J. Hortl. Sci.
Vol. 9(1):43-47, 2014

Effect of plant growth regulators on leaf biochemical characters and fruit yield components of bittergourd (*Momordica charantia* L.) cvs. MHBI-15 and Chaman Plus

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ABSTRACT

Effect of plant growth regulators on leaf biochemical parameters (chlorophyll pigments, sugars, nitrate reductase activity, total phenols) and fruit yield bitter gourd (*Momordica charantia* L.) was studied. The experiment consisted of foliar treatment with three plant growth regulators, GA_3 (20, 40 and 60ppm), NAA (50ppm) and CCC (100 and 200ppm) in two bittergourd varieties, MHBI–15 and Chaman Plus at 45 days after sowing (DAS). Results revealed significant difference between treatments on chlorophyll, sugar, total phenol content as also on nitrate reductase activity. Foliar application of CCC (200ppm) recorded maximum amount of total sugars (18.03% over Control), total phenol content (10.93%) as also nitrate reductase activity (16.12%). Among the treatments, application of GA_3 (20ppm) recorded maximum chlorophyll content (18.03% over Control). Highest increase in mean fruit yield over Control was recorded with application of GA_3 (20ppm) (39.88%), followed by CCC (200ppm) (34.15%) in both the cultivars.

Key words: Bittergourd, fruit yield, leaf biochemical characters, plant growth regulators

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is one of the important and popular cucurbitaceous vegetable grown in our country. It is considered as a prized vegetable owing to its high nutritive value, especially ascorbic acid, iron and medicinally important anti-diabetic property (Behera, 2004).

Plant growth regulators (PGRs) have a great potential in increasing productivity in vegetables. Growth promoters / growth retardants can be used judiciously to maximize yield in several vegetable crops. Response of a plant or plant parts to exogenous growth regulators varies with fluctuations in endogenous hormonal levels in the plant, and the manner in which natural growth regulators interact with applied growth regulators. Though plant growth regulators have a great potential to influence plant growth and morphogenesis, their application and actual assessment needs to be planned well in terms of optimal concentration, stage of application, species- specificity, season, etc. These constitute a major impediment in exploiting PGRs applicability. In view of their effect on virtually every aspect of plant growth, even a modest increase of 10-15 per cent could bring about increment in gross annual productivity by 10-15 million tons.

Fruit yield in bittergourd depends upon accumulation of photoassimilates and their partitioning to different plant parts. Yield in bittergourd was found to be strongly influenced by application of different growth regulators, thus indicating importance of these compounds in increasing yield potential through an effect on various physiological and biochemical traits. With this background, the present investigation was undertaken to find suitable plant growth regulators for increasing yield potential and quality in bittergourd.

MATERIAL AND METHODS

A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during *rabi* 2007-08. The experiment consisted of treatment combinations involving three plant growth regulators, viz., GA_3 (20, 40 and 60ppm), NAA (50ppm) and CCC (100 and 200 ppm) with two varieties of bittergourd MHBI–15 and Chaman Plus. Foliar treatments were imposed during flower initiation (45 days after sowing) in both the varieties, with three replications laid out in Factorial Randomized Block Design. Observations on leaf

biochemical characters and fruit yield components were made using standard procedures.

Extraction of chlorophyll was done following the method of Shoaf and Lium (1976) using dimethylsulfoxide (DMSO). Leaf material (250mg) was incubated for 30min at 65°C in 10ml of dimethylsulphoxide (DMSO) reagent. The supernatant was collected and volume made up to a known quantity (10ml) and absorbance read at 645 and 663nm. Using spectrophotometer (Spectro UV-VIS dual beam UVS-2700, Labomed Inc., USA), total chlorophyll, chlorophyll 'a' and 'b' were calculated and expressed as mg/g fresh weight.

Sugars were estimated following Nelson (1941). Reducing sugar content was estimated using copper and arsenomlybdate reagents. Colour development was read et 510nm using the spectrophotometer. Total sugars were estimated using anthrone reagent. Colour developed was estimated measuring absorbance at 630nm. Results were expressed as mg/g fresh wt.

Nitrate reductase activity (NRA) *in vivo* was estimated following Saradhambal *et al* (1978) by leaf disc method using NNEDA and sulphanilamide. Pink colour development was read using a spectrophotometer at 540nm. Activity of nitrate reductase was expressed as nmoles of NO_2 formed per gram fresh weight per hour. Estimation of total phenols was done by Folin Ciocalteau Reagent method (Sadasivum and Manikam, 1992). Results were expressed as mg/g fresh weight.

Total fruit yield was calculated by multiplying plant population per hectare by yield per vine in three randomly labeled plants. Total number of fruits was counted on each vine. Data were subjected to analysis of variance as per Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Biochemical parameters

Plant growth regulators had a profound influence on chlorophyll content in the leaf. Significant differences were observed among treatments, but interaction effect was found to be non-significant between treatments and varieties with respect to chlorophyll 'a', 'b' and total chlorophyll content in the leaf (Table 1). Maximum increase in chlorophyll 'a' (18.9%), 'b' (14.4%) and total chlorophyll (18.03%) over the Control was recorded with GA_3 @ 20ppm. In general, chlorophyll content was significantly lower in cv. MHBI-15 compared to that in cv. Chaman Plus in all treatment combinations, including the Control. Foliar application of GA_3 (20ppm and 40ppm) resulted in higher chlorophyll content. Increase in photosynthetic rate due to GA_3 application has been attributed to enhanced ultra-structural morphogenesis of plastids and increase in Rubisco activity (Arteca and Donga, 1981). Variation in chlorophyll content due to growth regulator application may be attributed to decreased chlorophyll degradation and or increased chlorophyll biosynthesis.

Data on reducing, non-reducing and total sugars indicated significant differences between varieties and treatments (Table 2). Significant increase in reducing sugars was noticed with application of CCC. Maximum reducing sugar content (22.1%) in leaf was recorded with CCC (200ppm). Non-reducing sugars (13.6%) also increased with foliar spray of CCC (200ppm). Foliar application of CCC (200ppm) also registered significantly high increase

Table 1. Influence of plant growth regulators on chlorophyll 'a', 'b' and total chlorophyll (mg/g fresh wt.) in bittergourd leaf

Treatment	Chlorophyll 'a'			Chlorophyll 'b'			Total chlorophyll		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T1 - Gibberellic acid (20ppm)	0.956	1.006	0.981	0.222	0.239	0.230	1.178	1.245	1.211
T2 - Gibberellic acid (40ppm)	0.913	0.950	0.931	0.215	0.229	0.222	1.128	1.179	1.153
T3 - Gibberellic acid (60ppm)	0.883	0.905	0.894	0.210	0.220	0.215	1.093	1.125	1.109
T4 - Naphthalene acetic acid (50ppm)	0.935	0.797	0.866	0.215	0.230	0.222	1.150	1.027	1.088
T5 - Cycocel (100ppm)	0.898	0.915	0.906	0.210	0.217	0.213	1.108	1.132	1.120
T6 - Cycocel (200ppm)	0.864	0.883	0.873	0.205	0.212	0.208	1.069	1.095	1.082
T7 - Control	0.821	0.830	0.825	0.198	0.204	0.201	1.019	1.034	1.026
Mean	0.895	0.898	0.896	0.210	0.221	0.216	1.106	1.119	1.113
For comparing means of	S. Em±	CD (*P=0.05*)		S. Em±	CD (*P=0.05*)		S. Em±	CD (*P=0.05*)	
Varieties	0.011	NS		0.003	0.009		0.017	NS	
Treatments	0.022	0.065		0.004	0.012		0.031	0.092	
V x T	0.031	NS		0.005	NS		0.044	NS	

V_1: MHBI-I5 V_2: Chaman Plus NS: Non-significant

Table 2. Influence of plant growth regulators on reducing sugars, non-reducing sugars and total sugars (mg/g fresh wt.) in bittergourd leaf

Treatments	Reducing sugars			Non-reducing sugars			Total sugars		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T1 - Gibberellic acid (20ppm)	2.05	2.29	2.17	4.86	6.07	5.46	6.93	8.36	7.64
T2 - Gibberellic acid (40ppm)	1.98	2.25	2.11	4.87	5.95	5.41	6.85	8.20	7.52
T3 - Gibberellic acid (60ppm)	1.91	2.11	2.01	4.83	5.97	5.40	6.74	8.08	6.99
T4 - Naphthalene acetic acid(50ppm)	2.03	2.22	2.12	5.02	6.26	5.64	7.05	8.48	7.96
T5 - Cycocel (100ppm)	2.08	2.28	2.18	5.08	6.31	5.69	7.16	8.59	8.08
T6 - Cycocel (200ppm)	2.16	2.36	2.26	5.17	6.34	5.75	7.33	8.71	8.25
T7 - Control	1.78	1.92	1.85	4.55	5.57	5.06	6.33	7.49	6.96
Mean	1.99	2.2	2.1	4.91	6.06	5.48	6.91	8.27	7.59
For comparing means of	S. Em±	CD (*P=0.05*)		S. Em±	CD (*P=0.05*)		S. Em±	CD (*P=0.05*)	
Varieties	0.01	0.03		0.01	0.03		0.1	0.29	
Treatments	0.02	0.05		0.02	0.06		0.19	0.54	
V x T	0.02	NS		0.03	0.09		0.27	0.77	

V_1: MHBI-I5 V_2: Chaman Plus NS: Non significant

in total sugars (18.5%) over the Control and in other treatments. In general, higher sugar content was recorded in cv. Chaman Plus compared to cv. MHBI-15 in all the treatments. Higher accumulation of sugar in CCC treated plants might be due to higher biosynthesis of chlorophyll and photosynthesis. Our results also confirm the earlier findings of Uprety and Yadavs (1985) in oat plants.

Plant growth regulators exhibited significant differences in nitrate reductase activity (NRA) in the leaf (Table 3). The enzyme activity increased by 16% with foliar application of CCC @ 200ppm compared to that in Control. Nitrate reductase a key enzyme in nitrogen metabolism, is known to be regulated by various environmental factors apart from presence of its substrate viz., nitrate. The enzyme catalyses reduction of nitrate to nitrite (Vadigeri *et al*, 2001). Similarly, Lawlor and Fock (1975) suggested that CCC-induced increase in photosynthesis was associated with an increase in NR activity. It is generally believed that nitrate reductase activity depends upon the activity of substrate and proteinaceous compounds. Therefore, it is suggested that application of plant growth regulators results in enhanced nitrate uptake by plants (Kuchenberg and Jung, 1988). Similarly, Goswami and Srivastava (1989) also reported increase in nitrate reductase activity to the application of growth regulators. Data on total phenols as influenced by plant growth regulators indicated wide differences among the two genotypes and treatments. Cultivar Chaman Plus recorded higher total phenols compared to MHBI-15 (Table 3). All the growth regulators used significantly increased total phenol content. Among the treatments, CCC (200ppm) recorded significantly higher increase in total phenol content (10.93%) over the Control. Plant phenolic compounds have been widely reported to be substances stimulatory to plant growth and function as promoters (Ghareib *et al*, 2010). This, as reported by other workers, is made possible by mobilization of metabolites like carbohydrates and total phenols (Talaat, 2005; Talaat and Balbaa, 2010). These data indicate that total phenol content can be enhanced with application of PGRs in bittergourd.

Table 3: Influence of plant growth regulators on nitrate reductase activity and total phenols in bittergourd leaf

Treatment	Nitrate reductase activity ($nmolNO_2$ g^{-1}fr.wt. hr^{-1})			Total phenols (mg g^{-1} fresh wt.)		
	V1	V2	Mean	V1	V2	Mean
T1 - Gibberellic acid (20ppm)	118.9	179.3	149.1	13.90	14.91	14.40
T2 - Gibberellic acid (40ppm)	117.6	175.8	146.7	13.96	14.73	14.34
T3 - Gibberellic acid (60ppm)	115.6	173.4	144.5	13.86	14.64	14.25
T4 - Naphthalene acetic acid(50ppm)	121	181.9	151.5	13.95	14.79	14.37
T5 - Cycocel (100ppm)	122.9	184.3	153.6	14.07	14.95	14.51
T6 - Cycocel (200ppm)	125.8	186.9	156.3	14.24	15.38	14.81
T7 - Control	108.6	160.6	134.6	12.94	13.76	13.35
Mean	118.6	177.4	148	13.84	14.73	14.28
For comparing means of	S. Em±	CD (*P=0.05*)		S. Em±	*CD (P=0.05)*	
Varieties	1.3	3.6		0.02	0.05	
Treatments	2.4	6.8		0.03	0.09	
V x T	3.3	NS		0.04	0.13	

V_1 : MHBI-I5 V_2: Chaman Plus NS: Non-significant

Yield and yield components

Number of fruits per plant was significantly higher with foliar spray of GA_3 @ 20ppm (11.6%), followed by CCC @ 200ppm (9.6%) compared to Control (Table 4). Fruit yield per plant and fruit yield per ha were also

Table 4. Influence of plant growth regulators on yield and yield components in bittergourd

Treatment	No. of fruits / plant			Fruit yield(kg/plant)			Fruit yield(t/ha)		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T1 - Gibberellic acid (20ppm)	16.4	18.3	17.3	1.203	1.417	1.310	8.113	9.249	8.681
T2 - Gibberellic acid (40ppm)	15.7	17.5	16.6	1.087	1.318	1.202	7.650	8.922	8.286
T3 - Gibberellic acid (60ppm)	15.2	16.8	16.0	1.059	1.252	1.155	7.398	8.579	7.988
T4 - Naphthalene acetic acid(50ppm)	15.6	16.7	16.1	1.100	1.164	1.132	7.770	8.625	8.197
T5 - Cycocel (100ppm)	15.9	17.8	16.8	1.116	1.266	1.191	7.834	8.745	8.289
T6 - Cycocel (200ppm)	16.1	18.0	17.0	1.173	1.359	1.266	8.004	9.029	8.518
T7 - Control	14.9	16.1	15.5	0.883	1.013	0.948	6.806	7.619	7.212
Mean	15.6	17.3	16.4	1.088	1.255	1.171	7.653	8.68	8.165
For comparing means of	S. Em±	CD *(P=0.05)*		S. Em±	CD *(P=0.05)*		S. Em±	CD *(P=0.05)*	
Varieties	0.2	0.5		0.06	0.172		0.014	0.039	
Treatments	0.3	1.0		0.115	0.323		0.026	0.075	
V x T	0.5	NS		0.157	0.456		0.036	0.103	

V_1: MHBI-I5 V_2: Chaman Plus NS: Non-significant

significantly higher with foliar application of GA_3 @ 20ppm, followed by CCC @ 200ppm. Lowest fruit yield was recorded in the Control. Higher fruit yield was obtained as a result of higher number of hermaphrodite flowers per plant and better vegetative growth observed by us in our earlier study (Geeta *et al*, 2010). Similar results were reported by Dostogir *et al* (2006) and Ram Asrey *et al* (2001). Significant increase in number and weight of fruits and total yield was observed in peach with application of CCC @ 500ppm (Mahajan and Sharma, 2000). Increase in fruit yield of treated plants may be further attributed to the fact that plants remain physiologically active to build up sufficient amount of assimilates for developing flowers and fruits, thereby, leading to higher yield. Improvement in yield could come about in two ways, i.e., by the existing varieties adapting to grow better in their environment, or, by altering the relative proportions of different plant parts to increase the yield of only the economically important parts (Pankaj *et at*, 2005). In addition, crop yield depends not only on accumulation of photosynthates during crop growth and development, but also on its partitioning to desired storage organs. These, in turn, are influenced by efficiency of the metabolic processes within a plant. Growth retardants are capable of redistributing dry matter in the plant, thereby bringing about yield improvement (Chetti, 1991).

From these results, it can be concluded that all PGR foliar treatments differed significantly for both the varieties in all the traits studied with reference each other and in Control plants. Among the different treatments, GA_3 @ 20ppm enhanced chlorophyll content. Significantly higher NRA, reducing, non-reducing and total sugars, and, total phenols were recorded with CCC (200ppm), and the lowest was recorded in Control. However, maximum number of fruits per plant was recorded with GA_3 (20ppm) followed by CCC (200ppm) and various treatments differed significantly with respect to fruit yield (kg/plant and t/ha), with GA_3 (20ppm) showing highest values compared to all other treatments.

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(MS Received 04 April 2013, Revised 04 November 2013, Accepted 20 January 2014)