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A Review On-Influence of Antitranspirants (ATs) in Vegetable crops

G. Koteswara Rao[1*], M. Surendra Babu[2], V. Sravani[3], M. Sindhuja[4]
[1&2]Dept. of Vegetable Science, [4]Dept. of Floriculture & Landscape architecture
ASPEE College of Horticulture & Forestry, Navsari Agricultural University, Navsari, Gujarat, 396450,
[2]Dept. of PSMA, KAU, Thrissur, Kerala, India
*Corresponding Author E-mail: gkraohorti@gmail.com
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ABSTRACT

Water is the most abundant compound found in nature and is the most limiting factor in agricultural production. More than 98% of water is lost in the form of transpiration and evaporation. Transpiration is the loss of water from aerial parts of plants in the form of vapor, which is also known as 'Necessary Evil'. It takes place through lenticels, cuticle and stomata. Transpiration is affected by both external and internal factors. Water is a scarce commodity and with the expansion of agriculture, water conservation measures are becoming more important particularly chemical manipulation of transpiration with antitranspirants. Antitranspirants are chemicals sprayed on transpiring plant surfaces with an attempt to reduce water use by reducing transpiration. Depending upon their mode of action, they are stomatal closing type, film forming type, reflectance type and growth retardants. Antitranspirants should have some of the ideal properties like non toxic, cheap, stable, long lasting in their effectiveness and they should have some of the assured benefits. Several researchers reported that antitranspirants not only reduce the water loss but also they improve the physiological, disease resistance, quality and yield aspects in many vegetable crops.

Key words: *Antitranspirants, ATs, Vegetables, Growth, Yield*

INTRODUCTION

Vegetables can be defined as the herbaceous plants or parts of plants which can be used as a raw or cooked or dessert form. They are also called as 'protective foods' because consumption of these vegetables prevent the attack of some of the diseases. Vegetables are nutritionally rich dietary sources plays an important role in our daily diet. India holds the second rank in area and production of vegetables after china. Vegetables play a major role in improvement of our national economy. Now a days due to climate change, poor water management practices and attack of pests and diseases crop yields are reduced to 20-30%. So Antitranspirants are an option for better water management and to increase the yield of vegetables under present situations.

Our solar system consists of 9 planets *viz.*, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto out of which the third most important planet is earth which is enriched with so many natural resources like water, soil, air, planta and fauna etc.

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The planet earth is covers or occupied with 71% of water only 29% of land is available for the agriculture, domestication and industrialization. Out of 100% of water on the earth nearly 97% of water is in the form of salt water deposited in oceans not suitable for plant growth and domestic purpose, whereas only 3% fresh water is available but 2.5% of fresh water is ceased in the form of frozen conditions or ice caps, ultimately 0.5% of fresh water is available for agriculture, drinking purpose, industrialization etc. so there is a great need or care we have to take for effective sustainable management of water in agriculture (Source;UNEP Global Environment Outlook).

Water is the most abundant compound found in nature and is the most limiting factor in agricultural production. The consumptive use of water includes the three main components in agriculture *viz*., Evaporation, Transpiration and Metabolic activities. Nearly 98% of water is lost in the form of transpiration and evaporation, whereas 2-3% of water is lost through metabolic activities.

The availability of water is one of the factors which may greatly affected plant growth and productivity. Shortage of water during vegetative growth will cause the plants being stunted, produced small fruits and the fruits drop easily. Only 5% water absorption that is used for plant growth while 95% were lost to transpiration[9]. It is important to balance water availability, water requirements and water consumption, particularly in dry season where water is the main limiting factor for plant growth.

The main aim of publishing this review article is to provide basic information regarding transpiration and antitranspirants to provide good antitranspirants for improving growth and yield characters of vegetable crops.

Transpiration

Transpiration is the process of loss of water from aerial parts of plants in the form of vapor. It occurs chiefly at the leaves while their stomata are open for the passage of CO_2 and O_2 during photosynthesis. Transpiration is the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers. Water is necessary for plants but only a small amount of water taken up by the roots is used for growth and metabolism. The remaining 97–99.5% is lost by transpiration and guttation. It is also called as 'Necessary Evil'.

Types of Transpiration

Depending upon the parts where transpiration takes place it is of three types *viz.,* Lenticular, Cuticular and Stomatal transpiration.

Lenticular transpiration; lenticels are the areas in the bark which are filled with loosely arranged cells known as complementary cells, are tiny, permanent openings present on the woody parts of the plants. The transpiration which is takes place through lenticels is called lenticular transpiration. From this process of transpiration very little amount of water is lost i.e nearly 1-5% from the total transpiration.

Cuticular transpiration; cuticle is the thin, waxy, shiny layer which is present on the adaxial part of leaf. The transpiration which is takes place through cuticle is called cuticular transpiration. Through this transpiration nearly 5-10% of water is wasted from the total transpiration.

Stomatal transpiration; stomata are minute pores of elliptical shape surrounded by two specialized epidermal cells called guard cells. They are kidney or bean shape in dicots and dumbel shape in monocots. The transpiration which is takes place through stomata is called stomatal transpiration. This is the major form of transpiration, through this nearly 80-90% of water is lost from the total amount of transpiration.

Factors affecting transpiration; generally transpiration is affected by two factors *viz.,* External and Internal factors.

A. External factors or Environmental factors

Atmospheric Humidity:

The rate of transpiration is roughly inversely proportional to atmospheric humidity. As the outward diffusion of water vapors through stomata is in accordance with the law of simple diffusion, the rate of transpiration is greatly reduced when the atmosphere is very humid. As the air becomes dry, the rate of transpiration also increases proportionately.

Temperature:

With the increase in atmospheric temperature, the rate of transpiration also increases. This is not only because evaporation occurs quickly in warmer air but also because warm air is capable of holding more water vapors than the cold air.

Light:

The rate of transpiration is roughly proportional to the intensity of light. The mode of action of light is both direct and indirect. The increasing light intensity raises the temperature of leaf cells and thus increases the rate at which liquid water is transformed into vapors. Direct effect of light is on the opening and closing of stomata. Bright light is the chief stimulus which causes stomata to open. It is simply because of this reason that all plants show a daily periodicity of transpiration rate.

Wind Velocity:

The velocity of wind greatly affects the rate of transpiration. Fast moving air currents continually bring fresh, dry masses of air in contact with leaf surfaces and thus maintain a high rate of transpiration.

Soil Water Content:

Availability of soil water greatly affects the rate of transpiration. If there is little water available, the resulting tendency for dehydration of the leaf causes stomatal closure and a consequent fall in transpiration. Such a condition usually occurs during periods of drought and when the soil is frozen or at a temperature so low that water is not absorbed by roots.

Atmospheric Pressure:

The rate of transpiration is inversely proportional to the atmospheric pressure.

Carbon Dioxide Concentration:

Reduced CO_2 concentration favours opening of stomata while an increase in CO_2 concentration promotes stomatal closing.

B. Internal or Structural or Plant Factors:

Leaf Area:

If leaf area is more, transpiration is faster. However, the rate of transpiration per unit area is more in smaller leaves than in larger leaves due to higher number of stomata in the small leaf. Number of stomata per unit area of leaf is called stomatal frequency.

$I = S/E+S \times 100$

I = Stomatal index

S = No. of stomata per unit area

E = No. of epidermal cells in same unit area

Structural Peculiarities of Leaf:

The anatomical features of leaves like sunken or vestigial stomata; presence of hair, cuticle or waxy layer on the epidermis; presence of hydrophilic substances such as gums, mucilage etc. in the cells; compactly arranged mesophyll cells etc. help in reducing the rate of transpiration.

Root Shoot Ratio:

The rate of transpiration is directly proportional to the root-shoot ratio. Transpiration rate increases with increase in root-shoot ratio.

Orientation of Leaves:

If the leaves are arranged transversely on the shoot they lose more water because they are exposed to direct sunlight. If placed perpendicularly they transpire at slower rate.

Process of transpiration

The process of transpiration depends on water potential. Because of transpirational pull theory the water moves from soil to root towards upper parts of the leaves. Generally in normal or good soils, the soil water has high water potential while atmosphere has less water potential because of this the water moves towards upper parts of the plants.

Why Transpiration is Necessary

- Creates transpirational pull for transport
- Supplies water for photosynthesis
- Transports minerals from soil to all parts of plants
- Cools the surface of leaves
- Keeps the cells turgid hence maintain their shape
- Serves to replace water lost through the leaves
- Remove excess water

Why transpiration is Evil

- Most of the absorbed water is lost without being utilized.

- If transpiration rates exceed water absorption rates the leaf cells loose turgor and show wilting.
- Deciduous trees shed their leaves during dry spell to avoid transpiration to protect the plant. Xerophytes show modifications of their leaves and other parts to minimize transpiration.

Antitranspirants

Antitranspirants are chemicals sprayed on transpiring plant surfaces in an attempt to reduce water use by reducing transpiration (or) Antitranspirants are chemicals capable of reducing the transpiration rate when applied to plant foliage[1]. A wide range of materials have been tried as antitranspirants[10].

Depending upon the mode or mechanism of action the antitranspirants are divided into 4 types *viz.,* stomata closing, film forming, reflective and growth retardant types.

Stomatal closing type

Fungicides like PMA and herbicides like atrazine in lower concentration serve as antitranspirants by inducing stomata closing. PMA was found to decrease transpiration than photosynthesis but it has a disadvantage that it is toxic to fruits and vegetables. ABA is plant hormone, non toxic with increase in ABA level confirming its role in stomata closure. A little rise in CO_2 concentration from the natural 0.03% to 0.05% induces partial closure of stomata. These reduce the photosynthesis. E.g. PMA, ABA, 2,4-D, Atrazine, Simazine, Triazine and High CO_2

Film forming type

This type forms a thin film coating on the surface of leaf and inhibits the loss of water vapour from the leaf. But they allow CO_2 to pass into the leaf through lower epidermis. Application to leaves induces stomatal closure and thus reduces transpirational losses of water from plants. The water proof films on leaf surface reduce the escape of water vapour from transpiring surface. Films on leaves formed from plastic emulsion exhibit a certain degree of selective permeability being more permeable to CO_2 and O_2 than to water vapour. E.g. Waxes, Silicons, octadecanol, folicote, vapour gard, hexadecanol, etc.

Reflectance type

These are white reflecting type materials. The reflectant coating may persist for more than 10 days. It lowers the leaf temperature and reduces the vapour pressure gradient from leaf to atmosphere. Thus decreases the transpiration. Reflecting materials reduce the energy load on the leaf by increasing the albedo. Light reflection for the reflectant coated upper surface of leaves within the canopy may cause an increased light penetration in the canopy. The reflectant may improve the distribution of light within the canopy and may prove beneficial in increasing the photosynthesis. E.g. Kaolin, Lime water, Calcium bicarbonate

Growth retardant type

Chemicals which reduce or slow down the shoot growth and increases root growth. Enable the plants to resist drought conditions through closure of stomata. These are useful for improving the water status of the plant E.g. CCC

Ideal properties of Antitranspirants

- Non toxicity
- Reducing transpiration without reduction in photosynthesis to be used on a commercial scale.
- Such chemicals should be cheap, stable and long lasting in their effectiveness.
- Antitranspirants form a supplement, rather than a substitute for, good water management and crop improvement.
- Non permanent damage to stomata mechanism.
- Specific effects on guard cells and not to other cells.

Benefits of Antitranspirants

- High water demanding crops growing in areas of water scarcity.
- Optimized yield levels under infrequent rainfall situations
- Transport of vegetable seedlings.
- Save several fruits from cracking.
- Getting normal sized fruits
- Managing drought
- To prevent the adverse effects of water stress on crop growth can be mitigated by the application of antitranspirants.

- Very useful for farmers with minimum irrigation facilities
- Saving large nurseries when water is scarce in summer months

Major constraints

- Maintaining control over the microclimatic conditions.
- Their effect being varied greatly with environmental factors.
- Difficult to cover the entire leaf surface of some crop plants does not receive proper application of the chemical and thus the effectiveness of the chemical may be reduced.
- The lack of knowledge on the type of nozzles and surfactant to be used.
- The cost of certain chemicals forbids their use as antitranspirants.
- Some of the chemicals particularly those to be applied through soil are required in relatively high dose and not thus economical and become a limiting factor in their use.

Precautions required while using Antitranspirants

- Spray after rainfall stops.
- Ensure 2 sprays of antitranspirant at an interval of one week.
- Surfactants should be mixed in spray for effective response.
- Repeat spray of antitranspirant if rains follow after one hour of sprays.

Review of Research work

Brinjal

Prakash and Ramachandran[9] studied the effect of chemical ameliorants on stomatal frequency and water relations in brinjal under moisture stress conditions. They reported that potassium chloride performed best in terms of stomatal behaviour and leaf water potential, whereas Cycocel proved best in the case of relative water content.

Kuruppaiah *et al*.[5], conducted an experiment on effect of antitranspirants on growth, photosynthetic rate and yield characters of brinjal. They found that Kaoline (7.5%) spray was found to be the best which improved the number of flowers, number of fruits per plant, yield per hectare, maximum net photosynthetic rate, RWC and minimum transpiration rate followed by salicylic acid (1000 ppm).

Cowpea

Farouk and Ramadan[2] reported that foliar application of chitosan @ 250 mg/l, increased plant growth, yield and its quality as well as physiological constituents in plant under stressed or non stressed conditions as compared to untreated plants in cowpea.

Cucumber

Wafaa[11] revealed that among different film forming compounds, Kaolin and Nu-film @ 1% were more effective in reducing spores counts germination, infected area and lesions number of downy mildew. Scanning electron microscope examination showed that Kaolin antitranspirant inhibited spores germination and made the sporangia becoming collapsed and lost its turgidity when applied either pre or post inoculation. Under protected cultivation Kaolin strongly protected cucumber against downy mildew and increased vine height and yield.

Sweet potato

Moussa[7] reported that foliar application of folicote @ 15% resulted in significant increases in water use efficiency, yield and yield attributing characters of sweet potato under low water areas.

Summer squash

Ibrahim and Selim[3] envisaged that foliar application of Kaolin @ 6% significantly increased the water use efficiency, foliage weight, leaves weight, mean fruit weight, total yield per hectare and TSS in summer squash during summer 2008 and 2009 seasons.

Okra

Pateliya *et al*.[8], found that foliar application of growth retardant CCC @ 300 ppm increased the fruit length, fruit diameter, number of green fruits per plant and fresh weight of fruit. However, highest net return with higher cost benefit ratio was also produced under the treatment of CCC 300 ppm as compared to rest treatments in okra.

Bell pepper

Kamal[4] reported that foliar application of Kaolin @ 4% and Potassium silicate @ 1.5% significantly increases the stem diameter, relative growth rate, net assimilation rate, leaf relative water content, number of fruits per plant, average fruit weight, yield and water use efficiency in bell pepper.

Potato

Kyaw *et al*.[6], observed that application of antitranspirant folicote formulation @ 6% on field grown potato, significantly reduced the extent of necrosis and necrotic tubers percentage in small sized potato, thus enhancing crop quality without significantly reducing yield.

CONCLUSION

From the foregoing discussion, it can be concluded that, Antitranspirants not only reduce the transpiration loss but also useful for improving physiological, growth, disease resistance, quality, yield and yield attributing characters in vegetable crops. Foliar application of antitranspirants like stomatal closing (Potassium chloride 1%), film forming (Chitosan 250 ppm, Nu-film 1%, Folicote 15% and Potassium silicate 1.5%), reflectance type (Kaolin 4 and 6%) and growth retardant (CCC 300 ppm) have been found to increases the growth, physiological, disease control, quality, yield and yield attributing characters with highest net return in brinjal, cowpea, cucumber, sweet potato, summer squash, okra, bell pepper and potato respectively.

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