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SHORT COMMUNICATION

INFLUENCE OF SODIUM DIKEGULAC ON GROWTH, METABOLISM AND YIELD OF SAFED MUSLI

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Foliar application of a plant growth retardant sodium dikegulac (NaDK) at 100, 200 and 300 µg ml^{-1} on 16-days-old safed musli (*Chlorophytum borivilianum* Sant. et Fernand.) enhanced potential status of the plants. This was measured in terms of shoot length, leaf length, leaf width, total number of leaves and leaf area per plant at 3 different stages (30, 60 and 90 days) of plant growth. NaDK deferred senescence of the contributory leaves as evidenced from the chemical-induced alleviation of the loss of chlorophyll, protein, DNA and RNA contents as well as catalase activity in leaves. NaDK also averted the deleterious effect of the increase of amylase activity and significantly extended the days to maturity of plants. These changes were associated with enhancement of length and thickness of fleshy roots, as well as total number and yield of tuberous roots per plant. NaDK 200 µg ml^{-1} exerted the best response for coveted modulation of growth, metabolism and crop yield. The importance of NaDK as promising chemical for manipulation of growth and productivity of safed musli is discussed.

***Key words*: *Chlorophytum borivilianum*, crop yield, foliar spraying, metabolism, plant growth, sodium dikegulac.**

Safed musli (*Chlorophytum borivilianum*, Family Liliaceae) holds an important position in Indian herbal medicine. Fasciculated roots of this species are widely used as holistic treatment with special significance to impotency, control of hypertension, blood sugar, joint pains and commonly used as an aphrodisiac in sex clinics with the property of total body rejuvenation. In the *Ayurvedic* literature safed musli is described as *divya aushad* due to its excellent medicinal properties. It is used in the preparation of over one hundred herbal drug formulations (Oudhia 2001). Amongst 13 species of safed musli known to occur in India, *Chlorophytum borivilianum* produces the highest yield and highest saponin (2-17%) content in comparison to other species (Bordia *et al.* 1995). Notified by the Government as an endangered species, mainstream cultivation is the only means and it is high time to devise methods or technologies to enhance productivity of this high value medicinal plant. Keeping in mind the prospect of this plant and the problem of enhancement of productivity, a comprehensive research program has been undertaken with the prime objective to identify suitable agrotechniques for manipulation of growth and productivity. In the present communication the effects of NaDK, a promising plant growth retardant, on regulation of some growth, biochemical parameters and yield attributes of safed musli, are reported.

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Field experiment was conducted at the research field of Bose Institute, Kolkata. The design of the experiment was a simple factorial randomized block design (RBD) with three replications. Planting materials (wet tubers with crown) of safed musli were purchased from medicinal garden of Ramkrishna Mission, Kolkata, West Bengal, India. Each planting root was cut with a portion of the crown.The planting roots were then grown in the field putting 1 root/pit. The main plot was divided into subplots of 5 m x 4 m. In each subplot the tubers were grown at a spacing of 30 cm row - to - row and 30 cm plant - to - plant distance. Care was taken to have the crown at the upper side of the tuber and non-crown part at the lower end. Plantation was commenced from 1st May and it was completed before the first shower of monsoon. Tubers started sprouting immediately after the first rain on 2nd week of May. Green leaves emerged from the surface of the soil within a week, white flowers appeared after 15 days of sprouting. At 16th day of plant age, a single foliar spray was given with 100, 200 or 300 µg ml^{-1} of aqueous solutions of sodium dikegulac (2,3:4,6-di-O-isopropylidene-α-L-xylo-2-hexalo furanosate, NaDK) containing 2% Tween 20 (surfactant). Control plants were sprayed with distilled water containing Tween 20. Effect of foliar spraying with NaDK on changes in post flowering developments of safed musli plants and metabolism of the contributory leaves were analysed at 30, 60 and 90 days old plants. The mean values of 10 uniformly grown randomly selected plants were considered for recording of the growth data, *viz.* shoot length, leaf length, leaf width, leaf number and total leaf area per plant.

Chlorophyll and protein levels were analysed from leaves following the method of Arnon (1949) and Lowry *et al.* (1951) respectively. Extraction of DNA and RNA were made from 100 mg leaves following the method described by Cherry (1962) with some modification and quantitative estimation was done as per the method described by Markham (1955) modified by Choudhuri and Chatterjee (1970). Extraction and estimation of the enzymes catalase and amylase were done following the method of Snell and Snell (1971) as modified by Biswas and Choudhuri (1978) and Khan and Faust (1967) respectively. Days to maturity in the life cycle of the safed musli plant was recorded from the field grown plants. Analyses of yield attributes like length, thickness, number and weight of fleshy roots per plant were measured. For assaying of the enzymes catalase and amylase, the blank was taken as zero time control and the activity was expressed as [(ΔOD x Tv)/(t x v)], where ΔOD is the absorbance of the sample after incubation minus the absorbance of the zero time control, Tv is the total volume of the filtrate, t is the time (minutes) of incubation with the substrate and v is the volume of the filtrate taken for incubation (Fick and Qualset 1975). Statistical analysis of the data was done in terms of least significant difference (LSD) which was calculated at 95% confidence limits Panse and Sukhatme (1967).

Foliar application of safed musli plants with NaDK significantly increased the shoot length, leaf length, leaf width, total leaf number and leaf area per plant (Table 1). The chemical played a prominent role as regards the arrestation of senescence as evidenced by higher levels of chlorophyll, protein, DNA and RNA along with higher catalase activity in leaves (Table 2). NaDK also significantly alleviated the ageing-induced increase of amylase activity (Table 2) of contributory leaves which are the main assimilate transporters. Efficacy of NaDK (100 and 200µg ml^{-1}) on augmentation of crop yield can be supported from the data of delayed maturity of plants, length, thickness and number of fleshy roots per plant as well as productivity of fleshy root yield (g) per plant (Table 3).

Numerous reports exist in the literature that during all types of senescence loss of chlorophyll takes place which is due to the degradation and/or subdued rate of biosynthesis of the macromolecule (Sabater 1984, Dey and Jana 1988). Efficacy of the chemical on the delaying of leaf senescence can also be proved from the results of the changes of protein, DNA and RNA levels during plant ageing. Data revealed that like chlorophyll, protein, DNA and RNA levels also declined with the advancement of ageing process, and the chemical identically checked the rapid rate of reduction. Beevers (1977) reported that during senescence protein level declines and during reversal of senescence, a corresponding change of protein level takes place. There are reports that both chlorophyll and protein contents fall

Table 1. Effect of different concentrations of sodium dikegulac (NaDK) on changes of shoot length, leaf length, leaf width, total leaf number per plant, leaf area per plant of safed musli at three different stages.

Treatments (µg ml^{-1})	Shoot length (cm)			Leaf length (cm)			Leaf width (cm)			Total no. of leaves / plant			Total leaf area/ plant (cm^2)		
	Developmental stages (days of plant age)														
	30	60	90	30	60	90	30	60	90	30	60	90	30	60	90
Control	14.6	26.1	26.9	12.3	24.6	25.2	1.8	2.0	2.1	4.5	6.4	5.1	99.63	314.88	269.89
NaDK (100)	18.1	31.6	46.0	15.2	30.5	44.1	2.0	2.2	2.7	8.3	13.8	14.8	252.32	25.98	1762.23
NaDK (200)	25.7	42.2	65.2	20.5	39.6	52.3	2.2	3.5	3.6	9.6	17.2	19.4	432.96	2383.92	3652.63
NaDK (300)	16.3	30.3	37.6	13.6	28.2	36.1	1.9	2.1	2.3	5.1	7.4	8.3	131.78	438.22	689.14
LSD (P=0.05)	1.26	2.45	2.85	1.18	2.25	2.37	0.15	0.18	0.20	0.48	0.65	0.54	10.33	34..96	27.01

NaDK was foliarly applied at the post flowering stage (16 days old) of safed musli.

Table 2. Effect of different concentrations of sodium dikegulac (NaDK) on changes of chlorophyll, protein, DNA and RNA contents, catalase and amylase activities of the contributory leaves of safed musli at three different stages**.**

Treatments (µg ml^{-1})	Chlorophyll (mg g^{-1} fw)			Protein (mg g^{-1} fw)			DNA (µg g^{-1} fw)			RNA (µg g^{-1} fw)			Catalase (unit h^{-1} g^{-1} fw)			Amylase (unit h^{-1} g^{-1} fw)		
	Developmental stages (days of plant age)																	
	30	60	90	30	60	90	30	60	90	30	60	90	30	60	90	30	60	90
Control	0.86	1.63	0.71	11.5	18.7	12.2	71.3	87.6	62.6	417.2	435.1	395.2	48.0	69.8	60.0	31..2	35.5	68.9
NaDK (100)	1.06	2.15	2.29	13.9	22.9	23.9	76.7	95.2	97.3	486.6	508.9	509.5	88.4	93.9	99.3	22.8	26.2	36.2
NaDK (200)	1.17	2.31	2.43	16.8	25.5	28.6	85.1	106.0	119.5	575.5	587.1	590.6	105.2	128.5	143.2	20.4	23.1	30.5
NaDK (300)	0.77	2.00	1.05	12.8	20.7	16.5	80.9	91.3	88.5	459.1	475.5	445.1	87.6	89.8	88.6	28.0	31.4	42.1
LSD (*P=0.05)*	0.08	0.15	0.07	1.11	1.97	1.20	4.69	6.23	6.02	37.25	40.38	38.06	4.76	7.01	6.05	2.03	2.50	3.10

NaDK was foliarly applied at the post flowering stage (16 days old) of safed musli.

Table 3. Effect of different concentrations of sodium dikegulac (NaDK) on changes of days to attain important developmental stage and their influence on crop yield of safed musli.

Parameters	Treatments				
	Control	Na-DK (100µg ml^{-1})	Na-DK (200µg ml^{-1})	Na-DK (300µg ml^{-1})	LSD (P=0.05)
Days to maturity	90	124	150	100	8.56
Fleshy root length (cm)	8.0	8.6	9.9	7.5	0.62
Fleshy root circumference (cm)	2.2	2.8	3.2	2.5	0.21
Fleshy root number per plant	8.0	10	14	7.0	0.68
Fleshy root yield per plant (g)	10	12	18	11	0.95

NaDK was foliarly applied at the post flowering stage (16 days old) of safed musli.

rapidly as senescence proceeds (Thimann 1980). In fact, protein and chlorophyll are vital plant macromolecules which help to maintain a standard metabolic status and potential of leaves (Jana and Choudhuri 1985).

Some crop physiologists critically analysed scientific crop production and source-sink relationship in various crop plants including a few medicinal plants and came to conclusion that a balanced source-sink relationship is an important determinant for crop yield (Biswas and Ghosh 1999, Singh *et al.* 2006, Lattoo *et al.* 2006). While studying the process of monocarpic senescence, Nooden *et al.* (1979) concluded that the prevention of the internally programmed degeneration might open a way to yield improvement. NaDK seems to be a potential plant growth regulator for a monocarpic plant like safed musli with regard to arrestation of leaf senescence.

It is now well established that senescence is accompanied by decrease of chlorophyll, protein, DNA and RNA. Enhanced plant potential by NaDK is further supported from the data on catalase activity. Catalase is regarded to be a scavenger type of enzyme which maintains the vital physiological plant processes by destroying the oxidants (Fridovich 1976). In the present study, high catalase activity in the contributory leaves even at preharvest corroborated the above fact.

Thus, a conclusion is made from our investigation that NaDK may be employed a potent chemical for modulation of growth, metabolism and yield attributing parameters of safed musli and the changes cumulatively result in the augmentation of its productivity. The promising response was recorded in the following order: NaDK 200 µg ml^{-1}, 100 µg ml^{-1} and 300 µg ml^{-1}.

REFERENCES

Arnon, D.I. (1949). Copper enzymes in isolated chloroplasts: Polyphenol oxidase in *Beta vulgaris*. *Plant Physiol.* **24:** 1-15.

Beevers, L. (1977). Senescence. In: J. Bonner and J.E. Varner (eds.), Plant Biochemistry, pp. 771-794. Academia Press, New York, USA.

Biswas, A.K. and Choudhuri, M.A. (1978). Differential behaviour of the flag leaf of intact rice plant during ageing, *Biochemie und Physiology der Pflanzen* **173:** 220-228.

Biswas, A.K. and Ghosh, A.K. (1999). Regulation of Senescence in Various Plants, Emkay Publications, Delhi, India.

Bordia, P.C., Joshi, A. and Simlot, M.M. (1995). Safed musli. In: K.L. Chadha and R. Gupta (eds.), Advances in Horticulture, Medicinal and Aromatic Plants, Vol. II, pp. 429-451. Malhotra Publishing House, New Delhi.

Cherry, J.H. (1962). Nucleic acid determination in storage tissue of higher plants. *Plant Physiol.* **37:** 670-678.

Choudhuri, M.A. and Chatterjee, S.K. (1970). Seasonal changes in the levels of some cellular components in the abscission zone of *Coleus* leaves of different ages. *Ann. Bot.* **34:** 275-287.

Dey, B.K. and Jana, S. (1988). Effects of antioxidants on dark-induced changes in some biochemical parameters in detached leaves of *Sechium edule* in Darjeeling hill of the Eastern Himalayas. *Environ. Ecol.* **6:** 381-385.

Fick, N.G. and Qualset, C.O. (1975). Genetic control of endosperm amylase activity and gibberellin responses in standard-height and short-statured wheat. *Proc. National Acad. Sci.* USA. **72:** 892-895.

Fridovich, I. (1976). Oxygen radicals, hydrogen peroxide and oxygen toxicity. In: W.A. Prior (ed.), Free Radicals in Biology, pp. 239-277. Academic Press, New York.

Jana, S. and Choudhuri, M.A. (1985). Effects of antioxidants on dark-induced decline in chlorophyll and protein contents and Hill activity in detached *Spinacia oleracea* L. leaves. *Photosynthetica* **19:** 428-430.

Khan, A.A. and Faust, M.A. (1967). Effect of growth retardants on α-amylase production in germinating barely seeds. *Physiol. Plant.* **20:** 673-681.

Lattoo, S.K., Bamotra, S., Dhar, Sapru, Khan, S.R. and Dhar, A.K. (2006). Rapid plant regeneration and analysis of genetic fidelity of *in vitro* derived plants of *Chlorophytum arundinaceum* Baker-an endangered medicinal herb. *Plant Cell Reprod.* **25:** 499-506.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. (1951). Protein measurement with the Folin-phenol reagent. *J. Biol. Chem.* **193:** 265-275.

Markham, R. (1955). Nucleic acids, their compounds and related compounds. In: K. Peach and M.V. Tracey (eds.), Modern Methods of Analysis, pp. 246-304. Springer-Verlag, Berlin.

Nooden, L.D., Kahanak, G.M. and Okatan, Y. (1979). Prevention of monocarpic senescence in soybean with auxin and cytokinin: an antidote for self-destruction. *Science* **206:** 841-843.

Oudhia, P. (2001). My experiences with wonder crop safed musli. In: Souvenir, International Seminar on Medicinal Plants and Quality Standardization, 9-10 June. VHERDS, Chennai, India.

Panse, V.G. and Sukhatme, P.T. (1967). Statistical Methods for Agricultural Workers (2^{nd} edn.), pp. 150-157. ICAR Publication, New Delhi.

Sabater, B. (1984). Hormonal regulation of senescence. In: S.S. Purohit (ed.), Hormonal Regulation of Plant Growth and Development, pp. 169-217. Agro Botanical Publication, India.

Singh, R., Dhingra, H.R. and Goyal, S.C. (2006). Biochemical changes during shoot differentiation in callus cultures of *Chlorophytum borivilianum* Sant. Et Fernand. *Indian J. Plant Physiol.* **11:** 130-135.

Snell, F.D. and Snell, C.T. (1971). Colorimetric Methods of Analysis, Vol. IV AAA, pp. 7-145. Van Nostrand Reinhold Co., New York.

Thimann, K.V. (1980). Senescence in Plants. CRC Press Boca Raton, Florida, USA.