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Effect of biostimulants on yield and post harvest quality of gladiolus cv. WHITE PROSPERITY

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ABSTRACT : The investigations on gladiolus cv. WHITE PROSPERITY were carried out at the Horticultural Research Station Yercaud, Salem district, during 2009-2010 to find out the effect of biostimulants on gladiolus with reference to growth, yield and post harvest quality attributes. The experiment was laid out in Randomized Block Design consisted of three biostimulants *viz.*, humic acid, *Panchagavya*, vermiwash and combinations comprising of seven treatments. Various growth characters were recorded at 15 days interval after planting. The yield components were recorded after spike emergence. The post harvest quality attributes were analysed after harvest. The physiological characters were also studied from 45 days after planting. The study revealed that, gladiolus showed better response to the foliar application of 0.2 per cent humic acid significantly. All the morphological parameters exhibited positive and better response in humic acid treatment compared to other biostimulants and its combination. The economic traits were positively influenced by humic acid application. Foliar application of 0.2 per cent humic acid led to early spike emergence (46.46 days) than control (55.33 days). The highest spike length, rachis length and number of floret per spike were higher in foliar application of 0.2 per cent humic acid. This also increased the yield of spike per plant and per square meter with regard to the post harvest quality characters, longevity of cut spike in tap water and in 2 per cent sucrose were greatly influenced by the same treatment. Foliar application of 0.2 per cent humic acid increased corm weight, corm diameter and number of cormels.

KEY WORDS : Gladiolus, INM, Biostimulants, Foliar spray

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Gladiolus is ideal both for use in garden and floral decorations. Nutrition is one of the most important aspects in increasing the yield and quality of gladiolus spikes. After the green revolution, use of chemical fertilizers and pesticides in plant production has increased, which is dangerous to the ecology and environment. Thus, the application of nutrients in small doses applied more frequently favours better growth and flower production. But, excessive use of chemical fertilizers and pesticides impose threat to the ecology and environment. Organic farming is one of the possible solutions for this problem, in recent days, biostimulants have emerged as a supplement to mineral fertilizers and hold a promise to improve yield as well as quality of the crop.

In India, a survey by agricultural and processed food products export development authority (APEDA) reveals that, since 1992, nearly 150000 hectare of agriculture and has been dedicated to export oriented cultivation of cut flower crops meant primarily for dutch market (Narayana Gowda, 1998). Broadly, floriculture products include bulbs, tubers, tuberous roots, corms, cuttings, and

their slips, cut flowers and flower buds, foliage, branches and other parts of plants, fresh, dried, dyed and bleached. Among the top four cut flowers in global trade, rose ranks first followed by carnation, chrysanthemum and gladiolus. Out of these cut flowers, gladiolus is greatly favoured for its magnificent spikes on which florets are arranged in raceme and open one by one.

In India, gladiolus are grown round the year in Bangalore (Mukhopadhyay and Banker, 1986) and with regard to Tamil Nadu, it is grown in few places like Ootacamund and Kodaikanal. Cultivation on a large scale is not take up in the plains. This paves the way to undertake this study by adopting foliar application of biostimulants, which can be combined or replaced further with in organic fertilizer.

With this view, to identify and standardize the concentration of biostimulants for increasing the growth, yield and quality of gladiolus cv. WHITE PROSPERITY this study was conducted with the following objectives :

- To assess the impact of biostimulants on the growth and yield of gladilolus
- To improve the quality of spike.

RESEARCH METHODS

The present investigation was carried out during 2009-2010 on the effect of biostimulants on yield and post harvest quality of gladiolus cv. WHITE PROSPERITY. The experiment was laid out in a Randomized Block Design (RBD) with seven treatments replicated thrice. The field lay out and randomizations of treatments of plot of size 1.2 × 1.2m (1.44 m^2) was used per treatment carried out as per the statistical methods given by Panse and Sukhatme (1985). The experiment was conducted in the field at Horticultural Research Station Yercaud, Salem district, which is located at 11° 4' to 11° 5'N Latitude, 78° 50' to 78°23' E Longitude and at an altitude of 1500 m above mean sea level. The mean annual rainfall of Yercaud is 1572.0 mm with 47 rainy days. The average maximum and minimum temperature is 31.0 °C and 12.4 °C, respectively. The average relative humidity is 75 per cent. The soil of the experimental field was sandy clay loam. Organic manures like farm yard manure (FYM), digested coir compost (DCC) and vermicompost were applied as soil application through basal dressing as per the treatment schedule. The inorganic fertilizers used for this experiment were urea, super phosphate and muriate of potash. The nitrogen was supplied in the form of urea, phosphorus in the form of single super phosphate and potassium in the form of muriate of potash. The recommended dose of fertilizers *viz.*, NPK 30:20:30 g per m^2 was applied as per the treatment. The humic acid used for application was the commercial product obtained from a Private company at Salem. Humic acid was applied at a concentration of 0.2 per cent by mixing 2 ml of liquid humic acid in 1 lit of water. For preparation of *Panchakavya*, five kg of fresh cow dung and 1 lit of ghee were mixed well by hand and kept in a plastic bucket for 3 days under shade. This was stirred once in a day and then on 4th day the remaining ingredients were added to the mixture, mixed well and transferred to a wide mouth mud pot covered with a wire mesh and kept under shade. Upto 15th day, this slurry was mixed well twice a day. After 15 days, the slurry which emits fermented odour was diluted to 3 per cent and then sprayed. Five hundred gram of earthworm was placed on a wide mouth funnel containing filter paper. This was placed on top of a conical flask. The earthworm was sprayed with water in the morning and evening to keep them moist. The coelomic fluid collected in the flask due to the rubbing of worms on each other was used as stock solution. This was diluted and 3 per cent vermiwash solution was used for spraying.

The humic acid 0.2 per cent, *Panchagavya* 3 per cent and vermiwash 3 per cent were sprayed at various stages of crop growth at fifteen days interval *viz.*, 15, 30, 45 and 60 days after planting (DAP) as per the treatment schedule. Observations on growth and floral parameters were recorded at monthly interval and the mean data were subjected to statistical scrutiny. The treatment details are furnished below :

T_1 - Control
T_2 - Humic acid 0.2 per cent
T_3 - *Panchagavya* spray 3 per cent
T_4 - Vermiwash 3 per cent
T_5 - Humic acid 0.2 per cent + *Panchagavya* spray 3 per cent
T_6 - Humic acid 0.2 per cent + Vermiwash 3 per cent
T_7 - Humic acid 0.2 per cent + *Panchagavya* spray 3 per cent + Vermiwash 3 per cent.

RESEARCH FINDINGS AND DISCUSSION

The effect of biostimulants on growth, flowering, yield and post harvest quality was assessed on gladioli cv. WHITE PROSPERITY and the results of the experiments are presented in Table 1, 2 and 3.

The plant height was recorded at fifteen days interval and it was observed that the treatments had significant effect on plant height during the period of growth. The results indicated an increasing trend in plant height with 0.2 per cent application of humic acid among the various treatments, 0.2 per cent humic acid (T_2) recorded the maximum plant height of 78.60 cm followed by 3 per cent *Panchagavya* (T_3) with 76.24 cm (Table 1). The most important morphological characters that have bearing on the growth of crop are plant height, number of leaves, leaf length and leaf breadth and these characters were significantly influenced by the biostimulants. Application of humic acid 0.2 per cent had significantly promoted the plant height, number of leaves, leaf length and leaf breadth. The possible reason for this acceleration of growth might be due to the effect of humic acid on cell elongation. The plant growth regulator activity of humic substances could be due to both a direct action of soluble humic complexes and an increase of endogenous hormone concentration in the tissues as a consequence of the inhibition of some catabolic enzymes such as IAA oxidase by soluble humic complexes as suggested by Cacco and Dell'Angola (1984). The direct effect of humic acid that enters into plant growth refers to regulation of nutrient availability similar to synthetic exchanges. Humic acid that enters into plant, mediates in respiration, acts as hydrogen acceptor, alerts the carbohydrate metabolism of plants and thus, promotes the accumulation of sugar.

Application of humic acid 0.2 per cent also recorded higher plant height, number of leaves, leaf length and leaf breadth and this might be due to the presence and enhanced activity of gibberellin like substances in humic acid which might have lead to increase in plant height, number of leaves, leaf length and leaf breadth as reported by Vaughan *et al*. (1985). The highest plant height observed with 0.2 per cent humic acid application might be attributed to the increase in the up take of N, P, Fe, and Cu which had resulted in enhanced plant height. These findings are in accordance with the reports of Adani *et al.* (1998) in tomato. Bohme and Papadopoulos (1999) reported that humic acid increased the content of calcium in shoots, leaves and fruits of tomato in hydroponic system. The growth stimulation by humic acid might be due to the effect on prolonged cell elongatoion. Cell elongation is ceased by a rapid increase in wall bound hydroxyl proline by complexing iron within the plant, which removes the iron from a key biochemical reaction involving hydroxyl proline synthesis. This mechanism reported by Vaughan (1974) could be applied for the effect of humic acid on increased plant height. Apart from that, carbonic acids in soil might have dissolved have the reserve mineral substances and made it more readily available to the plants. This could also have increased the plant height in gladiolus. This is in agreement with the work of Khandkar and Nigam (1996) in ginger.

The treatment T_2 (humic acid 0.2 % foliar spray) produced more number of leaves (10.20). This may be ascribed to the fact that humic acid has the optimum C:N ratio, which on decomposition releases nitrogen in the form of usable nutrient ions such as ammonium and nitrate. This increase in the mineral constituents might have exerted more number of leaves, since nitrogen is the chief constituent of amino acid and coenzymes of biological importance. This is in concurrence with the findings of Maheswarappa *et al*. (2001) in galangal.

The maximum leaf length and width of 53.26, 5.05 cm was recorded in T_2 -0.2 per cent humic acid, respectively. Foliar application of humic acid 0.2 per cent produced lengthier and broader leaves in gladilolus. A higher length and breadth of leaves due to the presence of precursors of growth substance *viz*., IAA in humic

Table 1 : Effect of biostimulants on morphological characters in gladiolus cv. WHITE PROSPERITY

Treatments	Plant height (cm)	Number of leaves/plant	Leaf length (cm)	Leaf breadth (cm)
T_1 - Control	67.08	8.2	37.04	4.00
T_2 - Humic acid 0.2%	78.60	10.2	53.26	5.05
T_3 - *Panchagavya* spray 3%	76.24	9.13	48.62	4.83
T_4 – Vermiwash 3%	68.55	8.53	39.10	4.11
T_5 – Humic acid 0.2% + *Panchagavya* spray 3%	73.82	9.0	46.28	4.42
T_6 – Humic acid 0.2% + Vermiwash 3%	70.38	8.73	43.51	4.11
T_7 – Humic acid 0.2%+*Panchagavya* spray 3%+Vermiwash 3%	74.21	9.73	50.47	4.70
Mean	72.7000	9.0762	45.4324	4.4643
S.E. ±	0.7239	0.3409	0.3010	0.0589
C.D. (P=0.05)	1.5773	0.7427	0.6559	0.1282

acid, could have increased the length and breadth of leaves. The present findings are in agreement with the observations of Cosenova *et al*. (1990). The increase in the length and breadth of leaves might be due to the higher uptake of nutrients,especially iron and magnesium from the soil resulting in greater photosynthetic area as both elements are needed much for photosynthetic process and thereby exerted lengthier and broader leaves. Similarly, in ginger Khandkar and Nigam (1996) observed that humic acid influenced the length positively and breadth and it is consonant with the present investigation.

Application of 0.2 per cent humic acid had taken lesser number of days for spike emergence (Table 2). This might be due to the increased synthesis and enhanced activity of cytokinin and auxin in the root tissue, due to translocated of humic acid and their substances transported to auxillary buds, that would have resulted in a better source mobilization of assimilates from the source to sinks at a faster rate. This would have helped in the early transformation and early spike emergence. The induction of early spike emergence initiation might have been influenced by triggering of such metabolic activity and narrowing of the C: N ratio by the significant accumulation of carbohydrates. The nutrients movement from source to sink would have taken place in a consistent manner and made the nutrient available to all plant parts for quick development of spike emergence. The result obtained in the study is in accordance with the findings of Vaughan *et al*. (1985).

The data on the number of days taken for spike emergence revealed that there was significant difference among treatments with application of biostimulants. Spike emergence was earlier in 0.2 per cent humic acid treatment (46.46 days) (T_2) than the other treatments. Application 0.2 per cent humic acid had taken lesser number of days to flowering when compared with other biostimulants. Balanced nutrition is of considerable importance in improving the yield and reducing the duration of flowering. The higher production of auxin and growth substances by humic acid at early phase of growth would have contributed to early flowering and reduction in the duration of flowering. This could also be attributed to the gibberellin like activity of humic acid as reported by Vaughan *et al.* (1985).

There was significant effect due to biostimulants spray on the number of days taken for 50 per cent flowering. Fifty per cent of the florets in a spike took a minimum of 59.66 days to open in (T_2). A positive significant effect was observed on the number of days taken for fifty per cent flowering and number of flower that remained open at a time due to the application of 0.2 per cent humic acid spray. Humic acid contain cytokinin and auxin that increased the antioxidant levels and resistance to senescence (Zhang and Schmidt, 2000). The presence of calcium in humic acid might have reduced the rate of respiration, decay and prevented cellular disintegration by maintaining protein and neucleic acid synthesis. This mechanism has also been reported by (Bohme and Papadopoulos, 1999).

The minimum number of florets remained open at a time in (2.90 days) (T_2) followed by (T_7) with 3.10 days. Humic acid 0.2 per cent treatment recorded the highest number of florets per spike in gladiolus. The

Table 2 : Effect of biostimulants on flower characters in gladiolus CV. WHITE PROSPERITY

Treatments	Number of days taken for spike emergence	Number of days taken for flowering	Days to 50 % flowering	Number of florets that remain open at a time	Spike length (cm)	Rachis length (cm)
T_1 - Control	55.33	65.80	70.3	4.06	47.21	87.86
T_2 - Humic acid 0.2%	46.46	56.66	59.66	2.90	59.84	120.17
T_3 - *Panchagavya* spray 3%	52.86	63.46	68.10	3.43	53.97	97.34
T_4 – Vermiwash 3%	51.66	61.66	63.96	3.93	47.33	90.70
T_5 – Humic acid 0.2%+ *Panchagavya* Spray 3%	49.66	59.86	63.33	3.63	48.80	99.54
T_6 – Humic acid 0.2% + Vermiwash 3%	52.53	62.8	65.83	3.73	47.56	92.39
T_7 – Humic acid 0.2%+ *Panchagavya* spray 3%+ Vermiwash 3%	49.60	59.53	62.16	3.10	54.33	103.08
Mean	51.1619	61.5905	64.7671	3.5524	51.3276	99.0352
S.E. ±(d)	0.3909	1.4501	0.4058	0.0926	0.6833	0.9396
C.D. (P=0.05)	1.8517	3.1596	0.8843	0.2017	1.4889	2.0472

higher production of auxin and growth substances by humic acid at early phase of growth would have contributed to the formation of more floral bud formation. This might be due to activity of humic acid consisting of active phenolic group that might have inhibited oxidase activity and promoted the prolonged persistence of IAA in plants which might have contributed to the increased number of florets per spike. Inhibition of peroxidase activity by humic acid due to auxin breakdown promoting the number of florets was reported by Muscolo *et al.* (1993). The increased florets production could also be attributed to the gibberellin like activity of humic acid, as reported by Vaughan *et al.* (1985).

The length of the florets was found to be more in the treatment (T_2) with 11.08 cm (Table 3). The treatment with the application of humic acid 0.2 per cent recorded the highest length of floret. The floret length stimulation by humic acid might be due to the effect on prolonged cell elongation. In general, cell elongation is ceased by a rapid increase in wall bound hydroxyl proline by complexing iron within plant, which removes the iron from a key biochemical reaction involving hydroxyl proline synthesis. The gibberellin like activity of humic acid also increased the floret length. This mechanism reported by Vaughan (1974) could be applied for the effect of humic acid on increased floret length.

The floret diameter recorded on the third day of floret opening indicated that the diameter of the floret ranged between 8.93 cm and 10.82 cm. The maximum diameter was observed in the treatment (T_2) with 10.82 cm. Significant variation was observed due to the treatments imposed. Maximum floret diameter was observed in the plants sprayed with 0.2 per cent humic acid. Cytokinin inhibits the longitudinal growth, but increases the diameter of the floret. The results of present study are well supported by Cacco and Dell' Angola (1984).

The length between florets was also found to be maximum in 0.2 per cent humic acid (T_2) spray with (5.57 cm). The treatment with the application of humic acid 0.2 per cent recorded the highest length between florets. Length stimulation by humic acid might be due to the effect on prolonged cell elongation. A rapid increase in wall bound hydroxyl proline by complexing iron within plant, removing the iron from a key biochemical reaction involving hydroxyl proline synthesis leads to cell elongation. The gibberellin like activity of humic acid might have also increased the length between florets. Apart from that, carbonic acids in soil dissolved might have the reserve mineral substances and made it readily available to the plants. This could also have increased distance between florets in gladiolus (Vaughan, 1974).

The rachis length was also found to be maximum in 0.2 per cent humic acid (T_2) spray (120.17 cm). The increase in spike and rachis length was observed with the application of humic acid 0.2 per cent. This could be due to the slow release of nutrients from soil resulting in greater up take of nutrients, which might have exerted greater spike and rachis length. Humus substances present in humic acid could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. This would have helped the better availability and utilization of nutrients. All these scavenging effects might have made quick

Table 3 : Effect of biostimulants on flower characters in gladiolus cv. WHITE PROSPERITY

Treatments	Number of floret / spike	Floret length (cm) /spike	Diameter of the floret on 3rd day opening	Distance between fourth and fifth floret / spike	Yield of spike/plant	Yield of spike/ square meter
T_1 - Control	12.40	8.99	8.93	4.54	1.13	12.59
T_2 - Humic acid 0.2%	15.33	11.08	10.82	5.57	2.00	22.21
T_3 - *Panchagavya* spray 3%	14.4	10.07	9.92	5.15	1.46	16.29
T_4 - Vermiwash 3%	12.46	9.44	8.99	4.44	1.33	14.14
T_5 – Humic acid 0.2%+- *Panchagavya* spray 3%	13.86	9.64	9.98	4.81	1.40	15.55
T_6 – Humic acid 0.2%+ Vermiwash 3%	12.60	9.00	9.15	4.74	1.13	13.33
T_7 – Humic acid 0.2%+- *Panchagavya* spray 3%+ Vermiwash 3%	14.60	9.71	9.12	4.96	1.60	17.77
Mean	13.6667	9.7081	9.6200	4.8905	1.4381	16.0795
S.E. ±	0.2675	0.1711	0.1015	0.1012	0.1234	1.3615
C.D. (P=0.05)	0.5827	1.3728	0.2212	0.2205	1.2690	2.9665

mobilisation of availabile nutrients, which would have aided in increasing cell division and cell elongation. This in turn could have assisted for greater spike and rachis length. This is in confirmation with findings of Mato and Mendez (1970).

The treatment 0.2 per cent humic acid (T_2) recorded maximum longevity of spike in plant (7.63 days) and minimum longevity of spike in plant (6.53 days) was observed in control (T_1) (Table 4). Foliar spray of 0.2 per cent humic acid improved the vase life in gladilolus over and above other treatments and control. This might be attributed due to the entry of humic acid into the plant, which might have mediated the respiration by acting as an hydrogen acceptor, and thus, altering the carbohydrate metabolism of plants promoting the accumulation of sugar as inferred by Cacco and Dell'Agnola (1984). Humic acid contain cytokinin and auxin that might have increased the antioxidant levels and resistance to senescence. Zhang and Schmidt (2000) leading to enhanced longevity of spike.

The yield of spike per plant was maximum in the treatment (T_2) 0.2 per cent Humic acid (2.0 spikes per plant) and minimum in (T_1) and (T_6) 1.13 (Table 3). The same trend was observed in the yield of spike per meter square. The treatment (T_2) yielded a maximum of 22.21 spikes /meter square, while the control (T_1) yielded 12.59 spikes per meter square. An increase in the number of spike per plant and per square meter was observed due to 0.2 per cent humic acid spray. This might have been aided by the balanced nutrition made available to the crop by the production of auxin like growth substances by humic acid at early phase of development. The result obtained in the current study is in accordance with that of Vaughan *et al.* (1985). The result are in concurrence with that of Suguna (2005), who reported a significant improvement in the growth and yield of carnation var. Mistral and that of Sathish (2006) in turmeric. Humic acid which consisted of active phenolic group would have inhibited oxidase activity and promoted the prolonged persistence of IAA in plants that might have contributed to the increased yield of spike as opined by Muscolo *et al.* (1993).

The treatment 0.2 per cent humic acid (T_1) recorded maximum vase life in sucrose 2 per cent solution (13.80 days) and minimum vase life was found in control (T_1) (11.80 days) (Table 4). The treatment with application of 0.2 per cent humic acid increased the longevity of cut spike in sucrose 2 per cent recorded the highest vase life in gladiolus. Sugar content was increased in the tomato fruits due to humic acid and their substances. The increased vase life might be due to by triggering of such metabolic activity and narrowing of the C:N ratio by the significant accumulation of carbohydrates. Humic acid that enters into plant, mediates in respiration, acts a hydrogen acceptor, alters the carbohydrate metabolism of plants and thus, promotes the accumulation of sugar (Cacco and Dell'Agnola, 1984). The treatment 0.2 per cent humic acid (T_2) spray at fifteen days interval recorded the maximum vase life in tap water (9.33 days) and the minimum vase life was found in control (T_1) (8.16 days).

The presence of humic substances in plant tissues should have changed the metabolic process of plants, imparting resistance to certain phytopathogens. The humic acid complex retained with in the tissues might have prevented bacterial accumulation in the tissues during post harvest period (Vaughan *et al.*, 1985). Rauthan and schnitzer (1981) had reported increased

Table 4 : Effect of biostimulants on longevity of cut spike in gladiolus cv. WHITE PROSPERITY

Treatments	Longevity of spike in plant	Longevity of spike in tap water	Longevity of spike in 2% sucrose
T_1 - Control	6.53	8.16	11.80
T_2 - Humic acid 0.2%	7.63	9.33	13.80
T_3 - *Panchagavya* spray 3%	7.06	8.83	13.46
T_4 - Vermiwash 3%	6.76	8.46	12.00
T_5 – Humic acid 0.2% +- *Panchagavya* spray 3%	7.16	8.80	12.93
T_6 – Humic acid 0.2% + Vermiwash 3%	6.73	8.36	12.30
T_7 – Humic acid 0.2% + *Panchagavya* spray 3% + Vermiwash 3%	7.43	8.46	13.06
Mean	7.0476	8.6333	12.7667
S.E. ±	0.1291	0.1089	0.2122
C.D. (P=0.05)	0.2813	0.2372	0.4623

cell membrane permeability due to presence of humic substances in cucumber and this phenomenon-might have helped in improving the shelf-life of gladioli.

The treatment 0.2 per cent humic acid (T_2) recorded maximum of 22.33 cormels per plant and the minimum 15.66 cormels per plant was observed in control (T_1) (Table 5).

Foliar spraying of 0.2 per cent humic acid expressed a positive significant influence on the corm weight, corm diameter and number of cormels per plant. This might be due to the translocation of humic compound to different parts of the plant, thus, enhancing the growth of the plant as opined by Rauthan and Schnitzer (1981), who observed similar results in cucumber. The plants which received 0.2 per cent humic acid (T_2) recorded maximum corm diameter of 5.19 cm and minimum was recorded in control (T_2) 4.54 cm. The increase in the corm weight, corm diameter and increased production of cormels could also be attributed to the mobilization of reserve food material to the sink through increased activity by hydrolyzing and oxidizing enzymes.

The data on the number of corms per plant revealed that there was no significant difference due to the application of biostimulants. Pertaining to the number of corms produced per plant, the variation due to the treatments was not significant. Though statistically not significant, the treatment T_2 produced 1.86 corms per plant while treatment T_1 1.33 corms per plant. However, the analysis indicated a significant difference in corm weight due to the treatments imposed. Single corm weight ranged between 36.26 g per corm to 51.20 g per corm. Single corm weight was maximum in (T_2) (51.20 g) while it was minimum in (T_1) (36.26 g).

The enhancement in plant height, number of leaves and thus, leaf area would have paved the way for increased photosynthetic activity causing the accumulation of photosynthetes. Yet another possibility suggested by Mato and Mendez (1970) is that the humic substances are capable of chelating metal ions,such as Fe, Zn etc., retained in exchangeable form in the soil. This form of nutrients are easily absorbed by the plants leading to improved metabolic activity that might have led to increase in corm weight, corm diameter, and production of more number of cormels per plant in the present study.

Sadanandan and Hamza (1998) obtained similar results in ginger and suggested that the humic acid acting as a good source of carbon and nitrogen might have improved the efficiency of biofertilizers activity, thus, aiding in photosynthate accumulation. The same phenomenon might have operated in gladioli crop leading to the increase in corm weight.

The treatment T_2, humic acid 0.2 per cent foliar spray increased the leaf area significantly (Table 6). This may be ascribed to the fact that the optimum C: N ratio in humic acid on decomposition had helped in the release nitrogen as usable nutrient ions such as ammonium and nitrate. The increase in mineral constituents in the plants have exerted high leaf area, since nitrogen is the chief constituent of amino acid and coenzymes of biological importance. The findings is in concurrence with the findings of Maheswarappa *et al.* (2001) in galangal. The results revealed that there was a significant difference in the total leaf area content among the various treatments of application biostimulants. A significant increase in leaf area per plant was recorded by biostimulants substances used in this investigation. Among the treatments the plants at (T_2) 0.2 per cent humic acid has recorded highest total leaf area of 168.93 cm^2 which was significantly highest compared to all other

Table 5 : Effect of biostimulants on corms and cormels in gladiolus cv. WHITE PROSPERITY

Treatments	Number of corms	Corms weight (g)	Corm diameter (cm)	Number of cormels
T_1 - Control	1.33	36.26	4.54	15.66
T_2- Humic acid	1.86	51.20	5.19	22.33
T_3 - *Panchagavya* 3%	1.73	43.20	4.91	18.80
T_4 - Vermiwash 3%	1.46	37.26	4.70	16.33
T_5 – Humic acid 0.2% + *Panchagavya* 3%	1.53	40.53	4.88	18.13
T_6 – Humic acid 0.2% + Vermiwash 3%	1.40	40.00	4.63	16.33
T_7 – Humic acid 0.2% + *Panchagavya* 3% + Vermiwash 3%	1.8	48.06	5.18	17.20
Mean	2.4476	2.3619	4.8657	17.8095
S.E. ±(d)	3.3061	2.7133	0.0741	1.7918
C.D. (P=0.05)	7.2035	5.9118	0.1615	3.9041

treatment.

Foliar spraying of humic acid would have increased the mineralization of organic matter that might have had a stimulatory effect on nitrogen, iron and magnesium uptake by plants leading to the increase in the number of leaves and leaf area, apart from chlorophyll content. The increase in leaf area may be attributed to the presence of some growth substances *viz.*, IAA present in humic acid.

The results indicated that the biostimulants substances had significant effect on leaf area index. The biostimulants are substances enhanced the leaf area index significantly regardless of its type or concentration. The highest leaf area index was noted in the treatment 0.2 per cent humic acid (T_2) value of 0.140 lit was followed by the treatment with the application of T_7 which recorded value of 0.137 leaf area index.

The plants ultimately depend on green leaf surface for physiological activity as the leaves intercept solar radiation and produce photosynthates through photosynthesis. The production, expansion and survival of green leaf area are important determinants of crop productivity. Highest leaf area index was observed with application of 0.2 per cent humic acid, that might be due to the activity of gibberellins leading to broader and elongated leaves, which in turn increase the leaf area index (Vaughan *et al.*, 1985).The results are consistent with the findings of Bohme *et al.* (2001) who reported 105 per cent increase in leaf area of cucumber by humic acid application. Similar observations of increases in leaf area were made by Medeiros *et al.* (2001) in lettuce. Increased leaf area index due to humic acid treatment could also be attributed to the enhanced nutrient and water uptake by plants as suggested by Liu *et al.* (1998)

Chlorophyll content :

The leaf chlorophyll content is the key factor determining the rate of photosynthesis. It is also considered as an index of metabolic efficiency of the plant to utilize the absorbed nutrients. Chen *et al.* (2001) reported that photosynthetic rate of cucumber was highly correlated with chlorophyll content.

The study on the effect of biostimulants substances on chlorophyll 'a' content of gladiolus revealed that there was significant increase in chlorophyll 'a' by the application of biostimulants substances was observed. The treatment with the application of 0.2 per cent humic acid (T_1) recorded the highest (1.07 mgg^{-1}) of chlorophyll 'a' content followed by the treatment (T_7) which recorded (0.98 mg g^{-1}) (Table 6).

Highest chlorophyll content was registered with the application of 0.2 per cent humic acid. The increase in uptake of Fe+ and Mg + might have resulted in enhanced chlorophyll synthesis. These findings are in accordance with the reports of Perg *et al.* (2001) in brassica. Experiments of Sladky (1959) showed 63 per cent increase in chlorophyll content due to the up take of Mg+ and Fe^{2+} in the presence of humic acid that resulted in enhanced chlorophyll synthesis. Humic substances are capable of chelating metal ion such as Fe, Mg etc. and retain them in soil in an exchangeable form. The humic acid sprayed on the leaves might have translocated to the other parts of the plants, including roots. The root lechates containing very low concentration of humic acid might have helped in the chelation of metal ions in soil making them available in absorbable and usable form for plant growth. Which might have attributed to increased chlorophyll content in the leaves and thus, photosynthetic efficiency causing more perfectional influx of

Table 6 : Effect of biostimulants on physiological characters in gladiolus cv. WHITE PROSPERITY

Treatments	Leaf area	Leaf area index	Chlorophyll-a	Chlorophyll-b	Total chlorophyll
T_1 - Control	134.89	0.114	0.74	0.25	0.32
T_2 - Humic acid 0.2%	168.93	0.140	1.07	0.60	2.18
T_3 - *Panchagavya* spray 3%	158.78	0.132	0.94	0.46	1.15
T_4 - Vermiwash 3%	144.38	0.120	0.79	0.32	0.66
T_5 – Humic acid 0.2%+- *Panchagavya* spray 3%	154.42	0.128	0.87	0.38	0.86
T_6 – Humic acid 0.2%+ Vermiwash 3%	149.60	.124	0.83	0.36	0.70
T_7 – Humic acid 0.2%+ -*Panchagavya* spray 3% + Vermiwash 3%	164.56	0.137	0.98	0.51	1.60
Mean	154.06	0.127	088	0.41	1.06
S.E. ±	0.8998	0.007	0.0094	0.0098	0.0519
C.D. (P=0.05)	1.9606	0.0016	0.0205	0.0213	0.1131

photosynthetaes to the sink.

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