant species. According to previous studies, approximately two-third of 300 species and their varieties are vulnerable to damage from amplified UV-B levels. The extent of damage may vary seasonally and can be affected by microclimate and soil fertility. Enhanced UV-B radiation was generally characterized as harmful for plants and its effects were species specific (Teramura and Sullivan, 1993). The impact of increased solar ultraviolet-B (UV-B) exposure due to stratospheric ozone depletion can negatively affect plant growth and physiology which ultimately decrease crop productivity. While some effects of prolonged elevated UV-B exposure on plants is clear, relatively little is known about the short-term effects of UV-B exposure, although there are evidence of short-term UV-B radiation increases that likely occur during summer. The level of increase in UV-B radiation at a certain locations depends on several factors including the amount of ozone, position of the sun (latitude and longitude), cloud cover and land cover of sand, snow or water. Based on models that predict UV level increased relative to 1979-1992 levels, 2010-2020 may receive UV doses increased by 14% in the Northern hemisphere and up to 40% in the Southern hemisphere. A 30% increase in UV-B radiation levels is expected to have significant impact on crop productivity (Kakani *et al.*, 2003).

Field investigations have focused on seed yields of economically important cultivated species with characteristically variable results. Enhanced UV-B radiation can have many direct and indirect effects on plants including inhibition of photosynthesis, DNA damage, changes in morphology, phenology and biomass accumulation (Caldwell *et al.*, 1995). Pea (*Pisum sativum*) yield was reduced by UV-B radiation (Mepsted *et al.*, 1996). Gwynn-Jones *et al.*, (1997) found an increase in berry production in the

sub-arctic *Vaccinium myrtillus*. However, the seed yield was not measured in these investigations. In another study with the Mediterranean shrub *Cistus creticus*, the number of flowers was not affected, yet pollination success was improved and seed yield increased (Stephanou and Manetas, 1998). In the few wild plants studied so far under field conditions and with realistic ozone depletion scenarios, a consistent trend towards an increase in flower number was observed in the Mediterranean *Mentha spicata* (Grammatikopoulos *et al.*, 1998) and in *Colobanthus quitensis* and *Deschampsia antarctica* in the Antarctic Peninsula (Day *et al.*, 1999).

Surplus UV-B radiation, acting as a premature environmental signal, could alter the timing (Ziska *et al.*, 1992) or the number of flowers (Musil, 1995; Grammatikopoulos *et al.*, 1998; Day *et al.*, 1999).

Globally, studies have shown that there is a significant diminution of plant biomass and plant height when exposed to increased UV-B radiation. Arctic plant species are more tolerant of enhanced UV-B radiation than expected. Further, there was no simple relationship found between UV-B absorbing compounds to UV-B exposure level (Callaghan *et al.*, 2004). This may suggest other unknown mechanisms that interact with UV-B tolerance. It also may be possible to genetically modify plant crops to resist effects of increased exposure to UV-B through UV-B absorbing compounds.

Ying Wang *et al.*, (2008) observed that fruit biomass was not affected by enhanced UV-B radiation in *Cerastium glomeratum* Thuill. Enhanced UV-B radiation delayed onset of flowering by 1 day and shortened duration of flowering by 5 days. But because of the long period of flowering time (83-88 days), this did not make any significant effect on flower number, seed number, pollination success (number of seeds per fruit) or reproductive success (fruit to flower ratio).

The chickpea (*Cicer arietinum*) is a legume of the family Fabaceae, subfamily Faboideae. Its seeds are

high in protein. It is one of the earliest cultivated legumes: 7500 year old remains have been found in the Middle East. The plant grows 20 to 50 cm (8-20 inches) high and has small feathery leaves on either side of the stem. Chickpeas are a type of pulse, with one seedpod containing two or three peas. It has white flowers with blue, violet or pink veins. Chickpea need a subtropical or tropical climate with more than 400 mm (16 in) of annual rain. They can be grown in a temperate climate but yields will be much lower. The *Desi* (meaning 'country' or 'local' in Hindi) is also known as Bengal gram or kala chana. *Kabuli* (meaning 'from Kabul' in Hindi, since they were thought to have come from Afghanistan when first seen in India) or *safed chana* is the kind widely grown throughout the Mediterranean.

India is the world leader in chickpea (Bengal gram) production followed by Pakistan and Turkey. *Desi* chickpeas have markedly higher fiber content than *Kabulis* and hence a very low glycemic index which may make them suitable for people with blood sugar problems. Chickpeas are a helpful source of zinc, folate and protein. Chickpeas are low in fat and most of this is polyunsaturated.

Based on the above perusal of literature and findings, a field experiment was conducted to investigate the effects of supplemental UV-B radiation on flowering, fruiting and their fresh and dry weight in *Cicer arietinum* L. The purpose of this study was to find out whether supplemental UV-B radiation was harmful, neutral or beneficial in this crop.

MATERIAL AND METHOD

The experiment was conducted in the Department of Botany, Govt. P.G. College, Noida, Gautam Buddha Nagar (U.P.). Seeds of chickpea (*Cicer arietinum* L.) were sown in soil, in rows spaced 0.1 meter apart in 4 plots of 1x1 meter square each. After seedling emergence, plants were irradiated daily with supplemental UV-B radiation supplied by sun lamps (300 watt) held in frames suspended 1 meter above the plants in the fields. The total supplemental UV-B irradiance received at the top of the plants beneath the lamps was $24.23 \text{ Jm}^{-2}\text{s}^{-1}$. Control plants (T_1) were not exposed to supplemental UV-B radiation. Plants of plots T_2 , T_3 and T_4 were exposed to supplemental UV-B radiation for 1 hour, 2 hour and 3 hour daily till maturity of crop. The experiment was laid out in Completely Randomized Block Design with three replications. The samples for growth analysis were taken regularly at 15 days interval after the seedling emergence till maturity of the crop. The fifteen identical plants were transported to laboratory for the observation of flower and pod in terms of number, fresh and dry weight (Kumar, 1981). Data were analyzed statistically using SPSS 7.5 version. The mean values of fifteen plants were calculated, represented in results with standard deviation and test of significance at 5% level.

RESULT AND DISCUSSION

The effect of supplemental UV-B radiation on the number, fresh and dry weight of flower and pod has been shown in table 1 (graph 1-3) and in table 2 (graph 4-6) in *Cicer arietinum* L.

Table 1: Effect of supplemental UV-B radiation on flower formation in field grown *Cicer arietinum* L.

Daily UV-B irradiance Parameters	CROP AGE IN DAYS					
	15	30	45	60	75	90(Maturity)
Control						
Flower no.	----	----	28.60±0.894	36.20±2.167	20.60±2.408	----
fw, gm	----	----	0.269±0.009	0.381±0.025	0.066±0.010	----
dw, gm	----	----	0.049±0.004	0.083±0.009	0.025±0.005	----
1 hour						
Flower no.	----	----	*32.60±3.577	55.0±4.000	*28.0±2.549	----
fw, gm	----	----	0.248±0.025	0.258±0.018	0.218±0.023	----
dw, gm	----	----	0.047±0.009	0.083±0.005	0.078±0.009	----
2 hour						
Flower no.	----	----	*22.0±2.000	68.20±1.923	22.0±2.549	----
fw, gm	----	----	0.114±0.012	*0.343±0.011	0.157±0.019	----
dw, gm	----	----	0.022±0.002	*0.116±0.007	*0.035±0.003	----
3 hour						
Flower no.	----	----	18.80±1.303	*48.20±3.114	4.80±0.836	----
fw, gm	----	----	0.048±0.003	0.286±0.015	*0.030±0.006	----
dw, gm	----	----	0.010±0.004	*0.058±0.005	0.005±0.001	----

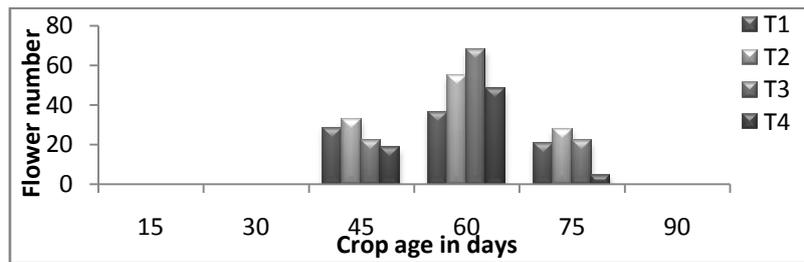
no.= number, **fw** =fresh weight, **dw** = dry weight, **gm**= gram, \pm =Standard Deviation, * = Significant at 5% level.

At 45 day stage of crop growth, number of flower was promoted 10% at 1 hr and inhibited 23% and

34% at 2 hr and 3 hr supplemental UV-B radiation. At 60 day stage, flower number was promoted 50%,

88% and 33% at 1 hr, 2 hr and 3 hr supplemental UV-B radiation respectively. At 75 day stage, flower number was promoted 36% and 6% at 1 hr and 2 hr

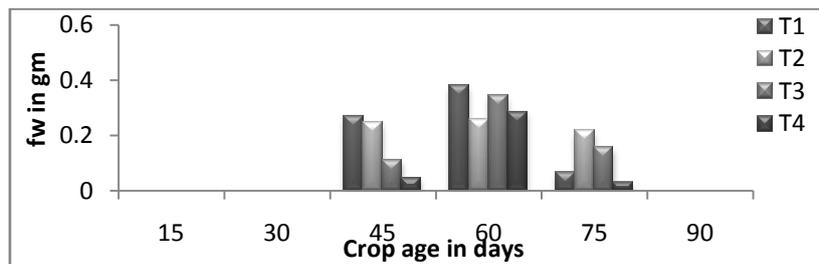
however inhibited 77% at 3 hr supplemental UV-B radiation.



Graph: 1 Effect of supplemental UV-B radiation on flower number in *Cicer arietinum* L.

Fresh weight of flower was inhibited 8%, 58% and 83% at 45 day stage and 33%, 10% and 25% at 60 day stage at 1 hr, 2 hr and 3 hr supplemental UV-B radiation respectively. Fresh weight of flower at 75

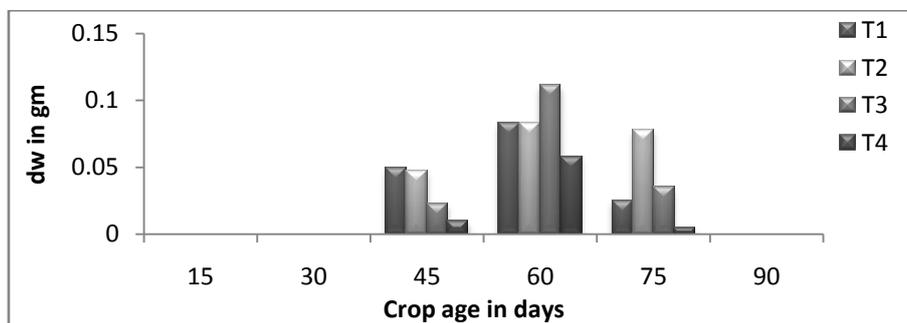
day stage was promoted 230% and 137% at 1 hr and 2 hr however inhibited 55% at 3 hr supplemental UV-B radiation.



Graph: 2 Effect of supplemental UV-B radiation on fresh weight of flower in *Cicer arietinum* L.

Dry weight of flower was inhibited 4%, 53% and 80% at 45 day stage at 1 hr, 2 hr and 3 hr supplemental UV-B radiation respectively. At 60 day stage, dry weight of flower was promoted 33% at 2 hr however inhibited 30% at 3 hr and no inhibition in dry weight of flower was observed at 1 hr supplemental UV-B radiation. At 75 day stage of

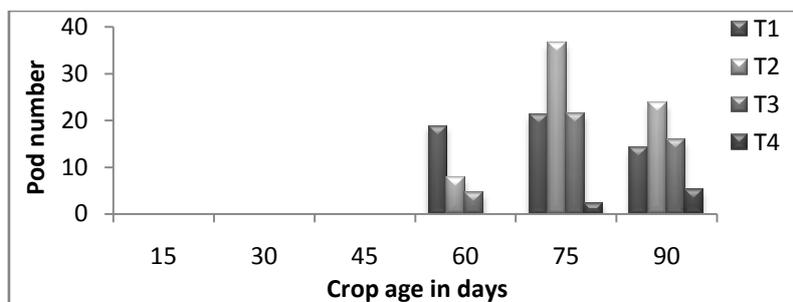
crop growth, dry weight of flower was promoted 212% and 40% at 1 hr and 2 hr however inhibited 80% at 3 hr supplemental UV-B radiation when compared with control. Response behavior of *Cicer arietinum* to supplemental UV-B is fluctuating stage to stage.



Graph: 3 Effect of supplemental UV-B radiation on dry weight of flower in *Cicer arietinum* L.

Pod formation was started at 60 day stage and it was observed first time in control plants. It shows that longer exposures of supplemental UV-B inhibited the pod formation in chickpea. At 60 day stage, number of pod was inhibited 59% and 76% at 1 hr and 2 hr however no flower was observed at 3 hr supplemental UV-B radiation. At 75 day stage, it was

promoted 72% and 1% at 1 hr and 2 hr however inhibited 89% at 3 hr supplemental UV-B radiation. At 90 day stage, pod number was promoted 67% and 11% at 1 hr and 2 hr however inhibited 64% at 3 hr supplemental UV-B radiation.



Graph: 4 Effect of supplemental UV-B radiation on pod number in *Cicer arietinum* L.

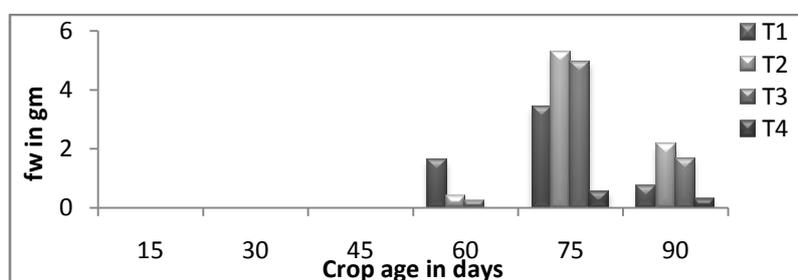
Table 2: Effect of supplemental UV-B radiation on pod formation in field grown *Cicer arietinum* L.

Daily UV-B irradiance Parameters	CROP AGE IN DAYS					
	15	30	45	60	75	90(Maturity)
Control						
Pod no.	----	----	----	18.80±1.303	21.20±1.923	14.20±0.836
fw, gm	----	----	----	1.636±0.112	3.420±0.299	0.754±0.046
dw, gm	----	----	----	0.274±0.018	1.374±0.118	0.732±0.047
1 hour						
Pod no.	----	----	----	8.40±1.341	36.60±2.073	23.80±1.923
fw, gm	----	----	----	0.390±0.065	5.286±0.304	2.146±0.176
dw, gm	----	----	----	0.084±0.013	1.434±0.082	*1.668±0.902
2 hour						
Pod no.	----	----	----	4.60±1.140	21.40±2.880	*15.80±1.303
fw, gm	----	----	----	0.228±0.054	*4.962±0.664	1.658±0.137
dw, gm	----	----	----	0.048±0.013	*1.686±0.100	1.412±0.119
3 hour						
Pod no.	----	----	----	----	2.40±0.547	5.20±1.788
fw, gm	----	----	----	----	0.562±0.125	0.292±0.100
dw, gm	----	----	----	----	0.200±0.054	0.236±0.080

no.= number, fw =fresh weight, dw = dry weight, gm= gram, ± = Standard Deviation, *= Significant at 5% level.

Fresh weight of pod at 60 day stage was inhibited 76% and 86% at 1 hr and 2 hr and no pod was observed at 3 hr supplemental UV-B radiation. At 75 day stage, fresh weight of pod was promoted 54% and 45% at 1 hr and 2 hr however inhibited 84% at 3

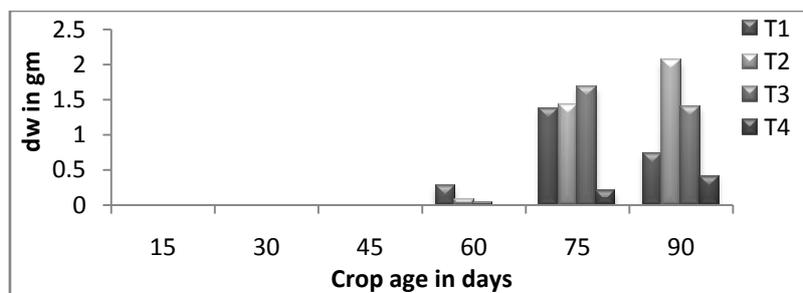
hr supplemental UV-B radiation. At maturity of the crop, fresh weight of pod was promoted 185% and 120% at 1 hr and 2 hr however inhibited 62% at 3 hr supplemental UV-B radiation.



Graph: 5 Effect of supplemental UV-B radiation on fresh weight of pod in *Cicer arietinum* L.

Dry weight of pod at 60 day stage was inhibited 70% and 83% at 1 hr and 2 hr and no pod was observed at 3 hr supplemental UV-B radiation. At 75 day stage of crop growth, dry weight of pod promoted 4% and 23% at 1 hr and 2 hr and inhibited 86% at 3 hr supplemental UV-B radiation. At 90 day stage

(maturity) of crop, dry weight of pod was promoted 182% and 92% at 1 hr and 2 hr however inhibited 45% at 3 hr supplemental UV-B radiation when compared with control. The podding was delayed to 10 days in 3 hour supplemental UV-B radiation when it was compared with control and other treatments.



Graph: 6 Effect of supplemental UV-B radiation on dry weight of pod in *Cicer arietinum* L.

Results indicated that supplemental UV-B radiation promoted the number, fresh weight and dry weight of flower and pod if it was given for shorter (1 hr and 2 hr) duration however longer exposures (3 hr) of supplemental UV-B inhibited number, fresh weight and dry weight of flower and pod in *Cicer arietinum* L. Saile *et al.*, (1996) observed the flowering delay up to a maximum of 5 days under higher UV-B radiation. Stephanou and Manetas, (1998) in *Cistus creticus* and Petropoulou *et al.*, (2001) in *Malcolmia maritima* observed that supplemental UV-B radiation had no effect on fruit biomass and flower number however flower diameter per flower was significantly increased by supplemental UV-B radiation. Kakani *et al.*, (2003) in *Gossypium hirsutum* observed the reduction in all floral parts due to UV-B radiation. Rajendiran and Ramanujam, (2004) in *Vigna radiata* L. and Ying Wang *et al.*, (2008) in *Cerastium glomeratum* observed the delay in flowering due to UV-B radiation.

Gwynn-Jones *et al.*, (1997) found an increase in berry production in the subarctic *Vaccinium myrtillus*. Stephanou and Manetas, (1998) observed increase in seed yield in *Cistus creticus* due to UV-B radiation. Murali and Teramura, (1986) and Teramura *et al.*, (1990) in *Glycine max* L. and Petropoulou *et al.*, (2001) in *Malcolmia maritima* and Ying Wang *et al.*, (2008) in *Cerastium glomeratum* observed that UV-B radiation had no effect on fruit biomass however Mepsted *et al.*, (1996) in *Pisum sativum* L. observed the significant decreases in the number of pods and dry weight of pods per plant but UV-B treatment had no effect on the number of peas per pod or average pea weight. Saile *et al.*, (1996) observed the flowering delay in several cultivars of maize (*Zea mays* L.) up to a maximum of 5 days under higher UV-B radiation. Probably due to this delay in the cob development the yield decreased under higher UV-B radiation at the first harvest after 12 and 14 weeks whereas at the second harvest after 14 and 16 weeks no reduction in yield was observed. Rajendiran and Ramanujam, (2004) observed that UV-B stresses delayed achievement of flowering in *Vigna radiata*

(L.) by which yield and seed number were reduced significantly by enhanced UV-B radiation.

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