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Sound: A Positive Stimulator of Plant Growth in Ornamental Crops

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Introduction

Plants are complex multicellular organisms that are exposed to nature and various environmental conditions which pose a great influence on their growth and development. Accordingly, sound is an external factor that has a great impact on the biological index of plants which can either promote or suppress the plant growth. A series of biological changes occurs in living plant systems upon exposed to sound waves that reflects its growth and development. Plants could emit sounds with the help of mechano-chemical enzymes such as myosins, which use chemical energy from the hydrolysis of adenosine triphosphate (ATP) in actin filaments to generate mechanical vibration within cells. Moreover, plants might have a meridian system as in humans and other animals namely, internal frequency by which plants can absorb and resonate to specific external sound frequencies spontaneously.

Plants can produce sound waves at relatively low frequencies of 50-120 Hz (Philodendron).When plants are exposed to soft rhythmic musical frequencies expedites seed germination, faster nutrient absorption from soil and better production of metabolites,improving plant height and more leaf productionleading to better growth and development. Plant exposure to sound waves with certain intensity and frequency can increase the activities ofcertain enzymes (viz., H^+ATPase, amylase), enhances cell fluidity, increases the contents of soluble sugar, soluble protein, enhances DNA synthesis, increase the content of RNA and the level of transcription and it can even faster the cell cycle. Sound waves speed up the protoplasmic movements in the plant cells by vibrating the plant leaves. Sound frequency technology stimulates opening of leaf stomata which increases uptake of spray fertilizer and dew.

The sound stimulation could strengthen plant immune systems by switching on stress-induced genes which decreases requirement for chemical fertilizers and biocides. The

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frequency of sound waves is very important as loud, non-rhythmic and unharmonious audio frequencies may tend to pose a negative effect on the growth of plants. There might be a regulatory mechanism in the plants called internal frequency that cause more sensibility to frequency than intensity. The effect of sound frequencies on various plant developmental activities are described hereunder:

Plant growth:

Classical music of specific frequency, interval and rhythm accompanied with dynamically changing lyrics positively influences plant as well as root growth and mitotic division in floriculture crops as reported in chrysanthemum that the root and seedling length were high upon exposure to external sound waves. The frequency and proportion of cell in S phase also increases under the stimulation of low frequency electromagnetic field in chrysanthemum. Soothing vibration in the form of Vedic chants and Indian classical music endorses growth of rose (*Rosa chinensis*) plants. Philodendron leaves shows better growth upon exposure to external sound frequency lower than 150 Hz.

A positive increment in plant growth rate in terms of height and biomass respectively by 20% and 72% is also observed when plants are exposed to classical music, i.e., raga music played on Indian musical instruments like flute, violin and harmonium. Petunias and marigolds will flower two weeks earlier to the scheduled time when exposed to the rhythm of Bharatanatyam, an ancient Indian classical dance style.

When sound waves generated in compression fashion by increasing pressure and rarefaction generated reduces pressure and this propagated along the surface of the leaves creating a scrubbing or brushing action on the leaf surface helps in removal of the moisture film from the surface and facilitates the leaf to breathe or transpire better in crops like chrysanthemum.

Exposure of chrysanthemum plants to sound waves enhances the synthesis of RNA and soluble proteins that increases the level of transcription and in turn promotes better growthof plants. Sound waves in the form of low magnetic field, increases the content of chlorophyll, proline, soluble protein and SOD activity by decreasing the membrane permeability and POD activity.

Marigold plants reports maximum plant height with light Indian music which could be applicable in nurseries and farms to enhance the growth of the plants reaping to good yields.

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Pollination:

Sound waves vibrate the plants mechanically with their frequencies, causing a plausible mechanism where the flowers are shaken vigorously as a response to sound waves thus ensuring pollination. But frequency of waves is critical for both the vibration and the nectar responses. Synthetic sound signals from 1000Hz to 50 Hz frequency similar to range of the wingbeat of natural pollinators, cause vibration of the petals and evoke a rapid response leading to an increase in the plant's nectar sugar concentration by 20% in flowers. Exposure of evening-primrose (*Oenothera drummondii*) flowers to the playback sound of a flying bee or to synthetic sound-signals causes vigorous shaking of branches containing flowers which potentially increases the chances of cross pollination and produces sweeter nectar with increased sugar concentration by three times.

Seed germination:

Plants pick up the sound waves through protoplasm. Hence, the frequency and the intensity of the sound waves applied are important as the ancient traditional Indian chants makes a remarkable change in the growth of plant and also helps in speeding up the germination process. So, these kinds of music can be used in plant nurseries to speed up the germination processes and also in the production of healthier plants in sexually propagated annual flower crops.

Drought tolerance:

Plants produce sound emission when exposed to drought or water stress as reported in Phylodendron plants produces 20-30dbsound when exposed to water stress and gradually decreaseswhen water is supplied to the plants. Sound emission increases the level of in dole acetic acid (IAA) and some stress-induced genes, superoxide dismutase (SOD), amylase, soluble sugar, proteins, calcium levels in callus by decreasing the level of abscisic acid in chrysanthemum.

Defense mechanisms:

Activity of Reactive Oxygen Species (ROS) increases when plants are exposed to sound vibration which is considered as a general stress signal and increases drought tolerance of plants. ROS also regulate the activity of membrane ion-channels and the influx and efflux of Ca^{2+} and K^{+} ion channels are implicated in opening and closure of stomata when the plant exposes to drought stress. Plants under sound vibration treatment shows an increase in

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polyamines (PAs), which has synergy with ROS to regulate Ca^{2+} and K^{+} channels. The activities of protective enzyme and peroxidise is enzyme will increase when chrysanthemum seedlings are exposed to 1000Hz and 100db for 9 days.

Arabidopsis thaliana plants infected with *Botrytis cinerea* when subjected to a daily 100-dB SVs of 1 kHz for 3h upto 10 days, both the disease level and lesion diameter were diminished andalso the plants accumulated salicylic acid, which cause better response against the Botrytis pathogen in *Arabidopsis thaliana*.

Shelf life:

Decrease in transpiration and ethylene production in tomato fruits after harvest were observed when subjected to1000 Hz sound waves for 6hextends the commercial life of products and reduce the losses during the post-harvest handling.

Frequencies of sound vibration applied to plants and its effects

Crop	Time and frequency	Result
Chrysanthemum	60 min per day for 9 days (100db intensity and 1000 Hz frequency)	Accelerates the growth of callus cultures
Rose	60 minutes in the morning between 6:00-7:00 AM for 62 days (100db intensity and 800Hz frequency)	Elongation of shoot, internode elongation, increase in number of flowers and the diameter of the flowers
Catharanthus	3hrs per day for 30 days	Increases phenol and reducing sugars, plant height, early bud initiation and flowering with maximum flower number per plant
Chrysanthemum	100db and 800Hz	Increases activity of SOD, soluble protein and absorption rate of calcium increased in callus
Trachyspermum	3hrs per day for 30 days	Increases chlorophyll content, early bud initiation and flowering
Chrysanthemum	1.4kHz and 0.095kdb	Content of endogenous IAA increased by reducing ABA levels in callus
Marigold	3hrs per day for 30 days	Early bud initiation and flowering, a

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		greater number of flowers per plant
Hibiscus	3hrs per day for 30 days	Early bud initiation and flowering
Dendranthema	3hrs per day for 30 days	Increase in total sugars

Conclusion:

Sound vibrations at low frequencies have positive impact on the growth and development of plants by enhancing various physiological activities within the plant cells. This technique helps to develop internal defence mechanisms which in turn reduces the requirement of external chemicals for crop growth. There is a wide scope to carry out further research in terms of effect of sound on growth in various agricultural crops.