Mitigatory Effects of Plant Growth Regulators Over UV-B Radiation Damage on Productivity and Biomass in Rice Crop

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***Abstract* : The aim of study was to evaluate the appropriate concentrations of plant growth hormones from various concentrations over the UV-B damage on Oryza sativa in case of productivity and biomass partitioning. Seeds of Oryza sativa were grown in laboratory for the seed germination and seedling growth and then sown in field plots (A, B, C, D) with appropriate concentrations of plant hormones for productivity and biomass partitioning . Plot-A of rice crop was treated as control and neither sprayed with growth hormones nor exposed to UVB radiation. Pot-B was treated with UV-B radiation (3-hrs. daily) only. Plot-C was sprayed with IAA concentration of (10-7 M), plot-D was sprayed with Kn concentration of (10-5 M) , along with UV-B radiation in Oryza sativa. IAA was found most effective in (10-7 M), Kn in (10-5M) in crop of Oryza sativa and observed enhancement in productivity and biomass partitioning at the germinating seedling stage in the laboratory and field study till to maturity of crop.**

Keywords: Oryza sativa,Plant growth regulators, IAA Kn, Productivity and Biomass partitioning ,UV-B radiatiion

INTRODUCTION

The ozone layer is found at altitude between 10 and 30 kilometers with concentration from 19 to 23 km . The total height of with of ozone colum above any spot on earth is quite small.At standard temperature and pressure , the entire stratospheric ozone layer would have a depth of only 0.3cm. the depletion of stratosphere ozone caused by increasing human activities have led to an elevation of ultraviolet-B radiation at hight altitude . Since ambient levels of ultraviolet- b radiation in tropics are already high ,any futher enhacement in UV-B could be of considerrable imporatace in these regions. It may significantly alter plant ecosystems by reducing the productivity of several ecomonically important crop plants. Rice wheat cropping system, which contributes to about 74 percent of food grains of the country and occupies about 10.5 mha, is one of the most predominant cropping system in Indo-gangetic plains of India (Gangwar *et al*., 1998). This system over exploits the natural resource base and consequently leads to degradation in soil health and fertility and finally decreases yield of both rice and wheat over longer period of time (Wood head *et al*., 1994). Among the most common food crops of the world are mainly rice and wheat, and form the principal food for more than half of human population. But as the total population is increasing exponentially and will continue to increase associated with meagre supply of food. Substantial increase in yield by improving our current ecology economy and agronomic technology through proper understanding of structure, function and utilization of the system will be required to help them escape from the threats of hunger and malnutrition. According to study released by the US General Accounting Office (GAO 1980), estimates of undernourished people in the world vary from 130-450 million, with some degree of malnutrition and condition over worsened since the organization of World Food Council (W.F.C.) in 1974.)

The change in the leaf area masurements observed under supplemental UV-B radiation were similer to those seen for fresh and dry wieght. Supplemental UV-B radition reduced the leaf area in treatment seedlings when compared to control seedlings. Similar trend in leaf area reduction have also been observed legumes [Singh,1996]. According to[Krizek *etal*.,1997] reduction in leaf area could b an adaptive mechanism to minimize the exposure to UV-B radiation. A reduction in calmodulin content, which is likely to be involved in leaf growth has also been reported under uv-b [Huang *et al*., 1997] . Reduction in leaf area might not be solely due to the result of reduced photosynthesis rate to inhibited or delayed cell division (Sisson *et al*1978). However, UV radiation seems to affect cell division process , as was observed on germinated seedlings exposed to UV-B radiation which generated dwarf plant with small leaves.

Leaf area , fresh weight and dry weight of leaf has been found greatly influenced by uv-b radiation . Dickson and Caldwell (1978) investigated that UV-B radiation inhibited the leaf ontogeny and ultimate size of leaf in *Rumx patientia.* He concluded the reasons of inhibition were alteration in cell divition due to UV-B exposure and abscisic acid level. Pal *et al*., (1999) obsereved leaf area expansion , net photosynthesis, specific leaf weight and chlorophyll concentration has greatly reduce in mung bean due to heavy dose of UV-B exposure time. Similar results were also reported by Murali and Teramura (1985,86) under well- watered conditions but no significant results were recorded under water stress.

Leaf area is generally redused by temperature, water mineral or salt stress . It is also supposed that the leaf area is also reduced by UV-B radiation. In a growth chamber study, screening over 70 unrelated crop species and cultivars, Biggs and Kossuth (1978) found that leaf area was significantly reducedin over 60%of the cases. In th most sensitive plants, leaf expansion was reduced by 60-70 % (Tervini *et al* ., 1981; Biggs etal., 1981). In the field grown crops, leaf expansion was substantatoally increased by moderae UV-B radiation enhancement in potato (70% increase) and mustard (30% incease), white leaf expansionwas unaffected in corn, cow pea peanut ,rice and radish (Biggs and Kossuth, 1978). Specific leaf weight was found to increas in a number of soyabean cultivears exposed to UV-B radiation (Biggs *et al*1981; Vu *et al*.,1982).

Poor yeild is atributed to several extranal factors and internal physiological constraints . Crop yeild can be inceased by preventing losses regulating external forces in some cases by growth regulators (Thomas,1983; Malik *et al*., 1986). Besides increase in yeild , other aspects such as quality and registance to diseases and physiological disorders , uniformity in maturity and short- term storage etc. can be improved by using chemical growth regulators (Nickell, 1983 ;Malik et al., 1985,1986).

MATERIALS AND METHODS

The present study was undertaken at the field of R.C. U. Government Post-Graduate. College, Uttarkashi during. The proper study site was located at Purikhet campus of the college near river Bhagirathi. Four plots measuring 1 x 1 in each were fenced by barbed wire to avoid any biotic interference. Certified seeds of cereals crop *Oryza sativa* were procured from extension branch of Indian Agricultural Research Institute, New Delhi.

General Experimental Design: - During laboratory studies following sets were taken into consideration:

Control: Seeds were soaked for 24-hr. in distilled water and placed on moistened filter paper in Peridishes.

UV-B: UV-B radiation was supplied for 3-hr daily by sunlamps (300 W), filtered with quartz interference filters (320 run, ORIEL, USA).I

Growth Regulators: Test solutions of IAA and Kn were prepared in three concentrations viz. 10^{-7}, 10^{-6}, 10^{-5} M (Molarity).Seeds of *Oryza sativa* were soaked for 24-hr in different concentrations of sd k growth regulators. Soaked seeds were placed in paired Petridishes lined with moistened filter paper. One set of Petridish containing soaked seeds was allowed to grow without any UV-B exposure.

Growth Regulators + UV-B: In second set-one from each concentration of different growth regulators was treated with UV-B radiation, for 3-hr daily.

During field study, both the crops were grown in field and the plot was divided by black paper. sheets into four blocks. Each field block was given treatment as:

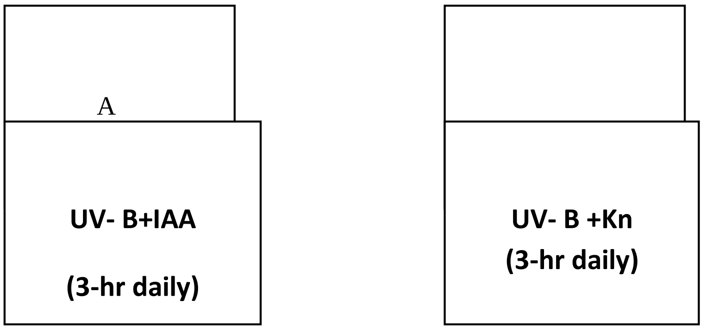
1. Plot A was taken as control. No treatment was given to the crop of this plot.
2. Plot B was irradiated with 3-hr daily UV-B radiation (24.23 Jm211) by Sunlamps (300 W) filtered with quartz interference filters (320 tim, ORIEL, USA).
3. Plot C was sprayed with IAA (10^{-6} M concentration) daily alongwith 3-hr supplemental UV-B radiation using the same source.
4. Plot D was sprayed with Kn (10^{-6} M concentration) daily alongwith 3-hr supplemental UV-13 radiation.

General experimental design may be summarized as:

IN LABORATORY CONDITIONS:

Treatments	Control	UV-B	IAA			Kn			UV-B+IAA			UV-B+Kn		
Concentration		(3-hr)	10^{-7}	10^{-6}	10^{-5}	10^{-7}	10^{-6}	10^{-5}	10^{-7}	10^{-6}	10^{-5}	10^{-7}	10^{-6}	10^{-5}

TREATMENT OF PLOTS IN FIELD CONDITIONS:



The field for cultivation was prepared before sowing of seeds as proposed by Dhasmana (1984). Pre-soaked seeds of the crops were sown in the experimental plots. The general experimental plan for different treatments was laid after full germination of both the crops (Kumar, 1981; Dhasmana, 1984; Ambrish, 1992; Dhingra, 1999; Neeta Bhatt, 2002).

All sets were supplied with respective solutions of growth regulators daily except control and UV-B irradiated set of experiments. These sets were supplied with distilled water daily. Daily UV-B irradiance received by seeds/seedlings was about 24.23 J M^{-2} S^{-1}.

Germination percentage was recorded on the basis of radicle emergence as 2 mm in length and considered as germinated.

GROWTH PATTERN:

Seeds of *Oryza sativa* (Rice) were sown in fields in sandy loam soil in rows placed 0.1 m apart in 4 plots (A, B, C and D) of 1×1 in each. Plot A of both the crops was treated as control and neither sprayed with growth regulators nor exposed to UV-B radiation. Plot B, C and D of both the crops, were treated with UV-B radiation (3-hr daily), supplied by Sunlamps (300 W) filtered with quartz interference filters (ORIEL, USA). Plot C of both the crops was sprayed with IAA solution of 10^{-6} M concentration daily through hand spray machine. Plot D of both the crops was sprayed with Kn 10^{-6} M concentration. Above treatments were carried out daily as described in both the crops till maturity (harvesting period).

The samples for growth analysis were taken regularly at 15-day intervals from each plots separately after the seedling emergence two leaf stage) till maturity. For each study, fifteen phenotypically identical plants from each plot were taken carefully to laboratory where these were washed in running water to remove the soil particles using a mesh of 0.32 mm pore size and tap water current. The growth measurements were taken on parts per plant basis for leaf, stem, root, fruits etc. for each treatment separately.

The mean values of 15 plants of each sample plot were calculated, results represented with ± S.D.

BIOMASS:

DRY MATTER:

For the estimation of biomass and productivity "Short term harvest method" (Odum, 1960) has been applied in the present study. The samples were collected on the basis of morphological similarities and standing crop was estimated on per plant basis. Fifteen plants were selected and harvested from each plot at regular interval of 15 days. The different plant parts viz. leaf, stem, root and fruit were separated at different stages of growth. After fresh weight measurement, the samples were dried at 80°C for 48-hr, for dry matter content for each treatment separately.

NET PRODUCTIVITY:

The net productivity was calculated by subtracting the values of biomass from that of subsequent stage. Summation of positive values represented net productivity of each component. Total sum of positive values of each part gives the values for total net productivity of a crop (Agarwal, 1981; Bist, 1981; Odum, 1960).

YIELD ATTRIBUTING PARAMETERS:

Harvesting Index and Shelling Percentage were calculated as described by Francis *et al*. (1978). Harvesting Index shows the contribution of economically useful part over the total production.

$$\mathbf{HI} = \frac{\textbf{Economically useful part (fruit, g/plant)}}{\textbf{Total dry matter production (g/plant)}}$$

Shelling percentage shows the actual nutritive value of seed over the fruit.

$$\mathbf{SP} = \frac{\textbf{Seed biomass(g/plant)}}{\textbf{Total fruit biomass (g/plant)}} \times \mathbf{100}$$

RESULTS

Effect of UV-13 radiation individually and in combination with IAA (10^{-6}M) & Kn (10^{-6}M) on standing crop, net primary productivity and yield attributes was also studied in *Triticum aestivurn* & *Oryza sativa*. The samples were collected on the basis of morphological similarities and standing crop was estimated on per plant basis as described in earlier chapter.

STANDING CROP:

Data. set in table 5.1 & 5.2 and fig. 5.1 & 5.2 reveal the amount of standing crops of various plant parts viz, root, stem, leaf, fruit and were found to increase linearly with the advancement in growth stage but at maturity, the leaves were found to reduce due to leaf fall crops.

The data of standing of crop of various plant parts of *Oryza* sativa as affected by different treatments are presented in table 5.2.. In control plot, the total biomass (root + stem + leaf + fruit) was observed minimum at 15-day stage and amounted to 2.65 g/pl. These values were observed increasing continuously and linearly as growth progressed to maturity and amounting to ca. 3.47, 5.46, 5.39, 5.53, 8.06 g/pl at 30, 45, 60, 75. 90 day stage of growth respectively. Plants of plot B, which was treated; with UV-B only was reported inhibition in total biomass at all the stages of growth as compared to control. Maximum inhibition was recorded at maturity and inhibited by ca. 49% as compared to with reference control. UV-B given in combination with growth regulators exhibits promotion in total biomass as compared to individual UV-B treatment. IAA was found to promote the total biomass at 15-day stage and a promotion of ca. 90% was observed as compared to UV-B treatment alone. An increase of ca. 69% in total biomass was reported at maturity when the UV-B was given alongwith Kn as compared to individual treatment of UV-B.

NET PRODUCTION (g/pl)

The result of net primary productivity as calculated from standing crop of biomass at 15 days interval are given in (table 5.4 and fig. 5.4). Overall results follow the trend of standing crop of biomass and indicate that the total net primary productivity of both the crops was affected due to UV-B exposure (3-hrs daily) individually and in combination of growth regulators. In general, UV-B inhibited the total net production of different plant parts while a promotion was observed where UV-B treatment was given in combination with growth regulators.

Table 5.4 reveals that at 15 day stage of growth, the value of total net production of *Oryza sativa* was amounting to 0.20, 1.5, 0.90 and 2.65 g/pl in control plot and T.N.P was recorded to increase consistently up to maturity and found as 8.06 g/pl. Plot B showed the inhibition in trend of T.N.P. The maximum inhibition was noted at maturity stage of growth and inhibited by ca. 49% as compared to control. When the crop was treated with UV-13 alongwith IAA, the maximum value was noted at 15-day stage and increased by ca. 89.8% as compared to UV-13 treated. When the crop was subjected to UV-13 alongwith Kn the maximum value of T.N.P was noticed at maturity and increased by Ca. 69.0% as compared to UV-13 treatment only.

COMPARTMENTAL PARTITIONING OF BIOMASS

Fluctuation in total biomass is often accompanied by substantial modifications in the partitionsing of biomass into component plant organs.

The table 5.6 showed that in *Oryza sativa*, the percent contribution of root, leaf and stem at 15 day stage of growth was noted as ca. 7.54%, ca. 58.49%, ca. 33.96% in plot A; 6.43%, 57.30% and 35.65% in plot B. Plot C & D was recorded as 10.73, 44.63, 44.63 & 9.8, 52.11, 38.02% respectively. The percent contribution of root, stem, leaf & fruit at maturity was also recorded. The Plot A showed as 2.48 %, 32.87, 40.19 and 24.44 %. The data recorded f `rom Plot B was 4.10, 25.36, 24.63, and 45.89. Plot C & D showed as 4.09, 46.48, 23.80, 24.71 and 4.14, 25.14, 41.42, 28.57% respectively.

STORAGE OF DRY MATTER

The table 5.8.accounts for the storage of dry matter of different plant parts of *Oryza sativa* as affected by various treatments considered for the study.

When the crop was subjected to combined treatments of UV-B+JAA, data showed an increase by ca. 13%, 13%, 42%, 85%, 2%, 93% for the live vegetation, above ground, underground, stem, leaves and fruit respectively. When the crop was subjected to combined treatment of UV-B+Kn data showed increased by ca. 41%, 41%, 8%, 13%, 49% and 55% for the live vegetation above ground, underground, stem, leaves and fruit respectively as compared to UV-B only.

Perusal of the data in table 5.8 reveals that live vegetation stored 8.06- g/pl dry matters during the whole life span in control plot. Out of which 7.86 g/pl contributed to above ground and 0.20 g/pl contributed to underground plant parts; stem accounted for 2.65 g/pl, leaves 3.24 g/pl and fruit 1.97 g/pl respectively of *Oryza sativa* crop.

When the crop was treated with UV-B+IAA, an increment was observed and noted as ca. 7%, 6%, 29%, 95%, 3% and 43% for the live vegetation, above ground, underground, stem, leaves and fruit respectively as compared to UV-B only. When the crop was treated with UV-B+Kn; an increment was recorded as ca. 54%, 54%, 70%, 14%, 184% and 5% for live vegetation; above ground, underground, stem, leave and fruits respectively as compared to UV-B treatment only.

DRY MATTER DYNAMICS

The dynamics of dry matter of *Triticum aestivum* and *Oryza sativa* as affected by UV-B individually and in combination with IAA (10^{-6}M) and Kn (10^{-6}M) are summarised in 5.10 .

A perusal of data in table 5.10 indicate that total net productivity was amounted to 8.06, 4.14, 4.41 and 6.39 g/plant in plot A, B, C and D respectively. The transfer of total net production to above ground was amounted 0.20 g/pl and to under ground 7.86 g/pl in plot A (control), stem, leaf and fruit relieved 5.41, 4.82, 6.09 g/pl respectively of dry matter production from TNP in control plot.

A decrease in dry matter which is transformed from TNP to ANP, UNP, stem, leaf and fruit was recorded as 51.85, 50.50, 57.36 g/pl respectively when the crop was subjected to UV-B only. When the crop was subjected to UV-B radiation alongwith (IAA), the transfer of TNP to above ground was recorded to increase by ca. 29%, to stem 24%, to leaf Ca. 7% to fruit ca. 48% respectively. When the was treated with UV-B radiation alongwith Kn 10^{-6}M, the transfer of to TNP to above ground was recorded to increase by ca. 70%, to stem ca. 67% to leaf ca. 11%, to fruit to ca. 95% respectively when compared to individual treatment of UV-B.

In *Oryza sativa* (table 5.12) HI was amounted 0.48, 0.37, 0.54, 0.54 in plot A, B, C and D respectively. When plot B was observed HI showed a marked reduction and reduced by ca. 77% as compared to control. Growth regulators in combination with UV-B radiation, exhibit a general promotion of HI as compared to UV-B. IAA was found to be most effective in promoting HI and promoted ca. 45% increase as compared to plot B (UV-B radiation treated), IAA and Kn wererecorded mitigation and promotion in shelling percentage was recorded as compared to UV-13 only and even control. Among GRs, IAA was found most effective and shelling percentage was recorded to increase by Ca. 13% as compared to UV-13 only.

In *Oryza sativa*, shelling percentage was recorded ca. 81% in control table (5.12). In UV-B treated (plot B), a significant reduction in shelling percentage was observed and it was reduced by ca. 26% as compared to control. When UV-B radiation was supplied alongwith IAA and Kn, a promotion in this parameter was recorded as compared to UV-B treatment. IAA was observed most counteracting against UV-B induced inhibition of shelling percentage and promoted by ca. 21% as compared to UV-B individual treatment

Table 5.2 : Standing crop (g/plant) on dry weight basic of field grown *Oryza sativa* as affected by UV-B radiation individually and in combination of IAA and Kn

Treatments	Parameters	CROP AGE IN DAYS					
		15	30	45	60	75	90
A	Root	0.200	0.210	0.310	0.390	0.380	0.200
	Stem	1.550	1.750	1.750	1.750	2.05	2.65
	Leaf	0.900	1.510	1.450	1.25	1.05	3.24
	Fruit	-	-	1.95	2.00	2.05	1.97
	Total	2.65	3.47	5.46	5.39	5.53	8.06
B	Root	0.12	0.110	0.190	0.200	0.350	0.170
	Stem	1.08	1.75	1.20	2.06	1.07	1.05
	Leaf	0.665	1.09	1.90	1.75	1.60	1.02

	Fruit	-	-	1.05	1.05	1.90	1.90
	Total	1.865	4.815	4.34	5.06	4.92	4.14
C	**Root**	0.38	0.28	0.29	0.385	0.36	0.22
	Stem	1.58	4.06	2.67	2.06	2.05	2.05
	Leaf	1.58	1.78	1.35	1.20	1.20	1.05
	Fruit	-	-	1.09	1.95	1.92	1.09
	Total	3.54	3.12	5.40	5.09	5.53	4.41
D	**Root**	0.280	0.260	0.280	0.380	0.380	0.290
	Stem	1.48	1.25	1.60	1.75	20.50	1.200
	Leaf	1.08	1.75	1.90	1.75	1.75	2.900
	Fruit	-	-	1.15	1.50	1.00	2.000

Table 5.4 : Net Primary Productivity on dry weight basis (g/plant/15 days) of root, stem, leaf, fruit of field grown *Oryza sativa* as affected by UV-B radiation individually and in combination of IAA and Kn

Treatments	**Parameters**	**CROP**	**AGE**		**IN**	**DAYS**	
		15	**30**	**45**	**60**	**75**	**90**
A	**Root**	0.200	0.210	0.310	0.390	0.380	0.200
	Stem	1.550	1.750	1.750	1.750	2.050	2.650
	Leaf	0.900	1.510	1.450	1.250	1.050	3.240
	Fruit	-	-	1.950	2.000	2.050	1.970
	Total	2.650	3.470	5.460	5.390	5.530	8.060
B	**Root**	0.120	0.110	0.190	0.200	0.350	0.170
	Stem	1.080	1.750	1.200	2.060	1.070	1.050
	Leaf	0.665	1.090	1.900	1.750	1.600	1.020
	Fruit	-	-	1.050	1.050	1.900	1.900
	Total	1.865	4.815	4.340	5.060	4.920	4.140
C	**Root**	0.380	0.28	0.290	0.385	0.360	0.220
	Stem	1.580	4.06	2.670	2.060	2.050	2.050
	Leaf	1.580	1.78	1.350	1.200	1.200	1.050
	Fruit	-	-	1.090	1.950	1.920	1.090
	Total	3.540	3.120	5.400	5.090	5.530	4.410
D	**Root**	0.280	0.260	0.280	0.380	0.380	0.290
	Stem	1.480	1.250	1.600	1.750	20.500	1.200
	Leaf	1.080	1.750	1.900	1.750	1.750	2.900
	Fruit	-	-	1.150	1.500	1.000	2.000
	Total	2.840	3.260	5.450	5.380	5.180	6.390

Table 5.6 : Percentage contribution of root,stem ,leaf fruit to the standing crop of field grown *Oryza sativa* as affected by UV-B radiation individually and in combination of IAA and Kn

Treatments	**Parameters**	**CROP**	**AGE**		**IN**	**DAYS**	
		15	**30**	**45**	**60**	**75**	**90**
A	**Root**	7.540	6.050	5.600	7.200	6.800	2.480
	Stem	58.490	50.430	32.050	32.460	37.070	32.870
	Leaf	33.960	43.510	26.550	23.190	18.980	40.190
	Fruit	_	-	35.710	37.100	37.070	24.440
B	**Root**	6.430	2.280	4.370	3.950	7.110	4.100
	Stem	57.900	36.340	27.640	40.710	21.740	25.360
	Leaf	35.650	22.630	43.770	34.580	32.520	24.630
	Fruit	-	-	24.190	20.750	38.600	45.890
C	**Root**	10.730	8.970	5..370	7.650	6.500	4.980
	Stem	44.630	33.900	49.440	40.470	37.070	46.480
	Leaf	44.630	57.050	25.000	23.570	21.690	23.800
	Fruit	-	-	20.180	28.760	34.710	24.710
D	**Root**	9.800	7.900	5.130	7.060	7.330	4.140
	Stem	52.110	38.340	29.350	32.520	39.570	25.140
	Leaf	38.020	53.680	34.860	32.520	33.780	41.420
	Fruit	-	-	21.100	27.880	19.300	28.570

Table 5.8: Storage of dry matter of different plant parts of field grown *Oryza sativa* as affected by UV-B radiation (3-hr daily) individually and in combination of IAA and Kn

Oryza sativa	**A**	**B**	**C**	**D**
Live Vigitation	8.060	4.140	4.410	6.390
Above Ground	7.860	3.970	4.190	6.100
Underground	0.200	0.170	0.220	0.290
Stem	2.650	1.050	2.050	1.200
Leaves	3.240	1.020	1.050	2.900
Fruit	1.970	1.900	1.090	2.00

Table 5.10: Dry matter dynamics (g/plant) of different parts of field grown *Oryza sativa* as affected by UV-B radiation (3-hr daily) individually and in combination of IAA and Kn

Oryza sativa	**A**	**B**	**C**	**D**
TNP	8.06	4.14	4.41	6.39
TNP to ANP	0.20	0.17	0.22	0.29
TNP to UNP	7.86	3.97	4.19	6.10
TNP to Root	7.86	3.97	4.19	6.10
TNP to stem	5.41	3.09	2.36	5.19
TNP to leaf	4.82	3.12	3.36	3.49
TNP to fruit	6.09	2.24	3.32	4.39

Table 5.12: Yield attributes of field grown *Oryza sativa* as affected by UV-B radiation (3-hr daily) individually and in combination of IAA and Kn

Treatments	**Biomass (g/plant)**		**Net Primary Productivity**	**Harvesting Index**	**Shelling Percentage**
	Fruit	**Seed**			
A	6.09	4.95	12.65	0.48	81.00
B	3.05	1.95	8.05	0.37	64.00
C	5.08	3.95	9.25	0.54	78.00
D	5.55	4.05	10.5	0.54	73.00

DISCUSSION

The inhibitory effects of UV-B radiation on seedling growth have been observed by various workers (Ambrish, 1992; Ballare et al,. 1996; Oudat et al. 1998) on different crop plants. Steinmetz and Wellmann (1986) observed the effects of solar UV-B radiation and found reduction in hypocoty1 and roots of young etiolated cress. Sullivan and Teramura (1989) studied the effects of UV-B radiation on growth of loblolly pine seedlings and reported pronounced reduction in growth and development. Sharma et al. (1988) reported a reduction in growth and development of pea seedling due to enhanced UV-B radiation.

In the present investigation,. In case of *Oryza sativa*, the length of epiloty1, hypocoty1 and radicle were reduced by ca. 23%13% and 22% respectively. Similar results of decrease in fresh and dry weight were reported for-both the crops Ambrish (1992) also reported the similar results while working with *Cicer arietinum* crop. All parts of plant under investigation were found susceptible towards the enhanced UV-B radiation in the present study.

Generally, combined effect, of UV-B and different growth regulators were found promotory when compared with the UV-B treated seedlings of both crops. Epicoty1, hypocoty1 and radicle length, fresh and dry weight has been found increased over UV-B individual treatment. IAA (10^{-6}M) and Kn (10^{-6}M) were found most effective in case of radicle, hypocoty1 and epicoty1 respectively. While the growth regulators have their pronounced promotory effects on different parts of the seedling as reported here and elsewhere and UV-B suppress the development of different parts of the seedlings, the combined treatment of UV-B and PGRs showed their promotory effect over individual treatment of UV-B. Similar results have also been observed by Kumar (1981), Jain et al, (1996); Russell et al. (1998) and Dhingra (1999).

In general individual treatment of UV-B radiation showed pronounced inhibitory effects on growth in terms of leaf area, fresh weight and dry weight of leaves, root and stem and their fresh and dry weight in both the crops. When crops under investigation were treated with UV-B in combination of PGRs, an increase in all the above parameters were observed as compared to individual treatment of UV-B radiation.

A Number of studies have been carried out in India and abroad on the effects of UV-B radiation on growth and development of various crops and natural vegetation (Murali and Teramura, 1985, 86; Steinmetz and Wellman, 1986; Kumar et al,. 1988, Ambrish, 1992; Tezuka et al., 1993; Grobe and Murphy, 1994; Teramura and Sullivan, 1994; Fiscus and Booker, 1995; Ballare et al., (1996); Dhingra (1999). Daily treatment of UV-B radiation (3hrs) showed overall inhibition in number and weight of all parts of plant in the present study. Biggs et al. (1981) reported reduction in plant height and dry weight of soybean when subjected to UV-B radiation. They reported that plant height and total dry weight of soybean was decreased by 56% and 42% respectively caused by UV-B radiation.

Fruiting determine the yield of a crop. Hart et al, (1975) observed a significant reduction in fruit in pepper as influenced by UV-B radiation. Biggs and Kossuth (1978), Ohtani et al. (1982) and Ambrish, (192) were reported similar results for flower and fruit development. Ohtani et al. (1982) reported inhibition of flowering due to blue light near UV-B radiation in *Lemma paucicostata.* Flowering was also found inhibited in rice during its kernel development due to UV-B radiation by Morie et al. (1989).

When the crops were treated with UV-B in combination of different concentrations of IAA and Kn, a promotion in all the growth parameters was observed over individual treatment of UV-B in both the crops. The IAA was found most effective in case of leaf, which enhanced ca. 174% of fresh weight, 118% of dry weight, 173% of area over individual treatment of UV-B in *Triticum aestivum;* while the dry weight was increased by 41% and 43% in both the crops respectively over individual treatment of UV-B. The above studies found support from the work of Jauhari et al. (1960), Castro and Bergmann (1973), Grunwald and Lockard (1973), Biggs and Kossuth (1978), Dickson and Caldwell (1978), Kumar (1981), Ohtani et al. (1982), Ambrish (1992), Agrawal et al. (1994), Kaur et al (1998), Russell et al. (1998) and Dhingra (1999).

Standing crop of biomass represents long-term integration of biochemical, physiological and growth of the plants. Therefore, UV-B and PGRs individually and in combination induced t1e physiological processes and expresses their effects significantly in biomass partitioning. Total plant biomass was found increased consistently and linearly in all the treatments in both the crops. Maximum inhibition of biomass due to Continuous UV-B exposure was observed ca. 65% and 49% at 105 day stage. in *Oryza sativa* . When the crops were treated with combined treatment of UV-B and PGRs, maximum mitigatory effects was reported for IAA amounting to ca. 98% approximately. The mitigatory effect of this hormone on total biomass of *Oryza sativa* was observed and enhanced by ca.

Various workers have shown that PGRs when applied to the crop individually enhance the accumulation of dry matter biomass and at the same time, UV-B reduces it substantially. Biggs and Kossuth (1978) reported that total dry weight reductions in field-grown corn, pea, tomato and mustard caused by UV-B radiation. These observations are in agreement of our results of biomass inhibition due to UV-B exposure. Brandle et al. (1977) found that total biomass of pea was significantly reduced after only 9 days UV-B treatment. It was reported by various investigators that the total dry weight accumulation was inhibited significantly due to UV-B radiation in different crop plants (Van et al., 1976; Vu et al., 1978) Teramura (1980) also observed the UV-B induced reduction of biomass in soybean.

Fiscus and Booker (1995) reported that the direct consequences of such effects caused a decrease in crop yields of 20-25%. Deleterious effects of UV-B may largely be partitioned between damages to the plant genome and to the photosynthetic machinery. Direct damage to DNA is a common result of absorption of high-energy UV-B photons. It has also been reported that in some plants under the proper conditions, almost every facet of photosynthetic machinery can be damaged directly by very high UV-B exposures. However, electron transport mediated by PS II appears to be the most sensitive part of the system. Vu et al. (1982) reported damage to virtually all parts of the PS II from the Mn binding site to the PQ acceptor site on the opposite surface of the thylakoid membrane.

Teramura and Sullivan (1994) observed that leaf optical properties of terrestrial plant apparently minimizes the exposure of sensitive targets to UV-B radiation. Secondary effects of this damage may include reductions in photosynthetic capacity, RuBP regeneration and quantum yield. Furthermore. UV-B radiation 1may decrease the penetration of PAR, reduce photsynthetic and accessory pigments impair stomatal functions, alter canopy morphology, thus, resulting into reduced accumulation of dry matter biomass.

TNP of both the crops were found altered due to individual and combined effects of UV-B radiation and PGRs, NPP was found increased in all the treatments except in control of *Oryza sativa* where it falls after 60 days. It may be due to drying of various plant parts of the crop. Goyal and Jain (1990) observed that 3-hr exposure of UV-B radiation to linseed crop exhibit significant reduction in primary production of different plant parts. Kumar et al. (1988) reported that TNP was reduced under supplemental UV-B radiation in the field grown lentil crop. Biggs and Kossuth (1978) studied the impact of solar UV-B radiation on crop productivity. The effects of UV-B radiation on the primary production of natural phytoplankton assemblages in Michigan Lake were also reported by Gala and Giesy (1991).

When UV-B was applied with daily spray of IAA and Kn an enhancement in NPP of different plant parts was noted in all the treatment of both the crops. It shows that application of PGRs in combination with UV-B mitigate the deleterious effects of UV-B upto certain extent. This increase in dry matter production may be the result of more uptakes of nutrients and synthesis of reserved food material as affected by growth regulators (Irulappan and Muthukrishnan, 1973 and Kumar, 1981).

Reports are available that application of PGRs ultimately affects the endogenous level of auxins (Andreae and Andreae, 1953; Kuraichi and Muir, 1963 and Wort, 1964), which finally affects the growth, and development of plant. Auxins interact with one or more components of the biochemical system involved in the protein synthesis. However, it has not been identified the proper step where auxins exert an effect. According to popular concept, auxins do act through influence upon enzyme production. There are definite evidences that nucleic acids are involved in growth. Roychoudhary and Sen (1964) found that application of auxins to peas resulted in an enhanced RNA synthesis.

Similarly, Key and Shanon (1964) found that the incorporation of labelled nucleotides into the nucleic acid is stimulated by auxins. Collectively, these experiments imply that the regulation of growth by auxins may involve the regulation of RNA synthesis and hence, the protein synthesis. Noggle and Fritz (1976) stated that auxins might cause the movement of more sugars into the vacuoles so that more water may enter the cell till the development of sufficient wall pressure. The above findings support the mitigatory effects or Auxins and Kn towards the deleterious effects caused by UV-B to NPP.

Harvesting Index represents the economic yield or distribution of dry matter in storage parts of the plant. In the present investigation, it was reported that different treatments affect the economic yield of both the crops significantly. The UV-13 radiation caused a decrease of Ca. 10% and 33% in case of *Triticum aestivum* and *Oryza sativa* respectively. A promotory effect was noted when UV-B was given alongwith IAA 10M (40% and 8% respectively). Other growth regulators did not show any promising results on this aspect. Ambrish (1992) while working with *Cicer arietinum* reported the similar results when treated with UV-B only. Since higher concentration of UV-B radiation reduces the photosynthetic capacity of plants and hence, the deposition of food material in storage organs may affect accordingly (Teramura, 1980; Kumar, 1988). Growth regulators increase the level of dry matter production (Krishnamoorthi and Subramanian, 1954; Mukherjee and Datta, 1962; Kaushik et al., 1974; Narang, 1979; Kumar, 1981; Agrawal et al., 1994). A promotory effect was noted for Harvesting Index in the present investigation.

Shelling Percentage of both the crops were affected adversely by UV-B radiation in the present investigation. However, an increase in Shelling Percentage was reported when the crop was subjected to combine treatment of UV-B and IAA. Alteration in number of fruits and seed quality and ultimately the SP was also found adversely affected as observed by Bartholic et al. (1975), Ambler et al. (1978) and Biggs and Kossuth (1978), thus, supporting the results obtained in present study. Teramura (1983) and Ambrish (1992) also observed that UV-B radiation significantly affected the growth and yield of certain crop plants. Since, PGRs were reported to increase the Shelling Percentage significantly, as studied by Kumar (1979), Shamshery and Gangwar (1979), Kumar (1981), mitigation of UV-B induced inhibition of SP by PGRs found in the present study, is supported by the above findings and Dhingra (1999) also reported similar results while working on urd and mung beans.

SUMMARY

1. Stem growth pattern were also found affected due to both the treatments: UV-B (3-hr daily) reduced the stem growth considerably in terms of length, fresh weight, and dry weight. The length, fresh weight and dry weight were found to be reduced Ca. 29%, 28% and 33% due to UV-B radiation as compared to control. When the crops were treated alongwith plant growth regulators in combination of UV-B radiation, the permotory effect was reported and maximum mitigation of length, fresh weight and dry weight were notified as Ca. 29%, 91%, 88% respectively.
2. Leaf growth pattern was found significantly reduced with individual treatment of UV-B in terms of fresh weight, dry weight, leaf area and was reduced by Ca. In *Oryza sativa*, the inhibition due to UV-B radiation was recorded Ca. 52%, 49%, 2% respectively in leaf growth pattern. A promotory trend was recorded in combined treatment with IAA and Kn and enhanced upto 67%. 40%, 137% and 118%, 92%, 137% in fresh weight, dry weight and leaf area respectively.
3. Similarly the root growth pattern was also found affected with both the treatments. In case of *Oryza sativa* the UV-B induced inhibition was recorded ca. 40% and 48% in fresh weight and dry weight respectively. IAA improved the inhibition in combined treatment and promoted ca. 87% and ca. 92% over UV-B individual treatment for fresh weight and dry weight. Kn improved the inhibition in combined treatment and promoted Ca. 62% and 90% as compared to UV-B individual treatment for the fresh weight and dry weight of root.
4. Fruiting is the index of the yield of crops. It was also found affected significantly due to individual and combined treatments of UV-B with different PGRS. In *Oryza sativa*, the inhibition was recorded as ca. 35% and 36% respectively in fresh and dry weight of fruit as compared to control. IAA improved the deleterious effects when given in combination and improved by ca, 17% and 104% in fresh and dry weight of fruits respectively. Kn when given alongwith UV-B as compared to individual UV-B exposure brought about an improvement of ca. 34% and 95% in fresh and dry weight of fruit of Rice.
5. Standing crop of biomass was found increased consistently and linearly in both the crops up to maturity except leaf biomass, which was found, reduced at maturity due to leaf fall. UV-B was found affecting biomass of each component when supplied individually in both the crops. The total biomass was found reduced by Ca. 65% as compared to control. In case of *Oryza sativa*, when UV-B was given, the total biomass was found reduced by Ca. 49% as compared to control. When (IAA + UV-B) and (Kn + UV-B) was considered, the total biomass was found to improved by ca. 90% and 69% as compared to UV-B treatment alone.
6. Net primary production was calculated at 15-day intervals of growth for both the crops in all treatments. Overall, results of net production follow the trend of standing crop of biomass. UV-B was found to reduce the production potential when given individually and an improvement was recorded when subjected alongwith PGRs over individual treatment of UV-B.

When the crops were treated with UV-B treatment alongwith Kn the maximum value of T.N.P. were found at 105 day stage promoted by 77% as compared to UV-B individual treatment , 49% in case of *Oryza sativa*. It was found increased when treated with combination of PGRs and the maximum enhancement was recorded by 90% with (IAA + UV-B) and 69% with (Kn + UV-B) as compared to UV-B treatment only.

7. Storage of dry matter was calculated for both crops as affected by UV-B individually and in combination with PGRs on the basis of average biomass. In case of *Triticum aestivum*, dry matter was found affected by ca. 44% decrease in dry matter, 44% in above ground dry matter and in 20% under ground. The different above ground plant parts viz. stem, leaves, fruits etc. were accounted a

decrease of ca. 47%, 26%, 46%, respectively as compared to control. The maximum ameliorative effect against UV-B of storage of dry matter was found with both 4 treatments (UV-B + IAA), & (Kn + UV-B) amounted Ca. 14% for live matter, 12% for above ground and 41% for underground, and 41%, 41%, 8% for live matter above ground, under ground matter respectively. When *Oryza sativa* was treated with UV-B, a total decrease of Ca. 49% for live vegetation, 49% for above ground, 15% for underground and 59% for stem, 68% for leaves and 4% for fruits. When the crop was treated with UV—B alongwith IAA, promotion was noted and amounted as ca. 6%, 5%, 29% for live vegetation, above ground, under ground, stem, leave and fruits. When crops were studied with (Kn + UV—B radiation), it showed as 54%, 53%, 70%, 14% 184, 5.26 for live vegetation, above ground, under, ground, stem, leaves and fruits.

8. The dry matter dynamics was calculated c the basis of net primary productivity of different plant parts as affected by various treatments in both the crops. A decrease of *Oryza sativa* . An improvement in T.N.P. was reported due to combined treatment of UV-B and IAA and it was increased by Ca. 7% .

13. Harvesting index, a measure of economic yield in cropland ecosystem, was also studied in present study under influence of different treatments. A decrease of Ca. 33% was observed in *Oryza sativa* due to UV-B radiation. IAA was found to be most counteracting when given alongwith UV-B radiation and improved by ca. 8% in *Oryza sativa* . These results showed that responded significantly in *Oryza sativa* when combined treatment of UV-B and IAA.

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