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3. Palmer, J.D. 1992. In Cell Organelles (R.G. Herman, Editor) Springer Verlag, Vienna, 99-133.
4. Weber, D.R. 1967. On the Interaction of Nonhomologous Segments of Chromosomes in Zea mays. Unpubl. Ph.D. Thesis, Indiana University, Bloomington, Indiana, USA. (For Indian Universities, Country's name not to be indicated).
5. Chandola, R.P., Bhatnagar, C.P. and Sah, Sudha. 1971. Nature of variability induced by radiations, In : Proc. Int. Symp on use of Isotopes, Radiations in Agriculture and Animal Husbandry Research, New Delhi 46-50.

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PROSPECTS OF CULTIVATION AND MARKETING STRATEGY OF AONLA IN TELANGANA STATE

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Jaipur-Rajasthan-302033

Introduction

The study was conducted by CCS National Institute of Agricultural Marketing, Jaipur to understand the various dimensions of cultivation and marketing of Aonla in the state of Telangana. As it is aware that the demand of aonla and its products is increasing locally and globally due to change in consumption pattern of consumers and to understand the substances prepared from the aonla and their use in our daily life. The products made from aonla are safe for health and body and its demand is increasing day by day. However, in spite of having a great demand, the marketing of aonla is very gray and complicated and not so easy to understand the supply chain of the marketing products at the level of the farmers. As a result farmers are facing difficulties in marketing of their produce due to lack of knowledge of marketing channels, packaging, grading, storage, collection process, primary processing and many more.

Methodology

The study conducted in Telangana state to find out the status of cultivation and marketing potential of aonla crop. To collect the data from the study area following strategy was adopted. Data collected from farmers, mandies, manufactures, traders, middlemen and cooperatives for the purpose of study.

1. **Sampling from village:** Sampling from villages carried out to study the cultivation/collection practices of the aonla farmers. Under this project only 4 districts (Rangareddy, Medak, Nalgonda and Mehaboob Nagar) from Telangana were selected for the purpose of study and to collect the data from bottom line of the farmers and to know the ground reality.
2. **Data collection from Mandies:** The next part of survey is done to analyse the existing and potential market of the produces prepared from aonla. For the same, the herbal market of the concerned produces were studied in major markets of Telangana to understand the demand-supply scenario, export and domestic market, consumer preference, industrial requirement and procurement channel, Telangana's present share, price spread, mandi efficiency etc.
3. **Data collection from industry:** For industrial analysis, data collected from Dabur, Vijay Durga Wineries, KSM 66, GCC processing unit and other industrial organizations that include micro, medium and large organization. The sample size was approximately 10%.

Aonla Market Scenario

There is a lack of access to markets for the farmers engaged in the collection /cultivation of medicinal plants they do not get fair value/price for their products due to over dependency on the middleman, aggregator and collectors of medicinal plant produce from the wild sources as well as cultivation. Beside markets, the system is experiencing lack of information regarding inputs like quality planting material and necessary inputs, proper harvesting collection methodology for uncultivated resources, marketing channels, quality control, grading and packaging of products and post harvesting/cultivation processing.

Due to lack of documentation of gathering process of medicinal plants and the damage to the Eco-system by over exploitation, the exact potential and its real issues has not been assessed. Under this project market analysis has been done for Aonla.

Market survey was done to determine the demand of Aonla to establishing forward and backward market linkages through its integration and help in access market by the stakeholders. In this study effort has been made to identify present and potential market scenario of crops identified for the study, analysis of seasonal price fluctuations in different markets of Aonla in different market of the country. Extensive survey of area of cultivation/gathering of plants was done to collect the back ground information through structured schedules from various cultivation/wild, market areas of Telangana state as well as from some important mandies of India. The existing value chain of identified medicinal plants was studied to know the gaps and add suggestions for appropriate measures.

Health Benefit of Aonla

The health benefits of Indian Gooseberry, also known as Aonla, can be partially attributed to its high vitamin C content. Aonla helps in boosting the immune system, slowing down aging, treating throat infections, reducing blood sugar levels, and improving heart health. Aonla acts as a diuretic agent, thereby enhancing food absorption, balancing stomach acids, fortifying the liver, and nourishing the brain and mental functioning. It also strengthens the lungs, enhances fertility, helps the urinary system, improves skin quality, and promotes healthier hair. This fruit acts as a body coolant, flushes out toxins, increases vitality, aids in vision care, and improves muscle tone.

Major Players

India exports a significant amount of aonla and aonla extracts to the countries like the U.S., Japan, Nepal, Bangladesh, Malaysia, Germany and the Netherlands, among others. Various herbal medicine manufacturing companies are formulating aonla extracts to provide novel dietary supplements in herbal tea and powders forms. Effective production, processing and marketing of aonla extracts is expected to boost the market size

during the forecast period. Biomax, Taiyo international (SunAmla), Arjuna Natural Extracts Ltd., Nutra Genesis and Archerchem are some key players in the aonla extract market. On analyzing the demand prospects it was found that pharmaceuticals, cosmetics, food and beverage industry acquire majority share in terms of volume. In food and beverage industry, it is used as an anti-oxidant agent in different food products. Geographically, the global hubs of Aonla include North America, Latin America, Europe, Asia Pacific, Middle East and Africa. Globally, Asia has emerged as the most dominant market for Aonla. Some of the key players identified across the value chain of the global *Emblica officinalis* market include the Green Labs LLC, Nutra Green Biotechnology Company Private Limited, Nexira, Indena S.P.A, Xi'an Pincredit Bio-Tech Company. Mountain Rose Herbs, Dabur India Limited, Himalaya, Patanjali, Zandu and Vaidhyanath and others. The companies are expected to expand their business by enhancing their product portfolio in global *Emblica officinalis* market. The companies are projected to frame certain strategies in future in order to gain the competitive advantage in global *Emblica officinalis* market till 2025.

Aonla Market Landscape

Global Aonla market is segmented on the following bases:

By Form: Pulp, Powder (Contribute more than 50%), Liquid

By Distribution: Health stores, drug stores, online retailing and other similar distribution channels

By Application: Diabetes, Skin and Collagen, Heart Health, Blood Vessel Health, Cosmetics, Dietary supplement, Pharmaceuticals, Food & Beverages.

By End-Use: Pharmaceuticals, Personal care and Cosmetics, Food and Beverages, Nutraceuticals

By Geography: North America, U.S., Canada, Europe, U.K., France, Germany, Italy, Russia, Rest of Europe, Asia Pacific, Japan, China, India and Australia.

Table 1: Local value chain of and Aonla

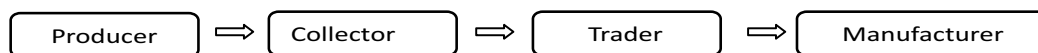
S. No.	Name of crop	Price realized by farmers (Rs. Per Kg)	Price realized by middleman (Rs. Per Kg)	Price realized by wholesaler (Rs. Per Kg)	Product made by the company
1	Aonla	70-100	100-150	160-170	Triphala churan, Aonla candy, murabba, pickle, chutney

Table-2: Prevailing market rates of Aonla products

S. No.	Crop / Raw Material	Farmer (Rs./kg)	Collector (Rs./kg)	Trader (Rs./kg)	Manufacturer		Name of Product
					Volume	Price (Rs.)	
1.	Aonla	70-100	100-150	160-170	500 ml	350	Aloe-vera Stevia juice
2	Aonla	70-100	100-150	160-170	500 ml	250	Aonla juice
3	Aonla	70-100	100-150	160-170	100 ml	250	Oshadhi hair oil
4	Aonla	70-100	100-150	160-170	100 ml	120	Bhringaraj hair oil
5	Aonla	70-100	100-150	160-170	100 ml	120	Aonla hair oil
6	Aonla	70-100	100-150	160-170	100 ml	120	Hibiscus hair oil
7	Aonla	70-100	100-150	160-170	100 ml	50	Saraswathi (Brahmi) Thailam
8	Aonla	70-100	100-150	160-170	125 ml	140	Ritha Shampoo
9	Aonla	70-100	100-150	160-170	125 ml	140	Herbal shampoo sachet

Marketing Channel

The analysis of the collected data reveals that, there is only one principal channel or route through which medicinal plants marketed from the producer (farmer) to the manufacturer. The major channel of distribution of medicinal plants observed was as follows:



Important observation made from the field visit is that, for medicinal plants marketing, decentralized marketing channel is in effect in the selected study area where the middle men or wholesale purchasers purchase directly from the farmers in absence of physical market.

Table-3: Price realized by various stakeholders' level in the marketing channel(Rs. /kg)

Crop	Producer	Collector	Traders	Manufacturers
Aonla	70-100	100-150	160-170	500-2500

Aonla raw material price at producer's level is in the range of 70-100 per kg. The same material collectors are selling in the range of Rs. 100-150 per kg and traders selling at Rs. 160-170 per kg. After value addition at the manufactures level the different end products realizing prices in the range of Rs. 500-2500 per one kg of aonla products.

Market margin and Price Spread

Marketing margin assists in understanding the difference between the price paid by the consumer and that obtained by the producer at the Farm gate. It is also shows the difference in price of a commodity at different stages of the marketing system. Whereas commodity-price spread explains the difference between consumer and producer prices. The spread includes the marketing cost incurred by the intermediaries as well as their margin. Price spread analysis not only shows the marketing costs and marketing margins at different levels of marketing by different marketing agencies or channels but also show a clear picture of the entire system of marketing.

$$\text{Price Spread} = \frac{(\text{Manufacture price} - \text{Net price of producer})}{\text{Manufacture price}} \times 100$$

Field Experience

The experience shared by Sh. Kasarala Jayachandran Reddy, Farmer from village Kanchanpally, Mandal Nalgonda, he informed that Aonla is cultivated in Medak, Rangareddy, Mehaboob Nagar and Nalgonda District of Telangana.



The area of about 4000 acre old plantation is spread over in these districts, however, 300 acre area of new plantation of Aonla was done during last year. It has been observed during the interaction with the farmers that market is a big problem faced by the farmers since last 3-4 years. BioMax, Hyderabad based company is only the purchaser of Aonla from the farmers and also purchase from the local mandies. Various small companies based at Hyderabad also purchased Aonla from the local weekly market.



The intercropping was done by the farmer in Aonla plantation by planting white sandal wood

trees in the field and red sandal wood trees near the boundary of the field. Sh. Jayachandran Reddy is growing NA-7, NA-10, Kanchan (NA-4) and Krishana (NA-5) varieties of Aonla in the field. However, a local variety BSR-1 is also available but not advisable due to small size of fruits. As informed by the farmer the market is available for Aonla in the district of Srikakulam, Vijayanagaram, Vishakhapatnam, Khammam, Guntur and Prakasam districts of Telangana. However, farmers are also selling Aonla fruits in the local market of Nalgonda. Basically, it is a fruits and vegetable market but the buyers of Aonla also arrived to buy Aonla from this market. The rate of Aonla fruits was given to the farmers is Rs. 30/-kg.

The local value chain of Aonla persist in the area which is look like - farmer (Rs. 20-30 per kg), middleman (Rs. 30-40 per kg), Big retailer (Rs. 40-50 per kg) and sometime Aonla is sold @ Rs. 1 per piece after dipping in the solution of salt. Sweet Candies also prepared by some local people and sold out on the local shop because it is very favourite to the children. It is also informed by the farmer that the Aonla in the Telangana is also transported to the nearby state like Odisha and Jharkhand. The Aonla fruit is dipped for a week in a home-made solution of Salt, Turmeric, Chilly, and water solution after giving some cuts in the Kali of Aonla. In doing so, the self-life of Aonla is increased from 6 month to 1 year and used by the local people as a pickle during the meal time. It is being sold by the local shopkeeper @ Rs. 1-2 per piece.

It is noticed during the discussion that a very nominal cost of Rs. 3000 per acre is required for plantation of Aonla and it starts fruiting after 3-4 years. As informed by the farmer, he is getting Rs. 50000/- per acre profit from 1st harvest and Rs. 30000/- per acre from the 2nd harvest of Aonla. It means farmers are getting Rs. 80000/- net return in a year from one acre piece of land. Generally, two harvests are being taken by the farmers in a year. He said that there is no problem of marketing of Aonla in our region because buyers from nearby states as well as from Telangana came frequently to purchase fresh Aonla.

Local Market Experience

The local market of Aonla is available in and

around Hyderabad those are hand holding with the farmers and support in procuring the raw material direct from the farmers. Important local market players are Bhaskara Bio-tech Pharma Company, Arogya Rama Genetics, Biomax, Youngever and Mediherbz. These companies are

based at Hyderabad and providing the local support to the farmers because they are buying the raw material of various medicinal crops including Ashwagandha,

Table 4: Local Value Chain

S. No.	Name of Company	Raw Material Procured	Annual Demand	Product Profile
1	Bhaskara Bio-tech Pharma Company	Aonla and other medicinal crops	2-3 tone	Aloe-detox, Aloe-Noni, Aloe-vera Face wash and body lotion, hand-made cream, shampoo, hand wash, multipurpose gel etc.
2	Arogya Rama	Aonla and other medicinal crops	3 tone	Herbal Powder, soap, face cream, Juice, Cosmetics, Shampoos, Neem powder, Tulsi ark, Arjun churn etc.
3	Genetics	Aonla and other medicinal crops	2 tone	Aloe-vera juices, oils, gels and creams, handmade soap, bath powder, shampoos, soap, powder, honey herbal pack, hair pack.
4	Bio-Max	Ashwagandha, Aloe-vera and Aonla and other medicinal crops	2 tone	Aonla Juice, Powder, Triphala, Candy, Chutney etc.
5	Youngever	Ashwagandha, Aloe-vera and Aonla and other medicinal crops	3 tone	Juices, oils, gels and creams, handmade soap, bath powder, tooth powder, shampoos, soap, powder, honey herbal pack, hair pack, hair treatment kit and tablets and capsules.
6	Mediherbz	Ashwagandha, Aloe-vera and Aonla and other medicinal crops	1.5 tone	Shampoos, Face Pack, Cream, Hair Oil, Massage Oil, Powder, Lotion, Gel, Face Scrub, Pain relieving Oil, Herbal Mehndi, Anti pimple cream, fair glow, soap, skin care oil, face wash etc.

Local Market of Medicinal Herbs

Begum Bazar, Hyderabad is a common and local market for buying and selling of Herbal raw material. In this local market various small, medium and large exporter and importers are working and engaged in procurement of different herbal raw material sourced from different part of the country. The farmers, tribal people and middle man are also come to meet out their requirement of herbal raw material like Aloe-vera, Aonla, Aswagandha, Soapnut, Tejpat, Cinnamon, other spices, gums, dry fruits and other Ayurvedic and Unani raw materials. During the visit to the market the interview was arranged at the shop of Sh. P. Ashok Kumar, the owner of M/s P. Kishan Lal Ashok Kumar, Exporter & Importer of different herbal product. It was informed by the owner that herbal raw material procured from farmers, tribal people, forest dwellers and sometime herbal raw material are also procured through auction arranged by the forest department time to time in a year.



Interview of trader Sh. P. Ashok Kumar at Begum Bazar, Hyderabad

Though Chennai has the highest price it should be noted that only four months have higher price

than average price in this market. The market average went high due to excessive demand in last April. The median price is Rs.72.5/- still making it higher than the other markets. Now viewing the data for Mumbai, it is found that that exactly 6 months have higher price than average of the market. The median price here is Rs.70.00/- indicating a fair stability in the prices. The third rank is Delhi followed by Neemuch. In these two markets, like Mumbai, exactly 6 months have price above the average price of the markets.

Table 5: Average price of the markets

Name of market	Chennai	Delhi	Mumbai	Neemuch
Maximum price incurred(Rs/kg)	100	82.5	90	85
Minimum price incurred (Rs/kg)	68	55	60	49
Deviation range from average	+31.5% to -10.5%	+27.1 % to -15.25	+24.65 % to -16.8%	+40.8% to -18.7%

The table calculated Neemuch as highly unstable market with highest price deviation.

The above table shows that Neemuch market has the highest deviation range indicating high price seasonality. The other three markets have similar range of deviation. The maximum shoot in price is in Neemuch but highest price incurred was in Chennai. The maximum fall in price was in Neemuch and Neemuch also fetches minimum price of Aonla.

Next, let us see the average price of Aonla in each month of the year. The table given below gives a month wise list of price of Aonla in India. The table will give a better insight about seasonality in price and the impact of harvesting season on price of Aonla in India.

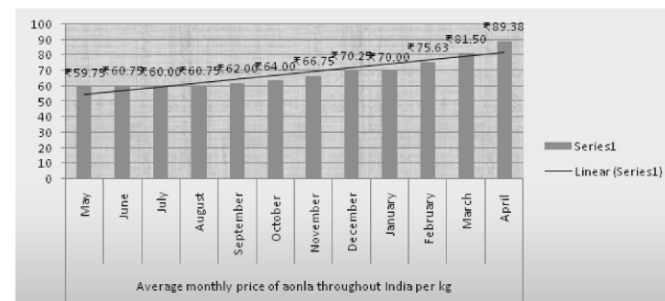
Table 6: Average monthly price of Aonla throughout India (per kg)

Average monthly price of aonla throughout India per kg											
May	June	July	Aug ust	Sep t	Oct	Nov	Dec	Jan	Feb	Ma rch	Apr il
59. 75	60.7 5	60	60. 75	62. 00	64. 00	66. 75	70. 25	70. 00	75. 62	81. 50	89. 37

From the above table, it is evident the

movement of price of Aonla in India. The data is taken from May 2016 to April 2017 from all four major markets of Aonla.

Table 7: Average monthly price of Aonla throughout India (per kg.)



The above graph is a neat linear trend with a positive slope from May to next April. The blooming period in price is from December to April. In the month of May, the price fell one third to its price in April. The price stayed stagnant until September and from the next month, it grew to a significant change. It can be noted that Aonla price heavily depends on harvesting period. The lean months are in mid-summer season for both dried as well as fresh Aonla produce.

Aonla Consumption

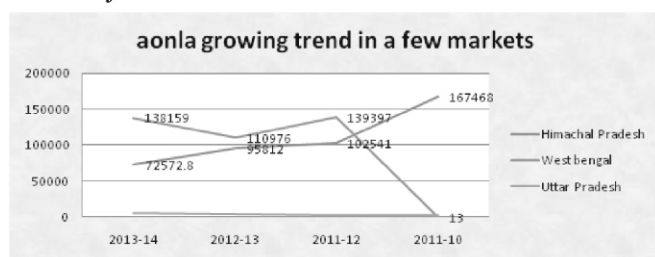
Aonla is the most consumed produce in the entire herbal sector. It is also said that aonla market will never mature as its application increases in every decade of time. The graph below named as "Aonla total" is showing the consumption trend of Aonla across different states of our country.

Like the previous produce the consumption of Aonla is also limited to a very few states. There are 3 major states namely Haryana, Uttarkhand, and Uttar Pradesh depleting the entire production of the country. Goa has been another significant consumer of the fruit. The presence of Aonla in other states is noticeable but comparing to the top 4 states there is no significant visibility. The graph above considers both fresh and dried Aonla. In addition, if we notice Aonla is being consumed by the 3 northern states only. This kind of trend again reflects anomaly with other data series used in the document as many other potential markets are seen in the country. As mentioned in the above section, this incongruity is created due to secretive nature of herbal market.

Table 8: Top 4 consuming states of Aonla

S. No.	State	Consumption	% share of consumption
1	Uttar Pradesh	443941.8	32.08
2	Himachal Pradesh	438393.8	31.68
3	West Bengal	388545	28.08
4	Goa	79736.4195	5.7
Total share of consumption by top 4 states= 97.54%			

The above table reflects that only 3 states majorly buy Aonla. The overall demand in these three states is almost equal thus unlike Gujarat in case of Ashwagandha, the Aonla market has a bigger geography of equal size. As a result, it will be interesting to see the trend of consumption in all 3 major states.



The growth trend among the top three states shows that Himachal Pradesh has shown maximum growth whereas Uttar Pradesh remains stable consumer. West Bengal on the other hand has decreased its consumption linearly throughout the period.

Table-9: The major buyers of Aonla from India are

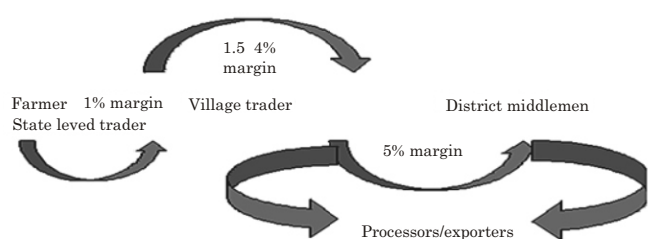
S. No.	Name of buying nation	Share % age of exporting Aonla
1	USA	97.3%
2	Japan	1.87 %
3	South Africa	0.17%
4	Nepal	0.14 %
5	Canada	0.13%
6	Singapore	0.1%
7	Malaysia	0.09%

Three types of value chains are projected are as follows:

1. Farmer - wholesale trader- processor- retailer-consumer
2. Farmer- wholesale trader- commission agents at mandies- processor- retailer-consumer
3. Farmer- local commission agent - commission agents at mandies- processor- retailer - consumer

According to major traders, it has been found

that 60% of the material that comes in the Mandies is procured by the intermediaries who resale it further. In addition, the middle men collects Ashwagandha from farmers' gate, village traders, village market (shandi) and resale it further. There are many levels of mediators and they have different sources of procurement and different customers:



The above flow chart shows an average margin drawn by each stakeholder in different value chains. As the value chain length increases the margin gets dropped to a lower value which also depends on the supply & demand of material during that time. It can be clearly seen that the farmers draw the least margin and due to presence of the middlemen there is an increase in price of about 9% without any substantial value addition in the product.

Conclusion

The biggest inefficiency in aonla value chain is low price received by farmers. The highest value addition in aonla value chain happens during processing and developed various products. Due to high perishability, aonla needs to be processed soon after harvesting. This limits the farmers to produce large quantity of aonla without any buy back contract as there is no scope of local processing available for them in the block or district level. Farmers are getting vary low price for aonla. The demand for aonla in drug, health and cosmetic industry is increasing everyday but in the form of extracts, candy, powder and dry. The farmers have the emergency to sell the raw aonla through traders or middlemen and take the advantage of the situation. The farmers can encouraged to produce large quantity of aonla only if they have the scope of selling processed material or fresh as such in the local market.



EFFECT OF GROWTH SUBSTANCES ON VASE LIFE AND BULB PRODUCTION IN TUBEROSE (*POLIANTHES TUBEROSA* L.) CV. PEARL DOUBLE

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Abstract

Tuberose, the alluring cut flower is a major representative of bulbous flower group. Hence, considering its economic importance, the present investigation entitled "Effect of growth substances on bulb production and vase life of tuberose (*Polianthes tuberosa* L.) cv. Pearl Double" was carried out at Horticultural Research Farm of Department of Horticulture, C. C. S. University, Meerut. The soil of the experimental area was sandy loam and neutral in reaction. The total number of treatments were 10 comprising 3 levels of each i.e. ethrel (100, 150 and 200 ppm), maleic hydrazide (50, 100 and 150 ppm) and cycocel (3000, 5000 and 7000 ppm) with control. The experiment was laid out in randomized block design with three replications. The salient features of the present study are summarized as the vase life along with all bulb production parameters were significantly influenced with all treatments. The longest vase life (13.03 and 13.53) as well as highest bulb per clump (3.24 and 3.30) were observed with T5 (MH-100ppm) while, maximum weight (80.84 and 83.07) and diameter (3.26 and 3.95) of biggest bulb per clump were recorded with T2 (Ethrel-150ppm). It is also evident from the data that maximum number of bulblets per clump (23.96 and 24.94) as well as weight of bulb (48.04 and 48.69) and bulblets (23.31 and 23.87) were recorded with T8 (CCC-5000 ppm) while, highest yield of bulb and bulblets (262.38 and 273.60 q/ha) were recorded with T5 (MH-100ppm) during both the years of investigation.

Key words: Tuberose, bulb production, vase life, ethrel, maleic hydrazide, cycocel, growth substances.

Introduction

The floriculture consisting of cultivation and trade of cut flowers, cut foliage, potted plants, garden-bedding plants, planting material, services etc. has become an important sector, experiencing rapid change the world over. Consumption of flowers in most countries is rising and associated with income development. Rising demand has resulted in development of new production centres in Latin America, Africa and Asia, which were traditionally grow in U.S.A, Japan, Italy, The Netherlands and Colombia. In Asia, India and China besides Thailand are moving in the direction of more intensive horticulture. Flowers are an integral part of human living. We have flowers and ornamental plants for

every occasion. Growing of flowers has been practiced in India since time immemorial. This is amply evidenced by the references found in Rigveda, Ramayana as well as their depiction in paintings, murals, coins etc. Use of flowers, which was largely limited of offering in temples, has got a pride of place among all types of people, lowers class to higher strata. Today, it is being adopted as a lucrative profession also. Thus, floriculture has emerged as a potential foreign exchange earner in India. Tuberose occupies a prime position in floriculture industry in India. The chief centers of its production in India are Thane and Pune districts in Maharashtra, Midnapur district in West Bengal, Madurai and Coimbatore districts in Tamil Nadu and Devanahalli district in Mysore. The tuberose (*Polianthes tuberosa* L.) is a bulbous ornamental plant popularly known as 'Rajanigandha'. Plant produces elegant fragrant spikes of waxy and white blossom, belongs to the Amaryllidaceae (family) and is a native of Mexico or South America. The light green leaves in tuberose are 70-80 cm long, narrow and in crowded form. The flowering stalk, which emerges, from the centre of the cluster of leaves is about 80-120 cm. long bearing leaves and the flower buds are tubular. Flowers are 5-6 cm. long, slightly bent near the base. Normally tuberose begins to flower in 90-95 days after planting. The flowers emit a delightful fragrance and are the source of tuberose oil. The natural flower oil of tuberose remains today one of the most expensive of the perfumery's raw materials and also used in soap and cosmetic industries. The most common constituents of tuberose concentrate are geraniol, nerol, benzyl alcohol, methyl benzoate, methyl salicylate, eugenol, benzyl benzoate and methyl anthranilate [13]. Tuberose flowers profusely during the summer and rains (April-September) in the plains and from May to July on the hills, while in mild climate tuberose remains in flowering throughout the year. There is not much more information about the application of ethrel, maleic hydrazide & cycocel in tuberose. In this condition growers are needed information about optimum dose and using direction for way to increasing quality production and more profit. Keeping the above points into consideration, present study was conducted to find out the optimum dose of ethrel, MH and cycocel for maximize the bulb production and vase life characteristics of tuberose cv. "Pearl Double" under Meerut conditions of western U.P.

Materials And Methods

The existing study was conducted at the Horticultural Research Farm Department of Horticulture, Chaudhary Charan Singh University, Meerut (U.P.) during two consecutive years. The climate of Meerut region remains hot in summer season and cold in winter season. Geographically, Meerut is situated at 29.01°N latitude and 77.43°E longitude with an altitude of about 222 meter above the mean sea level. Meerut region has a typical climate of semi-arid with extremes of weather conditions. The average annual rainfall is about 700 mm, bulk of which nearly 70% is received between June to September and rest between October and May. It remains hot in summer seasons and cold with frost in winter season. The maximum temperature ranges between 19.4°C to 45°C during the hottest month of May and June with extremes of 46.50°C and minimum during coldest month of December and January ranges between 3.9°C to 27.2°C. The relative humidity shows a reverse trend, the mean wind velocity of 8.9 km/hr in the month of June and 4.5 km/hr in January. The soil characters of the experimental plot were sandy loam and having EC value 0.087 (mS/cm) as physical features and chemically analysis of the soil samples collected from the experimental field were recorded as pH 6.90, organic carbon 0.44%, available N 0.053%, P 0.081% and K 0.0194%.

Mechanical analysis of the soil constituents was done by Bouyoucos Hydrometer Method [19]. Electrical conductivity (EC) was measured by Conductivity Bridge [11] and the pH by glass electrode pH meter [9]. Organic carbon was estimated by the method of Walkley and Black [24]. Available N was estimated by Macro-Kjeldahl method [3]. Available P was estimated with Olsen's reagent method [17], while available K was estimated by Flame photometer [18]. The well-developed, average size bulbs of tuberose were used for conducting the experiment. The experiments were laid out in randomized block design with ten treatments including control. All treatments were replicated thrice. Five plants were selected from each treatment and tagged for recording the growth observations i.e., Number of bulbs per clump, weight and diameter of biggest bulb per clump, weight of bulb, number of bulblets / clump, weight of bulblets as well as, yield of bulbs and bulblets.

Results and Discussion

The perusal of the data presented in Table-1 indicates that all the treatments significantly influenced the vase life of spike. All levels of ethrel, maleic hydrazide and cycocel enhanced the vase life and it was longest (13.03 and 13.53 days) with T5 during both the years of investigation followed by with T8 and T2. However, T5 was statistically at par with T8 and T2 treatments during both the years. The vase life of spike was 8.40 days and 8.90 days in control during respective years of investigation. The data presented indicate that the vase life of spike superior over all treatments was due to retardation of metabolism and respiration by maleic hydrazide. Inter comparison of data clearly states that maleic hydrazide at lower concentration produced its marked effect on maximum vase life of spike during both the years. [22] reported that the longest vase life was recorded with MH 100 ppm. [1] also examined the effects of maleic hydrazide on vase life of cut flowers and found the similar results. Increase in the vase life of spike at lower or medium concentration of ethrel is in confirmation with findings of [4,14 and 15]. Increase in vase life of flowers by application of cycocel was also reported by [7 and 16]. Maximum numbers of bulbs per clump [3.46 and 3.42] were recorded with T8 after that in T5 [3.24 and 3.30] and T2 [3.20 and 3.27] treatments, while minimum were observed in control [2.11 and 2.18] respectively during the course of investigation. Highest weight of biggest bulb [80.94 and 83.07] were observed with T2 (Ethrel 150 ppm) followed by T3 and T5 and minimum were recorded in control

correspondingly during both the years of study while, T2, T3 and T5 were statistically at par during both the years. Maximum diameter [3.26 and 3.95] of biggest bulb were also perceived with T2 (Ethrel 150 ppm) followed by in T6 and T3. It is evident from the data available in table-2 that maximum number of bulblets per clump [23.96 and 24.94], weight of bulb [48.04 and 48.69] and bulblets [23.31 and 23.87] were recorded with T8 (CCC 5000 ppm) followed by T5 (MH 100ppm) for weight of bulb and number of bulblets per clump, while T2 (Ethrel 150 ppm) for weight of bulblets per clump. More or less all the bulb characters significantly increased with the cycocel at 5000 ppm. These findings are in complete agreement with the findings of [2, 12, 20 and 21]. It is also clear from the data of present study that ethrel have a significant positive effect on yield of bulb and bulblets. These findings are in accordance with the results of [8 and 23], who found that treatment with ethrel inhibited plant growth but markedly increased the corm yield of gladiolus. Close supervision of the data reveals that yield of bulb and bulblets were recorded maximum (262.38 and 273.60 q/ha) with T5 (MH 100 ppm) followed by T2 (ethrel 150 ppm) and minimum (225.90 and 240.40 q/ha) in control. In case of bulb and bulblets production T5 (MH at 100 ppm) proved its superiority over lower (50 ppm) and higher (150 ppm) concentration of MH during both the years of investigation. In general all the levels increased the number, weight of bulb and bulblets over control during both the years of study. However, some previous reports state that MH has growth inhibitory effect over bulb and bulblets production [5, 6 and 22].

Table 1: Effect of growth substances on vase life, number of bulbs per clump, weight and diameter of biggest bulb per clump in tuberose.

Treatments	Vase life of spike (Days)		Number of bulbs per clump		Weight of biggest bulb /clump (gm)		Diameter of biggest bulb per clump (gm)	
	Ist Year	IIndYear	Ist Year	IIndYear	Ist Year	IIndYear	Ist Year	IIndYear
T1(Ethrel-100ppm)	11.98	12.48	2.98	3.01	66.05	68.39	2.76	3.42
T2(Ethrel-150ppm)	12.83	13.35	3.20	3.27	80.84	83.07	3.26	3.95
T3(Ethrel-200ppm)	12.29	12.84	3.15	3.20	79.38	81.94	3.22	3.88
T4(MH -50ppm)	11.35	11.91	2.92	2.97	69.85	72.30	2.80	3.48
T5(MH-100ppm)	13.03	13.53	3.24	3.30	79.30	81.63	3.21	3.84
T6(MH-150ppm)	12.71	13.21	3.17	3.21	77.13	79.47	3.23	3.92
T7(CCC-3000 ppm)	11.43	11.93	2.91	2.98	72.34	74.90	2.85	3.50

T8(CCC-5000 ppm)	12.87	13.37	3.36	3.42	78.16	80.50	3.26	3.76
T9(CCC-7000 ppm)	12.80	13.33	3.05	3.08	75.18	78.00	3.13	3.69
T10(Control)	08.40	08.90	2.11	2.18	64.30	62.47	2.40	3.10
Sem +	0.172	0.102	0.019	0.019	0.465	0.469	0.017	0.004
CD at 5%	0.476	0.282	0.053	0.052	1.290	1.298	0.047	0.011

Table-2: Effect of growth substances on weight of bulb, number of bulblets / clump, weight of bulblets, yield of bulbs and bulblets in tuberosa.

Treatments	Weight of bulb (gm)		Number of bulblets / clump		Weight of bulblets (gm)		Yield of bulbs and bulblets (q/ha)	
	Ist Year	IIndYear	Ist Year	IIndYear	Ist Year	IIndYear	Ist Year	IIndYear
T1(Ethrel-100ppm)	42.01	42.79	20.57	21.33	19.07	19.54	241.29	253.90
T2(Ethrel-150ppm)	46.63	46.49	23.09	23.89	22.97	23.36	261.24	272.91
T3(Ethrel-200ppm)	45.82	46.63	22.31	22.94	22.40	22.87	258.80	271.47
pnumT4(MH -50ppm)	41.02	41.76	20.20	20.94	19.58	20.00	242.02	254.69
T5(MH-100ppm)	47.14	47.70	23.21	24.03	22.74	23.14	262.38	273.60
T6(MH-150ppm)	46.10	46.46	22.56	23.19	22.11	22.62	257.93	269.99
T7(CCC-3000 ppm)	41.97	42.34	20.07	20.78	19.52	19.73	247.91	260.37
T8(CCC-5000 ppm)	48.04	48.69	23.96	24.94	23.31	23.87	252.95	247.80
T9(CCC-7000 ppm)	44.26	44.88	21.95	22.45	21.60	22.17	260.47	263.13
T10(Control)	37.04	38.20	14.52	15.34	15.40	16.30	225.90	260.40
Sem +	0.274	0.179	0.140	0.159	0.120	0.127	1.532	1.673
CD at 5%	0.760	0.496	0.389	0.441	0.331	0.353	4.248	4.637

Conclusion

The present investigation reveals that maleic hydrazide at 100ppm, ethrel at 150 ppm and cycocel at 5000 ppm are best suited for vase life as well as the bulb production and over all yield of tuberosa cv. 'Pearl Double'. These treatments enhanced the quality crop production under the agro-climatic conditions of Meerut region of western U.P.

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A CRITICAL REVIEW ON TRADITIONAL HERBAL PLANT 'TULSI'

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Abstract

The medicinal value of Tulsi is fantastic. Studies have also found that Tulsi has been beneficial in lowering blood glucose levels in diabetes. In the same analysis, overall cholesterol levels with Tulsi were greatly decreased. Another research found that its antioxidant effects had a positive effect on blood glucose. The Rama Tulsi is the powerful treatment for extreme acute airborne syndrome. Juice from her leaves provides frost, flu, bronchitis and cough relief. As an ear drop, tulsi oil is used too. In cure of malaria, Tulsi aids. It is particularly effective against indigestion, fever, hysteria, sleeplessness, cholera. Millions of people each day taking the new leaves of Tulsi. Tulsi, the medicinal queen, is renowned for its excellent healing properties for many generations. Modern science study has demonstrably demonstrated the reduction and resilience of stress, inflammation reduce, cholesterol reduction, contaminants removal, radiation safety, gastric ulcers avoidance, fevers reduction, metabolism and a high degree of antioxidant and other nutrients. This research often offers remarkable outcomes. Tulsis protects the heart, blood vessels, liver and lungs in particular and controls blood pressure and blood sugar. Recent studies indicate that Tulsi, like many modern painkillers, may be a COX-2 inhibitor due to its strong eugenol concentration (1-hydroxy-2methoxy-4-allylbenzene). Tulsi is also promising to guard against toxicity and cataracts. The oil from the Karpooora Tulsi is used primarily for herbal washing. It also uses the oil against bacteria and insects. Tulsi can keep the dreaded swine or H1N1 flu in the background, but can also lead to rapid recovery of a person suffering from Ayurvedic practises. "Medical researchers worldwide have recently uncovered Tulsi's anti-flu property. Tulsi strengthens the global system of defence, including its capacity to suppress infectious disease.

Introduction

Tulsi is known to be a ubiquitous plant in India. *Ocimum tenuiflorum* (tulsi) is an aromatic herb in the genus Lamiaceae. It is an upright, much branched sub shrub 30-60 cm tall with hairy stems and simple opposite green leaves that are heavily scented. tulsi plays a crucial role in our daily life and is said to be the queen of medicinal plants. It is the most popular household plant in India and it is sacred in hindu culture. Many Hindu epics describe the importance, properties and uses of tulsi. Tulsi is an erect sweet scented shrub which grows upto a height of 3 -5 feet. It is usually grown in gardens and in the outskirts of temples. It has got a pungent taste and fragrant scent. It is the only plant that can consume carbon di oxide through-out its life. It releases the oxygen in the early morning which is helpful for the people in respiratory dis-orders. Tulsi plant has a lot of importance for humanity, owing to the manifold medicinal advantages it offers. Tulsi leaves are commonly used in the preparation of Ayurvedic medicines [1, 3, 7]. [1, 3, 7]. It is believed to encourage the longevity of life. The extracts derived from the

plant was widely brought to use for treating numerous diseases such as the common cold, inflammation, malaria, respiratory disease, headaches, stomach disorders, kidney stones, heart disorders, and many more. The Indian Tulsi basil tends to purify the environment as well. In battling fly, mouse and mosquitoes the Tulsi plant acts as a fabulous repellent. It is highly useful in the war against malaria. It's said that the workers suffered from mosquito bites and persistent malaria during the establishment of the Victoria Gardens in Bombay (now Mumbai). Some Hindu managers suggested that the Tulsi plant be cultivated in a Garden in view of the pitiful condition of the workers. Fruitful findings were collected on the basis of their recommendations. Holy basil Tulsi thus helped limit mosquito development and malaria prevention. Tulsi plant is used in various forms. In Ayurvedic treatment of diseases, the plant finds its way gradually. Because of its soothing ability, Tulsi leaves are very popular. This sound has been used to sharpen the memory of the nervous system. This aromatic plant supports the separation from the bronchial tunnel of flegm and catarrhal compounds. It functions wonderfully even to avoid diseases of the stomach. Air disorders are also known as herb Tulsi. The blended sugar, ginger and tulips prepared decoction is very effective in the fight against asthma, bronchitis and influenza. During the rainy season, Tulsi's leaves are extremely helpful when diseases such as malaria and dengue are the victim of the world. Boil the patient with their tender Tulsi leaves in tea. The juice from the Tulsi leaves is the perfect treatment for fever relief. In the preparation of Ayurvedic cough syrups, tulsi is an important ingredient. In getting rid of cold and grip it is very helpful. The leaves of the herbal Tulsi plant are also very useful for sore throat. Only boil the Tulsi leaves in water and ask the patient to gargle. Tulsi is able to reinforce the kidneys. The decoction prepared by mixing the juice of Tulsi leaves with honey, if taken sincerely for six consecutive months, could remove these stones through the urinary tractor for those suffering from the renal kidney stones problem. Tulsi is highly useful to preserve a balanced heart. It decreases cholesterol levels in the blood. The most effective treatment for the battle against heart disease is therefore Tulsi [1,2].

Tulsi Used as Traditional Indian Ayurvedic Medicine

According to Organic India, an organization dedicated to organic agriculture and sustainable development, one of the qualities that make the Tulsi plant such a potent medicinal herb is its ability to reduce stress. Tulsi is abundant in essential oils and antioxidants, which are tremendously effective in reducing the effect of stress. On the body. Tulsi has got diverse healing properties. Though traditionally used by Hindus or Indians now others are using it too recognizing its immense therapeutic properties. The Tulsi has the property of acting as an adaptogen. It balances different processes in the body and is of great help in stress management. The extracts of Tulsi have been used in traditional Indian Ayurvedic system of medicine. It is also used in the Unani system of medicine. Ayurvedic remedies for common colds, headaches, stomach disorders, inflammation, infections, heart disease, poisoning, cataracts and malaria make use of the Tulsi. The Tulsi acts on the nervous system and strengthens it. It strengthens the heart. It acts as an appetizer and promotes digestion too. It facilitates the secretion of digestive enzymes and prevents flatulence. Having detoxifying properties the Tulsi purifies blood of any toxins that might be present in it. Studies have also shown the Tulsi to be effective in reducing blood sugar levels and in controlling diabetes. It has also been proved to be effective in reducing cholesterol levels. Having anti-bacterial and anti-parasitic properties makes it suitable for combating infectious diseases of various types. Recent findings have indicated that the Tulsi may well provide protection from radiation poisoning [6, 7]. It has also been indicated that Tulsi possesses anti-cancerous properties. There has come up a belief that a Tulsi leaf swallowed daily will ensure protection from cancer. Apart from its religious significance it is of great medicinal significance, and is a prime herb in Ayurvedic treatment. Marked by its strong aroma and a stringent taste, tulsi is a kind of "the elixir of life" as it promotes longevity. The plant's extracts can be used to prevent and cure many illnesses and common ailments like common cold, headaches, stomach disorders, inflammation, heart disease, various forms of poisoning and malaria. Essential

oil extracted from karpooora tulsi is mostly used for medicinal purposes though of late it is used in the manufacture of herbal toiletry. The Plant Cultures project of the Medicines and Healthcare Products Regulatory Agency (MHRA) of the United Kingdom notes that in Ayurvedic medicine the Tulsi plant has been used topically for skin conditions like eczema, ringworm and insect bites. It is also commonly used to reduce fevers, improve lung and digestion issues, reduce the effects of colds, eliminate toxins/poisons and as a preventative antibacterial for infections. [1,2]

Tulsi in Modern Medicine

In modern medicine there has been research indicating Tulsi might potentially be an effective treatment for conditions like ulcers, high cholesterol, Type 2 diabetes, obesity and compromised/suppressed immune systems (from conditions like cancers and AIDS). Plant Cultures says the traditional uses of Tulsi in Ayurveda might be due to some intrinsic properties in many varieties of Tulsi- -such as the essential oils containing an anti-inflammatory compound called eugenol, and various acids with antioxidant and anti-inflammatory properties that could support the claims of Tulsi being a treatment for so many conditions, according to Ayurveda.

Tulsi in your Home

The Tulsi plant, like most herbs, is a delicious way to enhance the flavor of your cooking, or make an excellent tea. This sub-shrub looks quite attractive in a decorative pot, is not harmful to animals and it is fairly easy to grow. Even outside of its medicinal properties, the Tulsi plant can make a great addition to your household either in your spice rack or in your garden.

Diabetes--Western Medicine

According to diabeteshealth.com, "Researchers have theorized that holy basil (tulsi) leaves may improve pancreatic beta cell function and thus enhance insulin secretion." The website reports that a small research study of patients with type 2 diabetes found blood glucose fasting levels lower in patients who took 2.5 grams of powdered tulsi compared to patients who took a placebo. Diabeteshealth.com reports that drug interactions with tulsi have not been reported; however, some

interactions might be possible in "diabetics treated with insulin or insulin secretagogues such as sulfonylurea (glyburide, glipizide, Amaryl), Prandin or Starlix." Because of this, diabetics who might consider using tulsi should check with their physicians first.

Snake and Insect Bites

Traditional Medicine: According to Plantcultures.org, oil from tulsi is a natural antiseptic and natural anti-inflammatory. According to Botanical.com, tulsi effectively treats snake bites, including those of poisonous snakes, when all parts of the plant are either ingested or mixed with other plants to form a paste that is applied to the bite area. Residents of the Asian subcontinent often put tulsi leaves into bowls of water outside their homes and in their bath water to ward off insects, which do not like the smell. **Natural Medicinal Uses:** Sidha, Unani and Ayurvedic medicine use tulsi to treat a wide variety of skin conditions, fevers, coughs and internal ailments. Ayurvedic medicine treats bronchitis with a liquid tonic made from tulsi leaves, which Indians mix with cardamom or lemon juice. All three medicinal systems date to ancient times and are based on natural remedies and treatments, primarily based on herbs and plants.

Medicinal Uses of Tulsi

Other medicinal uses, supported by studies conducted across the subcontinent, of tulsi include treating asthma, arthritis and heart problems. According to Globinmed.com, "The essential oil (of tulsi) has been found to have antibacterial, anti-yeast and insecticidal action. The seeds and oil have also been found to show mild antibiotic effects." Tulsi (*Osmium sanctum*), commonly known as Holy Basil, is an herb indigenous to South Asia. Tulsi's healing attributes have been documented for centuries, and it remains the core of Ayurveda (India's herbal medicine). Tulsi has long been one of the most common medicinal plants used in India, though the West is just waking up to its powers. Cosmetic companies have recognized its bactericidal attributes and now use it in a wide array of beauty products. [1]

Skin

Steven Maimes talks about the uses and benefits of Holy Basil in an article about his ongoing research for Salam Research, an independent company in Rochester, N.H. Published in November 2004, Maimes says Tulsi "reduces eczema and psoriasis ... and helps skin diseases like leprosy and staph infection." With its antibacterial properties, Tulsi flushes out dangerous toxins and regenerates skin.

Anti-Aging

Tulsi contains ursolic acid, a compound that prevents wrinkles and helps retain the elasticity prevalent in young faces. No wonder Tulsi became an instant hit with the beauty industry and a prime ingredient in herbal cosmetics, including face packs, creams and many other products. For fresh and youthful skin, mix Tulsi powder (available online) with water and apply to your face. Once dried, rinse your face thoroughly with water.

Beauty and Restoration

Tulsi enhances beauty; many Indian women make it a part of their daily beauty ritual. Applying Tulsi powder removes spots from your face. For natural freshness, boil water with Tulsi leaves and lemon juice. Cover your head with towel and refresh your face with the emanating steam. Tulsi cleanses and purifies the blood. Hecapedia recommends using Tulsi paste to treat acne. A homemade cure of Tulsi paste helps people with leukoderma.

Antibiotic Protection

Offers significant natural antibacterial, antiviral and antifungal protection and is, thereby, helpful in treating many serious systemic diseases, as well as localized infections. Heart and Vascular Protection Lowers dangerous cholesterol and stress related high blood pressure, protects the heart and blood vessels, and has mild blood thinning qualities, thereby decreasing the likelihood of strokes.

Liver Support

Generally contributes to healthy liver function, improves the metabolic breakdown and elimination of dangerous chemicals in the blood,

and counteracts various liver diseases. Lung and Bronchial Support In addition to contributing generally to respiratory health, Tulsi has been shown to be helpful in the treatment of a variety of serious allergic, inflammatory and infectious disorders affecting the lungs and related tissues.

Nutrition

Contains vitamins C and A, and minerals calcium, zinc and iron, as well as chlorophyll and many other phytonutrients. Also enhances the efficient digestion, absorption and use of nutrients from food and other herbs.

Allopathic Medicine Complement

Enhances the effectiveness and reduces the negative and often dangerous side effects of many standard modern medical treatments. Other Benefit Lowers fevers, protects against gastric ulcers, reduces dangerous blood sugar levels in diabetics, and supports dental and periodontal health (and diminishes "bad breath"). Also protects against mercury poisoning, speeds healing of bone fractures, reduces nausea, vomiting and cramping, and repels insects, including mosquitoes and lice.

High Safety Margin

Research indicates that Tulsi has a very high safety margin with exceptionally low toxicity, providing general beneficial effects at doses without adverse reactions or other undesirable side effects. Tulsi's Botanical Identity Tulsi is identified by botanists primarily as *Ocimum sanctum* (Rama and Krishna Tulsi varieties) or more recently *Ocimum tenuiflorum*, and *Ocimum gratissimum* (Vana Tulsi variety). Belonging to the Lamiaceae/Labiatae mint family, these and other closely related species and varieties (e.g., *Ocimum canum*) are cousins of the familiar sweet basil cooking herb *Ocimum basilicum*. In parts of India, all of the basils are honoured as Tulsi. Tulsi is traditionally taken in a variety of forms, including cold and hot fresh or dried leaf tea infusions (herbal teas), fresh green leaf, leaf juice, ground or powdered leaf, alcohol tinctures, poultices and oil (ghee) preparations, as well as seed, root and stem formulations, both internally and topically. In addition, modern human clinical studies and animal experiments also employ various extracts and isolated compounds,

sometimes administered by injection. Differing Tulsi preparations likely vary to a considerable degree, both chemically and in their overall pharmacological effects. Substantial evidence has accumulated that, in addition to Tulsi's many specific therapeutic applications, the herb's powerful general adaptogenic properties offer significant preventative and curative potential with respect to the stress-related degenerative diseases endemic to industrialized societies. Ongoing clinical investigation of Tulsi's health promoting qualities is sure to bear rich fruit.

Pharmacological Effects

In traditional Ayurvedic system of medicine, several medicinal properties have been attributed to this plant. Recent pharmacological studies have established the anabolic, hypoglycemic, smooth muscle relaxant, cardiac depressant, antifertility, adaptogenic and immunomodulator properties of this plant.

Antimicrobial Effects

Essential oil of Tulsi have antibacterial, antifungal and antiviral properties. It inhibits the growth of *E. coli*, *B. anthracis*, *M. tuberculosis* etc. Its antitubercular activity is one-tenth the potency of streptomycin and one-fourth that of isoniazid. Preparations containing Tulsi extract significantly shorten the course of illness, clinical symptoms and the biochemical parameters in patients with viral hepatitis and viral encephalitis.

Antimalarial Effects

Essential oil of Tulsi has been reported to possess 100% larvicidal activity against the *Culex* mosquitoes. Trials have shown excellent antimalarial activity of Tulsi. Its extracts have marked insecticidal activity against mosquitoes. Its repellent action lasts for about two hours.

Antiallergic and Immunomodulator Effects

Essential oil of Tulsi was found to have anti-allergic properties. When administered to laboratory animals, the compound was found to inhibit mast cell degranulation and histamine release in the presence of allergen. These studies reveal the potential role of *Ocimum sanctum* extracts in the management of immunological disorders including allergies and asthma.

Anti-diabetic Effect

A randomized, placebo-controlled cross-over single blind trial on 40 human volunteers suffering from Type II diabetes was performed. During the four week trial, subjects alternately received a daily dose of 2.5 g of Tulsi leaves powder or a placebo for two week periods. The results showed 17.6 % reduction in fasting blood glucose and 7.3% decline in postprandial blood glucose on treatment with Tulsi as compared to the blood glucose levels during treatment with placebo.

Antifertility Effect

One of the major constituents of the leaves, ursolic acid has been reported to possess antifertility activity in rats and mice. This effect has been attributed to its antiestrogenic effect which may be responsible for arrest of spermatogenesis in males and inhibitory effect on implantation of ovum in females. This constituent may prove to be a promising antifertility agent devoid of side effects.

For Heart Ailments

As 'Tulsi' (basil) has a positive effect over blood pressure and also a de-toxicant, its regular use prevents heart attacks. A tonic may be prepared by mixing 1 gm of dry 'Tulsi' leaves with a spoonful of butter and some candy sugar or honey. Take twice a day; first thing in the morning and before going to bed at night. The drinking of Tulsi-leaf tea keeps the blood pressure even.

Other Effects

The leaves in the form of a paste are used in parasitical diseases of the skin and also applied to the finger and toe nails during fever when the limbs are cold. The juice of the leaves is given in catarrh and bronchitis in children. The plant is said to have carminative, diaphoretic and stimulant properties. A decoction of the plant is used for cough and also as mouth wash for relieving tooth ache. It is good for headache, convulsions, cramps, fevers and cholera. The drinking of Tulsi-leaf tea keeps one free from cough and colds and other ailments associated with 'Kapha' dosha in the body. This tea is an instant pick-me-up (energy drink) also.

Amazing Medicinal Attributes of Tulsi

11, 15 Persistent use of this herb could be extremely beneficial in getting relief from a number of ailments. A few of them are enlisted below: [1]

Jaundice

Tulsi is one of the best remedy for jaundice. Prepare a combination of 10 tulsi and radish juice (10 gm) and take it thrice daily on a regular basis with jaggery for one month. It would alleviate jaundice completely.

Eye Problem

This herb is often used for treating eye disorders. A thick liquid prepared by crushing tulsi leaves is often applied to the eyes for healing up night blindness and inflammation.

Mouth Ulcer

Tulsi effectively cures mouth ulcers, lesions, and other related disorders. It is quite useful for sensitive teeth and gums. Tulsi extract in the paste form or by simply chewing tulsi leaves could give you relief from these mouth problems.

Piles

Tulsi is also useful for treating piles. Soak five tulsi leaves in drinking water for 30 minutes and drink the water afterwards. By following this process regularly you could get rid of piles.

Cold

If you have got common cold and associated fever then tulsi could be a good choice of medicine. Take pieces of 7 holy basil leaves and 5 cloves and mix them well in one glass of water and boil them until the volume of water becomes half of the original. Add rock salt into it and drink it hot and make the whole body sweat by covering with clothes. Fever immediately gets alleviated and the symptoms of cold also get improved. For children tulsi juice with 5 to 7 drops of honey could give instant relief from the symptoms of cold and stringy mucus in the respiratory tract.

Stomach-ache

Prepare tulsi and ginger juice and take one

spoonful of each of these extracts daily for healing up cramps and stomach-ache.

Worms in Stomach

Take one spoon of hot tulsi and ginger juice after every interval of 3 hours and continue this for two days in order to remove worms with stools.

Acidity

Tulsi is also useful for seminal problems. Prepare a mixture of 50 g of sugar candy and tulsi seeds and take 2.5 g of this mixture with milk on a daily basis. In absence of tulsi seeds you could also use tulsi roots. Regular use of this medication would help in thickening and strengthening sperms in male.

Tulsi Can Help Keep Swine Flu Away

Tulsi can not only keep the dreaded Swine flu or H1N1 flu at bay but also help in fast recovery of an afflicted person, Ayurvedic practitioners claim. "The anti-flu property of Tulsi has been discovered by medical experts across the world quite recently. Tulsi improves the body's overall defence mechanism including its ability to fight viral diseases. It was successfully used in combating Japanese Encephalitis and the same theory applies to swine flu," Dr U K Tiwari, an herbal medicine practitioner says. Apart from acting as a preventive medicine in case of swine flu, Tulsi can help the patient recover faster. "Even when a person has already contracted swine flu, Tulsi can help in speeding up the recovery process and also help in strengthening the immune system of the body," he claims. "Tulsi can control swine flu and it should be taken in fresh form. Juice or paste of at least 20-25 medium sized leaves should be consumed twice a day on an empty stomach."

Tulsi's effectiveness against Swine Flu may have come as news to people who are unaware of the wealth of benefits that the humble herb has to offer. Traditionally, Hindu temples provide water that has Tulsi leaves soaked in it to devotees. Tulsi leaves are boiled in water and the essence is given to children and adults who suffer from flu and common cold. [3]

Tulsi to Save Taj Mahal From Pollutants

Tulsi (*Ocimum sanctum*) chosen for its anti-pollutant antioxidation and air-purifying properties making it an ideal ornamental shrub in the vicinity of the Taj Mahal. Now Tulsi is being used to help Taj Mahal to retain its pristine allure. Even as the monument of love yellowing with age awaits its promised beauty pack for well over two years, forest department has come up with another quick-fix project -- plant a Tulsi drive in Agra. The recommended complexion care regimen, officer's claim, has full backing from ancient texts which hold Tulsi to be the panacea for all problems from cosmic to cosmetic. The department is all set to launch the Tulsi plantation drive from January 2009. The public-private joint venture is expected to provide an eco-protection cover to sensitive Taj trapezium zone surrounding the 17th century monument as well as the other two world heritage monuments -- Agra Fort and Aitma-ud-Daula tomb. [1]

Conclusion

All these medicinal ingredients makes Tulsi a must have for longer and peaceful life. This small plant is certainly a very good source of medicinal properties. After in depth and rigorous research it has been proved and certified that it is safe to consume Tulsi in any form. All these remedial properties are well accepted and honored by modern science. Tulsi is the herb that cures the mankind from all odds naturally in today's superficial not-so good lifestyle. It is considered as India's Queen of herbs. They are largely used in ayurvedic medicines. It has got medicinal

properties as well as cosmetic properties. Tulsi is grown in almost all Indian homes. Water boiled with tulsi leaves is good for sore throat. It can also be gargled. Chewing tulsi leaves treats cold and flu. Tulsi leaf when eaten in the morning purifies blood. It can be used as tooth powder by drying its leaves and mixed with water. It helps in protecting the entire respiratory tract. It has many cosmetic properties and used in herbal soap and also for body scrub. It helps in controlling dandruff. Tulsi oil can be used for controlling dandruff. It can be used by mixing with coconut oil. Tulsi leaves juice and ginger juice cures stomach ache, cramps and also gets relief from stomach worms. Tulsi or Basil leaves mixed with 1tsp of honey will cure severe cold.

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GENETIC HETEROSIS AND INBREEDING DEPRESSION ANALYSIS OF OKRA (*Abelmoschus Esculenus* L.)

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Abstract

Okra is an important vegetable crop in tropical, subtropical and Mediterranean regions of the world. Hundred grams edible portion of okra contains 1.9 g of protein, 0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 g fiber. The material for present investigation comprised 10 genotypes of Okra collected C. S. Azad University of Agriculture and Technology Kalyanpur- Kanpur. These comprised of commercial varieties and indigenous collection from different parts of India grown at research farm of Kisan P. G. College Simbhaoli - Ghaziabad. All the possible F1 crosses excluding reciprocal were made among these 10 parents during the season. All these F1 were selfed for procuring F2 seeds. The high magnitude Heterosis performance was found in cross combination KS-475xKS-418 yield per plant. Inbreeding depression was observed with nine F2 populations maximum 40.0% with cross KS-315xKS-418 found high yield due to Heterosis over economic parent for number fruits per plant, length of fruit and yield per plant. Crosses KS-315xKS-375, BO-2xKS-375, BO-2xKS-410 and ParbhaniKranti x PusaSawani showed maximum significant negative inbreeding depression for high yield per plant

Keywords: Genetic variability, heritability, Inbreeding depression, okra.

Introduction

Breeding method for the improvement of a crop depends primarily on the nature and magnitude of gene actions involved in the expression of quantitative and qualitative traits. Okra is an important vegetable crop in tropical, subtropical and Mediterranean regions of the world [15]. Carbohydrates, in okra, are mainly present in the form of mucilage, a typical heterogeneous polysaccharide [8]. Mucilage as energy reserves performs multitude of physiological functions. Moreover, it binds cholesterol and a bile acid carrying toxin dumped into it by the filtering liver and has reported to be beneficial for healing ulcers and controlling sugar. In developing countries like India, okra plays an important role in income generation and subsistence among rural farmers. Heterosis in okra, an often-cross pollinated crop, was first demonstrated by [17]. Heterosis in okra for yield and its components has been studied extensively. The combining ability studies are useful for the evaluation of newly developed lines for their use as parents in the breeding programmes and to know the gene action involved in the inheritance of various characters. Several reports of combining ability analysis in okra are available [14]. Diallel analysis is a useful breeding tool not only for the determination of combining ability and gene action for various traits,

but also for obtaining a generalized picture of genetics of the characters under investigation as has been extensively used in okra. The present investigation has been carried out to F1 on the basis of mean, evaluate GCA effect of parents, F1 heterosis over better parents, Heterosis over economic parents and inbreeding depression also estimate Heterosis for yield in relation to traits.

Materials and Methods

The material for present investigation comprised 10 genotypes of Okra namely Azad Ganga, BO-2, KS-315, KS-375, KS-408, KS-410, KS-415, KS-418, Parbhani Kranti and Pusa Sawani collected from the germ plasm stock maintained in Department of vegetable science, C.S. Azad University of Agriculture and Technology Kalyanpur- Kanpur. These comprised of commercial varieties and indigenous collection from different parts of India. All the homogenous parents parent procured from C.S. Azad University were grown at research farm of Kisan P. G. College Simbhaoli - Ghaziabad. All the possible F1 crosses excluding reciprocal were made among these 10 parents during the season. All these F1 were selfed for procuring F2 seeds. The parents were also maintained through selfing. Parent and F1 were sown in double rows while F2 in three rows with 10 plants. Fertility of experimental plots was maintained uniformly. The experiment was laid out in randomized block design with three replications. Seeds were sown at a spacing of 60 cm between rows and 45 cm between the plants. The observations were recorded on five randomly selected plants per replication for each genotype for characters. The analysis of variance was carried out as suggested by [5]. Genotypic and phenotypic coefficients of variation were estimated according to [2]. Heritability in broad sense was estimated as per the formulae suggested by [1] and Genetic advance was estimated as per the formula proposed by [3] and Johnson et al. [4].

Results and Discussions

Heterosis is amount by which the mean of F1 hybrid exceeds over its better and economic parent. It has been utilised in boosting yield in much self, often cross and often pollinated crops. Six hybrids

flowered earlier than their respective earlier better parents while eight hybrids were earlier than economic parent i.e. Pusasawani have reported Heterosis over better parent [11, 12]. In respect of plant height nineteen hybrids showed desirable Heterosis over better parent [13]. Inbreeding depression for this trait was observed in four F2 populations with maximum decrease 38.1 % in the cross BO-2xKS-415. Nine F2 populations showed increase plant height over their F1 and maximum increase - 80.8 % in cross BO-2x Parbhani kranti. Inbreeding depression was observed in 14 F2 populations. Fruit length, eight hybrids exhibited positive Heterosis over respective better parent while four crosses over economic parent suggesting that is possible to produce longer fruits than economic variety Pusasawani.

Number of fruits per plant fifteen hybrids showed Heterosis over respective better parents. This Heterosis character also supported by [12]. Inbreeding depression was observed in sixteen crosses with maximum decrease 45.0% in cross KS-315xKS-418. Thirteen F2 crosses showed negative inbreeding depression suggesting increased number of fruits per plant. It was most encouraging that boost of yield 285 gram per plant compared to highest parental yield 235 gram per plant. The high magnitude Heterosis performance was found in cross combination KS-475xKS-418 yield per plant. Inbreeding depression was observed with nine F2 populations maximum 40.0% with cross KS-315xKS-418 (Table-1). [13] found high yield due to Heterosis over economic parent for number fruits per plant, length of fruit and yield per plant.

Three crosses were selected primarily on the basis of performance and again on the basis of Heterosis and general combining ability effects (Table-2). From these results, it is evident that parental line showing good general combining ability effect for FYPP might be due to its good general combining ability effects for some of the yield-contributing characters. These findings are in agreement with the earlier findings of [6] and [9]. Comparison of crosses with high performance and heterosis better over economic parent. These crosses did not showed definite relationship with combining ability effects. The best heterosis crosses were observed between high x high, high x moderate, high x low, moderate x

low, low x low general combination for different characters. Estimates of heterosis over better parent F-1 BP and over economic parent F-1 EP develop mean of parents.[10] suggested every possibility of getting a cross with high performance with low heterosis in case parental performance was also high. There could be cross with poor performance with high heterosis response observed in cross combination KS-315 x KS-410 which gave maximum heterosis over economic parent (Table-3). Considering predominance of non-additive gene action for yield and some components manifesting high magnitude of hybrid vigour, heterosis breeding may be useful proportion for improving fruit yield in okra. The possibilities of exploiting hybrid vigour in cross

KS-375 x Pusa Sawani depend upon extent and cost of hybrid seed production. Seven crosses showed significant positive heterotic over economic parent with in breeding depression. Crosses KS-315xKS-375, BO-2xKS-375, BO-2xKS-410 and Parbhani Kranti x Pusa Sawani showed maximum significant negative inbreeding depression for high yield per plant (Table-3). The present findings are also in agreement with days to first flowering, plant height, fruit length, fruit weight, fruit yield per plant and mucilage content those obtained by[7] and [16]. From these results, it is evident that parental line showing good general combining ability effect for FYPP might be due to its good general combining ability effects for some of the yield-contributing characters.

Table 1: Heterosis in percent for yield in relation to its traits under study over better economic parents in okra

Cross combination	No. branches/ Plant	Length of fruits	No. of fruits/ plant	Yield/ plant	Inbreeding depression				
					BP	EP	BP	EP	
KS-375xPusa Sawani	-	45.0**	24.8**	28.8**	22.0**	22.0**	57.9**	57.9**	40.0**
KS-8xKS-410	-	-	-	-	19.0**	-	48.3**	49.5**	38.0**
BO-2xPusa Sawani	-	-	-	-	-	-	43.9**	44.2**	22.6**
KS-315xParbhani Kranti	30.05**	44.0**	-	-	26.3	-	14.7**	23.5**	31.4**
KS-315xKS-410	-	40.1**	-	-	-	-	16.2**	16.2**	34.0**

**** Significant at 1% level**

BP= Better parent

EP= Economic parent

Table 2: Best cross combination, Heterosis, general combining ability and inbreeding depression of okra yield and yield attributing characters.

Characters	F1 on the basis of mean	F1 on the basis of heterosis over better parent	GCA effect of parents
Days of flowering	KS-410xPusa Sawani	KS-410xPusa Sawani	Low x High
	BO-2xKS-408	KS-408xPusa Sawani	High x High
	BO-2xKS-315	BO-2xKS KS-408	High x High
	BO-2xParbhani Kranti	BO-2xKS KS-415	High x Low
	BO-2xPusa Sawani	-	High x Low
Plant height	KS-408xPusa Sawani	KS-408xPusa Sawani	Moderate x High
	KS-415xParbhani kranti	KS-410xParbhani kranti	Low x Low
	KS-375xPusa Sawani	BO-2xKS-315	Low x High
	BO-2xKS-315	KS-315xPusa Sawani	High x High
	KS-315xKS-375	-	Low x Low
Branches/ Plant	KS-375xPusa Sawani	KS-315xParbhani kranti	High x Low
	KS-415xParbhani kranti	BO-2xKS-408	Low x Low
	KS-408xParbhani kranti	BO-2xPusa Sawani	Low X High
	KS-315xKS-375	KS-375xKS-408	High x Low
	KS-375xKS-410	-	Low x Low

Length of fruit	KS-375xPusa Sawani	KS-375xPusa Sawani	Moderate x High
	KS-408xPusa Sawani	BO-2xKS-315	Low x Low
	KS-408xKS-410	KS-315xPusa Sawani	Low X High
	BO-2xKS-315	KS-408xPusa Sawani	High x High
	KS-408xParbhani Kranti	KS-315xKS-410	Low x Low
Fruits/Plant	KS-408xPusa Sawani	KS-408xPusa Sawani	Low X Moderate
	KS-375xPusa Sawani	KS-408xParbhani kranti	Low x Low
	KS-315xKS-410	KS-315xParbhani kranti	High x High
	KS-315xKS-375	KS-375xPusa Sawani	Low X Moderate
	KS-315xPusa Sawani	BO-2xKS-315	Low x High
Yield/Plant	KS-315xKS-410	KS-375xPusa Sawani	Low X Moderate
	KS-375xPusa Sawani	KS-408xKS-410	High x Low
	KS-408xKS-410	BO-2xPusa Sawani	Low x Moderate
	Bo-2xPusa Sawani	KS-408xPusa Sawani	Moderate x Moderate
	KS-408xPusa Sawani	KS-315x KS-373	High x Low

Table 3: Heterosis over economic parent on the basis of inbreeding depression of okra yield and yield attributing characters.

Characters	F1 on the basis of Heterosis over economic parent	On the basis of inbreeding depression
Days of flowering	KS-410xPusa Sawani	KS-375xParbhani kranti
	BO-2xKS-415	KS-315xKS-375
	KS-408xPusa Sawani	KS-373 x Ks-410
	BO-2xKS-315	KS-4408xParbhani kranti
	BO-2xPusa Sawani	KS-315xPusa Sawani
Plant height	KS-408xPusa Sawani	BO-2 x ParbhaniKranti
	BO-2xKS-315	KS-375 x KS-408
	KS-375xKS-410	KS-315 x KS-408
	KS-315xPusa Sawani	BO-2xKS-408
	-	KS-408 x PusaSawani
Branches/ Plant	KS-375xPusa Sawani	KS-410 x ParbhaniKranti
	KS-315xParbhani kranti	KS-315 x KS-408
	KS-315xKS-410	ParbhaniKrantixPusaSawani
	KS-408xParbhani kranti	BO-2 x PusaSawani
	KS-375xKS-408	KS-375xParbhani kranti
Length of fruit	KS-375xPusa Sawani	KS-375 x KS-408
	KS-408xPusa Sawani	KS-375 x KS-408
	-	BO-2xKS-410
	-	KS-375 x Parbhanikranti
	-	ParbhaniKrantixPusaSawani
Fruits/Plant	KS-408xPusa Sawani	KS-315xPusa Sawani
	KS-375xPusa Sawani	KS-315 x KS-408
	KS-315xKS-410	KS-315 x KS-408
	-	ParbhaniKrantixPusaSawani
	-	KS-410 x Parbhanikranti
Yield/Plant	KS-315xKS-410	KS-408xKS-315
	KS-375xPusa Sawani	BO-2xKS-408
	KS-408xKS-410	BO-2xKS-410
	Bo-2xPusa Sawani	PusaSawani x Parbhanikranti
	KS-408xPusa Sawani	KS-315xPusa Sawani

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ANDROGRAPHIS PANICULATA (KALMEGH): A CRITICAL STUDY ON MEDICINAL EFFECTS

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Abstract

Andrographis paniculata (Burm.f.) Nees (Acanthaceae) is a medicinal plant traditionally used for the treatment of cold, fever, laryngitis and several infectious diseases ranging from malaria to dysentery and diarrhea in China, India and other south east Asian countries. The plant is claimed to possess immunological, antibacterial, antiinflammatory, antithrombotic and hepatoprotective properties. In Malaysia, the plant is used in folk medicines to treat diabetes and hypertension. The contents of diterpenoids like andrographolide, neoandrographolide and dehydroandrographolide are the chief criteria for monitoring the quality of *A. paniculata*. Andrographolide, though found in all plant parts, is most concentrated in the leaves. It is a diterpene containing a γ -lactone ring connected to a decalin ring system via an unsaturated C-2 moiety. It has multiple pharmacological properties such as protozoacidal, antihepatotoxic, anti-HIV, anticancer, antitumor, hypoglycemic and hypotensive activities. Andrographolide is an interesting pharmacophore with anticancer and immunomodulatory activities and hence has the potential to be developed as an anticancer chemotherapeutic agent as well. In this review, we have explored the various dimensions of the *Andrographis paniculata* plant and compiled its vast pharmacological applications to comprehend and synthesize the subject of its potential image of multipurpose medicinal agent. The plant is widely cultivated to large regions of the world and its importance as a medicinal plant is growing up substantially with increasing and stronger reports in support of its multifarious therapeutic uses.

KeyWords: *Andrographis paniculata*, andrographolide, neoandrographolide, hepatoprotective, anticancer, antitumor, anti-HIV, medicinal plant.

Introduction

Andrographis paniculata (Burm. F.) Wall. Ex Nees (AP) also called Kalmegh or "King of Bitters" belongs to family Acanthaceae. It has been used for centuries in Asia to treat gastro-intestinal tract and upper respiratory infections, fever, herpes, sore throat, and a variety of other chronic and infectious diseases. Indian Pharmacopoeia narrates that it is a predominant constituent of at least 26 Ayurvedic formulations. In Traditional Chinese Medicine (TCM), *Andrographis* is considered as the herb possessing an important "cold property" useful to treat the heat of body in fevers, and to dispel toxins from the body. In Scandinavian countries, it is commonly used to prevent and treat common colds. It grows abundantly in southeastern Asia: India (and Sri Lanka), Pakistan and Indonesia but it is

cultivated extensively in China and Thailand, the East and West Indies, and Mauritius. AP is normally grown from seeds ubiquitously in its native areas where it grows in pine, evergreen and deciduous forest areas, and along roads and in villages. In India, it is cultivated during rainy phase of summer season (Kharif) crop. Any soil having fair amount of organic matter is suitable for commercial cultivation of this crop. About 400 g seed are sufficient for one hectare. The spacing is maintained 30×15cm. No major insect and disease infestation has been reported. The plants at flowering stage (90-120 days after sowing) are cut at the base leaving 10-15cm stem for plant regeneration. About 50-60 days after first harvest, final harvest is performed.

Plant Parts used: The aerial parts of the plant (leaves and stems) are used to extract the active phytochemicals and thus used for its medicinal importance. Very rarely roots are also used.

Genetical Aspects

Total number of chromosomes in kalmegh are $2n = 50$. Lattoo et al., 2006, induced genetic male sterility (6.0 to 14.0 %) in *A. paniculata* at M-1 following 20 KR gamma irradiation and the male sterile gene was found to be monogenic recessive to normal. The male sterile gene acted upon the tapetal layer and also affected non sporogenous tissue within the anther locule resulting in encroachment of the locule and thereby, significantly reducing the pollen production and enhancing the formation of abortive pollen. However, female fertility remained unimpaired and fully intact in this plant.

Botanical Description

AP is an annual, branched, herbaceous plant erecting to a height of 30-110 cm in moist shady places with stem acutely quadrangular, much branched, easily broken fragile texture stem. Leaves are simple, opposite, lanceolate, glabrous, 2-12cm long, 1-3cm wide with margin acute and entire or slightly undulated and upper leaves often bractiform with short petiole. Inflorescence of the plant is characterized as patent, terminal and axillary in panicle, 10-30 mm long; bract small; pedicel short. The flowers possess botanical features of calyx 5-partite, small, linear; corolla tube narrow, about 6 mm long; limb longer

than the tube, bilabiate; upper lip oblong, white with a yellowish top; lower lip broadly cuneate, 3-lobed, white with violet markings; stamens 2, inserted in the throat and far exserted; anther basally bearded. Superior ovary, 2-celled; style far exserted. Capsule of the plant is erect, linear-oblong, 1-2 cm long and 2-5 mm wide, compressed, longitudinally furrowed on broad faces, acute at both ends, thinly glandular-hairy. Seeds are very small, subquadrate [1-5].

Phytochemistry

The characteristic secondary metabolites encountered in the plant have considerably enhanced its importance in the arena of medicinal plants and medicines. It is specifically rated very high in therapeutic action in curing liver disorders and common cough and cold in humans. A number of diterpenoids and diterpenoid glycosides of similar carbon skeleton have been isolated from *Andrographis*, mainly the most bitter compounds among them are andrographolide, neoandrographolide, deoxyandrographolide. Other such phytochemicals amassed by the plant are 14-deoxyandrographolide, 14-deoxy-11, 12-didehydroandrographolide, andrographiside, deoxyandrographiside, homoandrographolide, andrographan, andrographon, andrographosterin and stigmasterol [6]. The leaves of *Andrographis* contain the highest amount of andrographolide (2.39%), the most medicinally active phytochemical in the plant, while the seeds contain the lowest [7]. Andrographolide has highly bitter taste, is colorless crystalline in appearance, and possess a "lactone function". Both growing region and seasonal changes have a strong impact on formation of the diterpene lactones. The highest concentration of the active components is found just before the plant blooms, making early fall the best time to harvest. In those parts of Asia where *Andrographis* is sold commercially as medicine, a variety of lab level methodologies are used to ensure a standardized level of andrographolides: thin-layer chromatography, ultraviolet spectrophotometry, liquid chromatography, and volumetric and colorimetric techniques and HPLC among them is most robust and reliable for quantitative and qualitative profiles of andrographolides. For extraction of andrographolides, a solvent extraction method is

usually employed using ethanol, and liquid extracts or tinctures are the most common form of dispensing the product. Varied methodologies for isolation and extraction of andrographolides from the plant have been adopted by different working groups. In general, extraction of andrographolides is aqueous or aqueous methanolic and the extract is further fractionated with methanol-chloroform, dichloromethane and/or petroleum ether or hexane in accordance with the andrographolide fractions/moieties desired to be enriched for specific application(s). Usually aqueous or little amount of ethanol/methanol is used to isolate andrographolides for pharmacological investigations. To advance, solid-liquid extraction of stem and leaves of

Andrographis paniculata is in precisely defined relative proportions of water and ethanol in order to obtain andrographolide [8].

Pharmacology

Researches conducted in past decades have confirmed that *Andrographis*, if properly administered, has a surprisingly broad range of pharmacological effects, some of them are extremely beneficial:

- Abortifacient (can abort pregnancy; although Ayurvedic tradition allows it to be taken for short duration during pregnancy thus all women are advised to avoid its use during pregnancy as a precaution. In almost every other respect *Andrographis* has an extremely low toxicity. (note: in this case, slightly rubefacient to the skin)
- Analgesic (pain killer) reduces swelling and cuts down exudation from capillaries; anti-inflammatory action probably mediated, in part, by adrenal function)
- Antibacterial (fights bacterial activity; although *Andrographis* appears to have weak direct
- Antibacterial action, it has remarkably beneficial effect in reducing diarrhea and symptoms arising from bacterial infections.)
- Antiperiodic (counteracts periodic/intermittent diseases, such as malaria)
- Antipyretic (fever reducer - both in humans and animals, caused by multiple infections or by toxins)
- Antithrombotic (blood clot preventative)
- Antiviral (inhibits viral activity)
- Cancerolytic (fights, even kills, cancer cells)
- Cardioprotective (protects heart muscles)
- Choleric (alters the properties and flow of bile)
- Depurative (cleans and purifies the system, particularly the blood)
- Digestive (promotes digestion)
- Expectorant (promotes mucus discharge from the respiratory system)
- Hepatoprotective (protects the liver and gall bladder)
- Hypoglycemic (blood sugar reducer)
- Immune Enhancement (increases white cell phagocytosis, inhibits HIV-1 replication, and improves CD4+ and T lymphocyte counts)
- Laxative (aids bowel elimination)
- Sedative (relaxing herb, though not with the same effect as the accepted herbal sedatives, valerian root, hops, skullcap, etc.)
- Thrombolytic (blood clot buster)
- Vermicidal (kills intestinal worms)
- Andrographolide (the main carbon skeleton 14-deoxyandrographolide)

Medicinal Uses

Effects on HIV and other Viruses

Immune deficiency is at the root of susceptibility to a variety of infections, and it is the basis of the Acquired Immune Deficiency Syndrome (AIDS). Impairments of immune function result in variable clinical symptoms. To understand how to treat the disease and why infection with the human immuno-deficiency virus (HIV-1) is resistant to conventional and alternative therapies, we need to understand just what AIDS is. AIDS appears to have first arisen in Africa. It may have started when the HIV virus that previously only affected

African primates most likely mutated and was able to infect humans. In this modern age of fast intercontinental travel, the virus spread all over the world. The initial cases in North America were reported in 1981, before the condition had even been named. Studies of hospital records and frozen tissue samples, however, indicate that AIDS was

present as early as 1969. Two strains of HIV have been since identified: HIV-1 and HIV-2 (which seems confined to Africa). HIV, like all viruses, cannot reproduce itself or even live, without using the resources of other cells. When HIV virus finds a suitable cell, it attaches to the cell, using proteins on its cell surface. In the case of human cells, the HIV virus enters the cells by binding two molecules on the cell's surface. The first of these to be identified was CD4; other, more recently identified molecules are CCR5 and CXCR4. The brain and certain skin tissues are areas where the HIV virus tends to concentrate. HIV also attacks and debilitates cells in the immune system. Helper T cells - the "T" represents the thymus gland where the cells are produced - are a main target of the virus. These cells signal the lymph nodes and the spleen to produce more antibodies against the HIV virus. Once the antibodies inactivate the virus, suppressor T cells produce chemicals that stop further production of antibodies. The HIV virus, however, attaches itself to the helper T cell. Through a series of manipulations of the helper cell's genetic machinery, the virus tricks the cell into producing chemicals that the virus needs. HIV takes over the "machinery" of the helper T cell and thus becomes a virus production factory that is no longer part of the immune system. Without the T-cells, the other components of the immune system do not receive any messages to produce antibodies and resistance to HIV is seriously compromised. Conventional treatment consists of a combination of drugs designed to achieve maximum viral suppression. Often referred to as a "cocktail," this mixture consists of compounds called protease inhibitors and reverse transcriptase inhibitors. Without going into detail, a protease is an enzyme needed by the HIV virus for replication and assembly of new virus parts. Reverse transcriptase is another enzyme that the HIV virus uses to copy its genetic material when inside the T cell. While inhibiting these enzymes has been effective treatment in many cases, reducing the amount of HIV in the blood does not mean that a patient will suffer from fewer AIDS-related diseases.

Researchers are not certain how long a new combination of drugs will work before virus strains become resistant to the treatment. It is always the case with drug treatment that a few resistant virus

particles will survive and go on to reestablish the infection. Protease inhibitors (Invirase, Norvir, Viracept, and Crixivan) do not work on everyone and are not well absorbed. Large doses (36 pills a day) may be required with costs as high as \$16,000 a year. Dangerous side effects, such as diabetes and hypertension, can develop or become worse in patients taking protease inhibitors.

■ Effects in Common Cold, Fever & Inflammation

The prevention of the common cold with an extract of AP was shown in a pilot double-blind study. AP is also used as a folk medicine remedy for fever, pain reduction, and disorders of the intestinal tract. The ability of AP to lower fever has been demonstrated independently in several laboratories. Rat studies done in China have shown that andrographolide, neoandrographolide, and dehydroandrographolide can lower the fever produced by different fever-inducing agents, such as bacterial endotoxins (toxic chemicals released from bacteria), pneumococcus, hemolytic streptococcus, typhoid, paratyphoid, and the chemical 2,4-dinitrophenol [22]. Researchers tested AP to try and determine whether it did, in fact, work in these conditions [23]. Fever was induced in rats. There was a reduction in rectal body temperature for 30, 100, and 300 mg of andrographolide/kg bodyweight. While the analgesic (painkilling) activity of andrographolide extracted from AP was weak compared to aspirin, the antipyretic (fever-reducing) activity was comparable to that of aspirin. The study found that 300 mg/kg bodyweight of andrographolide was as effective as the same amount of aspirin, in fact, the AP extract was found to possess antiulcerogenic activity. It reduced the development of ulcers by 31%, while the standard ulcer drug, cimetidine had an 85.43% reduction rate. Andrographolide caused a significant decrease in total stomach acidity and acid stomach juice secretion, without the cost and side effects associated with ulcer therapy. In another study, AP extracts were found to produce results comparable to 200 mg of aspirin/kg bodyweight [24]. The researchers also established that there was a wide margin of safety in using AP extracts, an indication of the lack of toxicity. The anti-inflammatory effects of various AP compounds have been shown in many studies

in which the inflammation was produced by chemicals. Inflammation caused by histamine, dimethyl benzene, croton oil (hemolytic necrosis), and acute pneumocystis produced by adrenaline was significantly reduced or relieved [25]. This effect was observed for all major andrographolides: deoxyandrographolide, androgr-apholide, neoandrographolide, and dehydroandro-grapholide.

Antidiarrheal & Intestinal Effects

Experiments on animals demonstrate that AP can prevent or stop diarrhea. Diarrhea-type diseases are one of the top ten causes of death worldwide and are a leading cause of death in children in developing countries, especially those that are under five years of age. The use of antibiotics is producing antibiotic-resistant strains of bacteria. While there are many drugs used to relieve the symptoms of diarrhea (kaolin-pectin, bismuth, Lomotil, loperamide hydrochloride, and others), many have undesirable side effects. An inexpensive and easily obtained herbal remedy would benefit many, especially people in developing countries where diarrheal disease is almost catastrophic. Extracts of AP have been shown to have significant effects against the diarrhea associated with *E. coli* bacterial infections [23]. Acute bacterial diarrhea in patients was treated with a total dose of 500 mg andrographolide divided over three dosing periods per day for six days (2.5 to 3.0 mg/kg of body weight). This regimen was combined with rehydration. There were 66 cures of 80 patients treated - an 82.5% cure rate. Seven additional patients responded favorably to the treatment and only seven patients (8.8%) did not respond. The effectiveness of the treatment was confirmed by laboratory tests of stool samples [16]. In another study, AP was used to treat 1,611 cases of bacterial dysentery and 955 cases of diarrhea with overall effectiveness of 91.3% [35].

Cardiovascular Benefits

It has been demonstrated that extracts of AP can increase the time it takes for blood clots to form, thus decreasing the risk of subsequent closing of blood vessels (restenosis) seen after angioplasty procedures. In studies done on rabbits given angioplasty, AP extracts was shown to

significantly prevent constriction of blood vessels. The rabbits received AP for three days before angioplasty and for four weeks after surgery. While the arterial narrowing occurred in 100% of animals not given AP, only 70% of those receiving AP showed narrowing [26]. Narrowing caused by injury to the inner lining of the blood vessel and by high cholesterol in the diet was also found to be decreased by AP. It appears that AP may be quite effective in preventing repeated narrowing of vessels after coronary angioplasty. In 80 to 90% of patients with destroyed heart muscle resulting from an acute myocardial infarction (heart attack), clots are found in the heart shortly after the beginning of symptoms. When heart muscle is deprived of its blood supply, and therefore of oxygen, the tissue dies. Physicians and researchers believe that the best treatment is to limit the size of the myocardial infarction (the area of tissue damage) in order to preserve the pump function of the heart. Agents that dissolve the clots and increase blood flow through the blocked artery are constantly being sought. AP may have the potential to be part of the treatment plan in such cases. Researchers at the Tongji Medical University in China have demonstrated that AP given to dogs one hour after development of myocardial infarction decreased the damage that occurred to the heart muscle [27]. Such damage occurs after the blood supply is restored to the muscle. This is due to a sudden influx of oxygen (which produces free radicals that damage tissue) and abnormally high amounts of calcium. In subsequent studies at the same university, the researchers demonstrated by electrocardiograph that abnormal changes in heart readings were prevented by pretreatment with AP. Also, clumping of platelets (the blood particles that initiate clotting) was inhibited and no clot (thrombus) that could cause infarction was induced [27]. An added effect of AP was that it activated fibrinolysis, the natural process in the body that dissolves clots [28]. Another way to prevent cardiovascular disease is to correct high blood pressure. Researchers have reported that an extract of AP produced antihypertensive (blood pressure lowering) effects [28]. The extract was given intravenously to hypertensive rats. Noradrenaline, a hormone secreted by the brain, acts to constrict blood vessels and increase heart

rate, blood pressure, and blood sugar levels. AP inhibited the increase in blood pressure that is caused by noradrenaline.

Antifertility Effects

AP has cleared antifertility as well as pregnancy-terminating effects. In India, where AP is used for common ailments such as diarrhea, fever, and other digestive disorders, it is recommended that the herb be used only for short-term treatment. This is due to the content of compounds that are contraceptive in nature. To determine the actual effects on fertility, studies were done in male rats. In one study, it was found that AP, given as dry leaf powder (105mg powder/kg body weight) each day for 60 days, stopped spermatogenesis (development and maturation of sperm cells). The authors suggested an anti-spermatogenic (sperm production blocking) or antiandrogenic (blocking effects of androgens) ability of the plant. It should be noted that many herbal extracts have effects on reproductive functions and thus should not be used during pregnancy. When 2 gm/kg body weight of sun-dried AP powder were given to the rats every day for six weeks, none of the animals were pregnant after mating (five times) with proven fertile males who did not receive the AP. The mice who did not receive the AP had normal litters when bred with similar males. The effect of AP may have been to prevent ovulation. Studies done in cultured human placental tissue showed that andrographolide sodium succinate (derived from AP) was effective in inhibiting human progesterone production [26]. This hormone is necessary for pregnancy to be successful.

▪ Liver & Gall bladder Protection; abdominal benefits

In Ayurvedic medicine, there are 26 different formulations containing AP that are used to treat liver disorders. AP's four related medicinal compounds were tested for a protective effect against liver toxicity produced in mice by giving them carbon tetrachloride (a cleaning solvent), alcohol, or other toxic chemicals. These chemicals damage the liver by causing lipid peroxidation. This is a process whereby free radicals (reactive

molecules) produced by the chemical attack and destroy cellular membranes that surround liver cells. When the AP compounds were given to animals three days before the toxic chemicals, there was a significant protective effect in the liver. This effect was attributed to the antioxidant ability of the AP compounds, which was effective as silymarin (another plant antioxidant from milk thistle; *Silybum marianum*). In another study, andrographolide from AP was shown to produce a significant increase in bile flow. Bile is produced in the liver and stored in the gallbladder and aids in digestion. When a chemical, paracetamol, was given to animals pretreated with andrographolide, the usual decrease in bile production seen with this chemical was prevented. In this case, andrographolide was found again more potent than silymarin. Infective hepatitis is an acute inflammatory condition of the liver. It is often followed by liver cirrhosis and may progress to a coma and death. In India, where ancient physicians used AP to treat similar liver ailments, a study was conducted to evaluate the effect of AP in infective hepatitis. There was marked improvement in the majority of patients tested, when given a decoction or infusion of AP. Appetite improved on the fifth day of treatment, jaundice (yellow color of conjunctive of the eye and skin) gradually diminished and completely disappeared within 24 days, and fever subsided after 7 days on average. Other indications of effectiveness of AP included improvement in liver function tests. The researchers concluded that AP was a useful remedy for treatment of infective hepatitis. The andrographolides present in AP are potent stimulators of gallbladder function. In animal experiments, those that received andrographolides for seven consecutive days showed an increase in bile flow, bile salts, and bile acids. These increases are beneficial and result in enhanced gallbladder function. Use of AP might, therefore, decrease the probability of gallstone formation and might also aid fat digestion. The andrographolides also prevented decreases in the amount of bile that are caused by acetaminophen toxicity [35].

Effects on Central Nervous System and Brain

Many compounds do not penetrate the blood-brain barrier. However, andrographolide does so and concentrates in the brain and particularly in the spinal cord [24]. Several studies have shown that AP products have a sedative effect. In mice given barbital as anesthesia, the animals became sedated more quickly and the anesthesia lasted longer. Also, it was possible to give less of the anesthesia if it was given along with AP [35]. The studies indicate that AP products may act at the barbital receptors in the brain.

Effects on Respiratory System

Andrographolide has been used to treat tonsillitis, respiratory infections, and tuberculosis. In one study, AP was used to treat 129 cases of acute tonsillitis. Sixty-five percent of patients responded to the therapy. The same authors used andrographolide to treat 49 pneumonia patients. Thirty five cases were found to show positive changes and nine patients completely recovered. In another study, andrographolide was used to treat 111 patients with pneumonia and twenty with chronic bronchitis and lung infection. The overall effectiveness of AP treatment was 91%. Fever subsided within three days in 72% of the patients and 40% of these patients had smaller areas of infection within one week. Tuberculosis is usually treated within the antibiotic rifampin. When used alone, rifampin therapy still results in 22.5% of patients dying. In a study using an injectable solution of 2.5% andrographolide given so as to provide 50 to 80 mg/kg body weight per day for two months, results were improved. Of seventy cases of tubercular meningitis, 30% of patients were considered cured with a fatality rate of 8.6%. The combination of andrographolide plus rifampin resulted in a 2.6-fold decrease in fatality rates.

Effects in Other Diseases

Leptospirosis is a disease caused by the bacterium **Leptospira interrogans**. Infection with this organism results in fever, hemorrhagic (blood-containing) lesions, central nervous system dysfunction, and jaundice. Several studies have reported efficacy in approximately 80% of patients treated with deoxyandrographolide, andrographolide, and neoandrographolide tablets.

In a study reported from India, twenty cases of infective hepatitis (hepatitis A) in men and women were treated with a decoction of AP (Kalmegh) equivalent to 40 g of the crude compound for over twenty-four days. In all twenty patients, the yellowing of the conjunctiva of the eye and of the urine returned to normal coloration. Ninety percent of the patients regained their appetite and 83% had relief from general depression. Overall, 80% of the patients were considered cures and 20% improved based on biochemical tests and changes in symptoms [32]. In a similar study in China, 112 cases of hepatitis were successfully treated in 83% of patients [35]. Acute pyelonephritis is an inflammation of the kidney, particularly due to local bacterial infection. In a study evaluating the effectiveness of AP in treating this disease, AP was compared with nitrofurantoin, a standard clinical drug for pyelonephritis therapy. AP was found to be as effective as the standard drug, but with fewer side effects. Chorioepithelioma is a highly malignant tumor derived from the placenta. It is surrounded by "lakes" of blood. Hemorrhagic metastases develop relatively early in the course of the illness, and are frequently found in the lungs, liver, brain, vagina, and various other pelvic organs; one where a hydatidiform mole is present. AP was found to have a unique effect on these conditions. In one study, sixty patients with these conditions were treated with AP and AP-derived compounds. Forty-one of these patients had confirmed metastasis (spread of the cancer) of the lesions. Twelve patients treated with AP alone recovered. Of these patients, four women subsequently became pregnant (this condition usually results in difficulties in trying to get pregnant). Of patients treated with other drugs in addition to AP, forty-seven did not experience a re-growth of the tumor during the time of the study. In a case study of patient with an anal tumor, results were reported as "satisfactory" when the tumor was treated with a decoction of AP.

Use of Kalmegh Against Covid19

Recent researches evaluate the compound andrographolide from *Andrographis paniculata* as a potential inhibitor of the main protease of SARS-COVI-2(MPro) through in silico studies such as molecular docking, target analysis, toxicity prediction and ADME prediction.

andrographolide was docked successfully in the binding site of SARS COV-2 MPro. computational approaches also predicts this molecule to have good solubility , pharmacodynamics property and target accuracy. This molecule also obeys Lipinski's rule , which makes it a promising compound to pursue further biochemical and cell based assays to explore its potential for use against COVID19.

Conclusions

We conclude from the vast literature study and experimental results analysis that *Andrographis paniculata*, is a traditional remedy for fever and various infections, employs various immunological applications in cancer and viral disease like HIV and others. The plant is beneficial in treating cardiovascular disease and in preventing liver toxicity thus improving functions of heart and liver. It also finds immense utility in abdominal problems, body pain, snake biting, respiratory disorders, allergic reactions, and central nervous system and brain functioning. *Andrographis* is reported to decrease fertility in both male and female animals and human being. Taking great concern of the useful benefits of the plant, it can be advocated as a safe, highly important, medicinal plant for general mankind.

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VEGETABLES: SOURCE OF ADEQUATE HEALTH BENEFITS

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Abstract

Vegetables are considered essential for well balanced diets since they supply vitamins, minerals, dietary fiber and phytochemicals. Vegetables are essential for balanced diets since they contribute a crucial source of nutraceuticals in our daily life. Nutrition is both a quantity and a quality issue and vegetables in all their many forms ensure an requisite intake of most vitamins and nutrients, dietary fibers and photochemicals which can bring a much needed measure of balance back to diets contributing to solve many of these nutrition problems. The nutraceuticals are the substances found as a natural component of foods or other ingestible forms that have been determined to be beneficial to the human body in preventing or treating several diseases or in improving physiological performance. The boosting of healthy vegetable products has coincided with a surging consumer interested in the healthy functionality of food. Each vegetable comprise a unique combination of phytonutraceuticals which differentiate them from other vegetables. In the daily diet vegetables have been strongly associated with improvement of gastrointestinal health, good vision and reduced the risk of heart disease, stroke, chronic diseases such as diabetes and some forms of cancer. This paper makes a review and discusses the health benefits of commonly used vegetables.

Keywords: Vegetables, Vitamins, minerals, Dietary Fiber, Antioxidants, Phytochemicals.

Introduction

India is the second largest producer of horticultural crops and vegetable crops in the world after China. During 2017-18, production of horticulture crops was 311.71 million tonnes from an area of 25.43 million hectare. The production of vegetables has increased from 101.2 million tonnes to 184.40 million tonnes since 2004-05 to 2017-18 [19]. Vegetables can play an even more important role in the nutritional quality of diets. Vegetables contribute a major source of nutraceuticals for well balanced human diet. The nutraceuticals are the substances found as a natural component of foods or other ingestible forms that have been determined to be beneficial to the human body in preventing or treating one or more diseases or in improving physiological performance beyond adequate nutritional affects in a way that is relevant to either improved stage of health and well being and reduction of risk of numerous disease. These components can be beneficial antioxidants, minerals, vitamins which often have added advantages [13,20]. Wide range of climate and physio-geographical conditions around world ensures

availability of most kind of vegetables. Leafy and other vegetables are also good suppliers of vitamins, minerals and dietary fiber. This can be accomplished through better dissemination about their nutritional value and through changes in eating habits that will benefit people, especially those on marginal diets. A high vegetable diet has been associated with lower risk of cardiovascular disease in humans [24]. According to the 2007 World Health report unbalanced diets with low vegetable intake and low consumption of complex carbohydrates and dietary fiber are estimated to cause some 2.7 million deaths each year, and were among the top 10 risk factors contributing to mortality [8,35]. In many areas of the world, increased consumption of vegetables has been stimulated by a growing apprehend of the health implications of diets high in vegetables, along with an increasing variety of vegetables for consumption. A world survey showed that at least 402 vegetables are cultivated and commercialized worldwide [12]. They represent 69 families and 230 genera. Most of the vegetables are perishable and marketed fresh with only a small proportion processed. Consumption shortly after harvest guarantees optimal vegetable quality. Vegetables not only provides calorie but also in all their many forms ensure an adequate intake of most vitamins and nutrients, dietary fibers, and phytochemicals which can bring a much needed measure of balance back to diets contributing to solve many of these nutrition problems in both a quantity and a quality issues. Increased consumption of vegetables has been associated with protection against various age-related diseases [9]. The promotion of healthy vegetable products has corresponded with a surging consumer interested in the healthy functionality of food. There is an increasing awareness among the general public of the advantages of diets rich in vegetables to ensure an adequate intake of most vitamins and micronutrients, dietary fibers, and phytochemicals that promote health. Therefore, the success of these initiatives, measured in terms of increase in daily consumption per person per serve, remains modest. Overall, it can be safely stated that, there is an increasing awareness among the general public of the advantages of diets rich in vegetables to ensure an adequate intake of most vitamins and micronutrients,

dietary fibers, and phytochemicals that encourage the good health. Consequently there is a need to select vegetables which are rich in phytochemicals and enhanced level of nutraceuticals. This chapter makes a review and discusses the health benefits of commonly used vegetables.

Health advantages effects of vegetables

The importance of vegetables in the human diet has been recognized by the World Health Organization (WHO), which promotes and recommends the consumption of at least 400g of vegetables to provide the optimum health and necessary nutrients lacking in other food groups [8,27,34]. The evidence of specific vegetables and indeed specific compounds is less convincing, although epidemiological studies of cancer suggest that it is mainly the highly colored green or yellow vegetables that are associated with reduced incidence and mortality rates [11]. Vegetables in the daily diet have been strongly associated with overall good health, improvement of gastrointestinal health and vision, reduced risk for some forms of cancer, heart disease, stroke, diabetes, anaemia, gastric ulcer, rheumatoid arthritis and other chronic diseases [2,16]. Some efforts to increase nutrient intake have been made by bio-fortification and nutrient supplementation. The consumption of fresh vegetables gives the consumer a variety of compounds that have a positive influence on human health. The phytochemicals found in fresh vegetables have anti inflammatory, enzyme inhibiting and bioactive features capable of combating the activities of oxidants. Until few years ago it was believed that 14 vitamins and 16 essential minerals were the key for human nutrition and health. Some phytochemicals are robust antioxidants and are believed to reduce the risk of some chronic ailments [21,30]. Besides the common nutrients such as carbohydrates, amino acids and protein, there are certain nonnutrient phytochemicals in vegetables that have biological activity against chronic diseases. They are low in fat and like all plant products, contain no cholesterol. Vegetable intake has been highly correlated with improved gastrointestinal health and reduced risk of heart attack, some types of cancer and chronic ailments such as diabetes [2,10,15,24]. This has been linked to lycopene, which gives tomatoes their red colour [5]. The most

important phytonutriceuticals in vegetables that have biological activity against chronic diseases are: dietary fiber, vitamins, minerals, dietary antioxidants and flavonoids [17,20].

1. Dietary fiber

Dietary fiber includes heterogeneous mixture mostly include non-starch polysaccharides such as celluloses, hemicelluloses, gums and lignin, pectins, resistant dextrins and resistant starches which are indigestible in the small intestine [36]. Some excellent sources of soluble fiber are green peas, spinach, carrot, parsnips, beet green, turnip, green beans, eggplant, asparagus, cabbage, lettuce, broccoli and leeks [36,37]. Foods rich in fiber satisfies hunger without contributing excessive calories thus aids weight loss [4] and lowers blood pressure level. Most health agencies recommend that adults should consume 20-35 grams of fiber daily [3].

2. Vitamins

Vegetables are an excellent source of various vitamins that can do wonders for your body. Vitamins (A, B, C, D, E, K, β -carotene and lycopene and counted how many times each food appeared. The vegetables rich in vitamins include dark leafy greens, broccoli, bell peppers, peas and winter squash [3]. A healthy body needs vitamins and was originally thought to be amines but not all vitamins are amines. They are essential for normal body functions, cell function regulation, growth and development. Vitamins must be obtained from the diet, as the body cannot produce them in adequate amounts broccoli, green peppers and tomato are examples of foods high in vitamin C [34]. All vegetables are sources of vitamins and consequently have health benefits. Vitamins such as A, B6, C and K are important to the human body and can be provided by vegetables [15,20]. Carotenoids are a class highly pigment which is responsible for yellow, orange and red color in vegetables. Vegetables high in vitamin E include spinach, squash, and broccoli. Hence β -carotene complements the antioxidant properties of vitamin E [20].

3. Minerals

Minerals are inorganic substances that are originally found in rocks and soil. The vegetables have abundance of minerals which are required by the body for growth and also have certain health

benefits. Minerals can be divided into two groups. Major minerals, macronutrients, with a high prevalence of inadequate intake in worldwide diets include calcium, magnesium and potassium. Trace minerals, micronutrients, identified as nutrients with great health implications and benefits, usually with a high prevalence of inadequate intake, include iron, zinc and selenium [28,35]. Calcium plays an important role in building stronger, denser bones early in life and keeping bones strong and healthy later in life [9,27]. Magnesium is needed for bone, protein, making new cells, activating vitamin B groups, relaxing nerves and muscles, clotting blood, and in energy production [20]. Potassium ions are necessary for the function of all living cells. It is essential for the body's growth and maintenance [1]. Iron plays an important role in human health, forming complexes with molecular oxygen in hemoglobin and myoglobin [22,23]. Dark green leafy vegetables, beans, peas, as well as all the other legumes and are especially good sources of iron, even better on a per calorie basis than meat. The World Health Organization advocates zinc supplementation for severe malnutrition and diarrhea [35]. Zinc supplements helps to prevent disease and reduce mortality, especially among children with low birth weight or stunted growth. Zinc is found in vegetables such as beans, peas, pumpkin seeds and sea vegetables [33].

4. Dietary Antioxidants

Antioxidants protect the body from adverse biological reactions involving oxygen. Antioxidants counteract or neutralize the harmful effects of free radicals. These act as scavengers for free radicals and reactive oxygen species, thereby preventing them from disrupting the chemical stability of the cells. Fortunately the body has a natural defense system against cellular damage by free radicals, which comprise primarily of antioxidant nutrients (vitamin C, vitamin E and certain carotenoids), which are assisted by a variety of phytochemicals from the diet. Vitamins, minerals and phytochemicals contained in vegetables each have antioxidant activity. Orange and yellow vegetables as well as green leafy vegetables are rich sources of carotenoids. With the exception of vitamin E, these antioxidants are widely distributed in vegetables [20].

5. Flavonoids

A largest group of antioxidant phytonutrients, termed flavonoids present in vegetables. Flavonoids are further classified into anthocyanins, flavonols, flavones, and isoflavonoids [7]. It is attributed to the fact that high intake of flavonoid rich foods has been advanced in the protection against diseases, such as cancer and also reduces the risk of cardiovascular disease [15,24]. Anthocyanins are one of the largest and most important groups of water soluble pigments in most species in the plant kingdom. Anthocyanins give vegetable leaves and fruits their purple and/or red colour appearance, such as in eggplant, red cabbage, purple and black broccoli, red onion, beet, rhubarb, purple and red-skinned potato, purple sweet potato, purple corn, red lettuce, red endive and red radish [7,29]. These pigments may reduce the risk of coronary heart disease through inhibition of platelet aggregation [15]. Flavonols include quercetin, kaempferol, fisetin, myricetin, and rutin. Quercetin is one of the most widely distributed flavonoids in the human diet as onions. In recent years, scientific and public interest in flavones has grown enormously due to their putative beneficial effects against atherosclerosis, osteoporosis, diabetes mellitus and certain cancers [2].

Benefits of consumed Vegetables

The health benefit of vegetables should not be linked to only one compound or one type of vegetable, but a group of vegetable that provide better protection against certain chronic diseases. The main difference is that each vegetable group contains a unique combination of phytonutrients, which distinguishes them from other group of vegetables. The most commonly consumed vegetables such as allium, crucifer and solanaceous vegetables. Cruciferous vegetables includes cauliflower, cabbage, broccoli, brussels

sprouts, kales, chinese cabbage, turnip, rutabaga, radish, horseradish, watercress, mustards, among other vegetables provide the richest sources of glucosinolates in the human diet [13]. Dias [13,14] mentioned that a diet rich in crucifers is likely to protect humans against colon, rectum, and thyroid cancers, and when consumed with vegetables rich in other phytonutrients, can protect against cancer in other organs. Allium vegetables include, garlic, onion, leek, chive and among other vegetables. They are rich in a wide variety of thiosulfides, which have been linked to reducing various chronic diseases. Solanaceous vegetable includes tomato, potato, eggplant, sweet pepper and hot pepper. Tomato is a good source of lycopene, folate, vitamin C, vitamin A and vitamin E and widely grown vegetable in the world after potato. Tomatoes, with their distinctive nutritional attributes play an important role in reducing the risk of cardiovascular diseases, several types of cancers and associated diseases. Potato is perceived only as a source of carbohydrates, but is also an excellent source of essential amino acids. Eggplant (brinjal) is an excellent source of digestion supportive dietary fiber and bone building manganese, enzyme catalyzing molybdenum and potassium. Eggplant is also a good source of bone-building vitamin K and magnesium as well as copper, vitamin C, vitamin B6, folate, and niacin. Eggplant is also effective in the treatment of high blood cholesterol [37]. Antioxidant vitamins A and C help to prevent cell damage, cancer and diseases related to aging, and they support immune function. They also reduce inflammation like that found in arthritis and asthma. Vitamin K promotes proper blood clotting, strengthens bones, and helps protect cells from oxidative damage [1]. The main constituents of vegetables that have a positive impact on human health and their sources are given in Table 1.

Nutrients	Function in the Body	Vegetable Sources	Impacted human diseases
Vitamin A	Essential for vision, skin and the immune system. Promotes growth. Protects against some types of cancer.	Cantaloupe, apricots, dark green and deep yellow vegetables such as pumpkin, carrots, sweet potatoes, spinach, greens and bell peppers	Cancer, heart diseases, stroke
Vitamin B	Requisite for cell health, growth of red blood cells, energy levels, good eyesight, healthy brain function, good digestion, healthy appetite, proper nerve function and cardiovascular health	Leafy vegetables (broccoli, asparagus, fenugreek, lettuce, cabbage and spinach)	Loss of appetite, weight loss, weakness
Vitamin C	Strengthens blood vessels, improves wound and bone healing, increases the resistance to infections and increases the absorption of iron another important nutrient for growth.	Asparagus, sweet potatoes, bell peppers, broccoli, Brussels sprouts	Scurvy, bleeding sores, tooth loss, Dry hair and skin
Antioxidants and Phytonutrients	Antioxidants are vitamins, minerals and other substances that fight free radicals, which play a role in the progression of cancer and heart disease. Phytonutrients are the color pigments in the fruits and vegetables that either act as antioxidants or enhance the antioxidant benefits.	Vegetables bursting with color such as berries, tomatoes, and dark green and deep yellow vegetables.	Cancers, heart disease, eye disease and other human health conditions
Folate	Important for normal cell division, wound healing and prevention of birth defects.	Orange, dried peas and beans, green leafy vegetables such as mustard and turnip greens, collards and spinach.	Birth defects, cancer, heart disease
Dietary fiber	Important to maintain digestive health, as well as reduce blood cholesterol.	Peas, Brussels sprouts, parsnips, broccoli, black beans.	Diabetes, heart disease
Calcium	Important for strong bones, blood clotting, muscle contraction and nerve function	Rhubarb, okra and green leafy vegetables such as mustard and turnip greens, collards, kale and spinach.	Building stronger, Denser bones early in life and keeping bones strong
Potassium	It lowers your blood pressure and also protects you from blood pressure increases after consuming sodium.	Baked potato or sweet potato, cooked dry beans, cooked greens, winter squash	Hypertension, stroke

Conclusion

Regular consumption of a vegetable rich diet has undeniable positive effects on health since phytonutriceuticals of vegetables can protect the human body from several types of chronic diseases. The mechanism by which vegetables decrease risk of disease is complex and largely unknown. Nutrients such as potassium contribute to blood pressure regulation. The dietary fiber content and type of different vegetables may also contribute to the overall health benefit, such as improving bowel transit, lowering cholesterol, helping manage blood glucose concentrations, and by transporting a significant amount of minerals and phytochemicals linked to the fiber matrix through the human gut. Finally, increasing vegetables in

the diet may reduce the intake of saturated fats, and foods with higher caloric density, all of which may be related to a healthier overall diet. Because each vegetable contains a unique combination of phytonutriceuticals a great diversity of vegetables should be eaten to ensure that individual's diet includes a combination of phytonutriceuticals and to get all the health benefits. The availability of a large diversity of vegetables year-round, allied to increase in mean per capita incomes in recent years and knowledge of vegetable health benefits, have enable consumers to include a variety of health promoting phytonutriceuticals in their diet. Hence, a regular consumption of vegetable-rich diet has undeniable positive effects on health since phytonutraceuticals of vegetables can protect the

human body from several types of chronic diseases. The mechanism by which vegetables decrease risk of disease is complex and largely unknown but various components of the whole food are likely to contribute to the overall health benefit. Eventually it can be concluded that health benefits can be improved by increased consumption of vegetables as it contains vast phytochemicals which may be an important source of vitamins, dietary fiber, minerals and antioxidants.

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EFFECT OF PLANT GROWTH REGULATORS ON PHYSIOLOGY, YIELD AND QUALITY OF GUAVA

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Abstract

Guava (*Psidium guajava* Linn.) commonly known for its food and nutritional values throughout the world. Guava is an economically feasible, hardy and commercial fruit crop of tropics. It is also known as the Apple of the tropics or the poor man's fruit is the fourth most widely grown fruit crop in India[1]. As the population of India increasing at a rapid rate and in order to meet demand for high quality guava, plant growth regulator plays a vital role. The pre-harvest spray of growth regulators and minerals are the new practices now-a-days adopted for higher fruit production and improved fruit quality[2] and [3]. Thus, the study will be done to investigate the impact of plant growth regulators on yield and quality attributes of guava in winter season. The use of plant growth regulators has assumed an integral part of modern fruit production to improve the quality and production of fruits, and it has resulted in outstanding achievements in yield and quality [4]. This review describes the study of guava, its common names, various species and nutritional status. Firstly the study of guava have been described. Then a literature review concerning with advances in guava is presented in a year wise manner.

Keywords: Quality, Physiology, Shelf life, Physio-Chemical, Guava and Yield.

Introduction

Guava belongs to family Myrtaceae and has its origin in tropical America. It is an ideal fruit crop, resistant to drought but sensitive to frost and water logging conditions. The crop covers about 2.60 lakh hectare area of the country with an average productivity of 14.75 metric tonnes per hectare[5]. In Punjab, guava is cultivated on a large scale in the districts of Patiala, Amritsar, Ropar, Ludhiana and Jalandhar occupying an area of 82.25 ha with an annual production of 180775 MT[6]. The fruit type of guava is berry and edible part is fleshy thalamus. Guava produced in Allahabad region of U.P is best in quality in the world[7]. Winter Guava is considered best in quality in North India because of less incidence of fruit fly. It is an indispensable source for nutritional security in India. It is a rich source of antioxidants, vitamin C, fibre, pectin, calcium, phosphorous, iron etc. It boosts immunity, maintains weight, lower the blood pressure, good for digestion, skin and oral health. It has astrigency property due to which its mature leaves, fruits, roots and bark are used in medicines to treat gastroenteritis, diarrhea and dysentery[8]. Guava ripe rapidly and highly perishable, it can be stored for 2 to 3 days under ambient condition[9]. All available high production technologies such as use high yielding varieties, high density orcharding, the use of PGR's has been proved as a powerful tool to meet this demand by influencing fruit production directly or indirectly[10].

Common Names

Guava is known by distinct names in various regions of the world. The common names of *Psidium guajava* include.

Arabic	guwafah
Bengali	Piara
Brazil	araca
Cambodia	trapaeksruk
Chinese	fan shiliu
English	apple guava
French	gouyave
Germany	Guavenbaum
India	Guavenbaum
Spanish	guayaba
Thailand	farang
Philippines	bayabas

Various Species

<i>Psidium amplexicaule</i>	<i>Psidium friedrichsthalium</i>	<i>Psidium incanescens</i>
<i>Psidium araao</i> Raddi	<i>Psidium galapageium</i>	<i>Psidium montanum</i>
<i>Psidium araca</i> Raddi	<i>Psidium guajava</i>	<i>Psidium pedicellatum</i>
<i>Psidium australe</i> Cambess	<i>Psidium guineense</i>	<i>Psidium robustum</i>
<i>Psidium cinereum</i>	<i>Psidium harrisianum</i>	<i>Psidium rostratum</i>

Nutritional Status

Guava is an extremely good source of vitamin, minerals, protein, fat etc which is well known as a booster for vision health. The food value per 100g guava is presented in the following table.

Name	Content
Calories	77-86g
Moisture	2.8-5.5g
Protein	0.1-0.5
Fat	0.43-0.7mg
Ash	9.5-10mg
Carbohydrate	9.1-17mg
Vitamin G4	36-50mg
Vitamin B3	35 I.U
Carotene	0.046mg
Iron	200-400 I.U
Calcium	17.8-30mg
Phosphorous	0.30-0.70mg
Thiamine	0.03-0.04mg
Crude fiber	0.9-1.0g
Niacin	40 I.U

Literature Survey

In the following, we review literature that we believe is relevant in the context of Guava. The progress in the Guava is given in table. In the literature survey, the researcher investigated Effect of Plant Growth Regulators on Physiology, Yield and Quality Attributes of Guava.

S.No.	Author Name	Year	Technique/ Method Used	Remarks
1	[13]	2013	Effect of plant growth regulators on quality of winter season guava (<i>Psidium guajava</i> L.) cv L-49	Maximum TSS, reducing sugars, non-reducing sugars, total sugars and ascorbic acid were observed under 40 and 20 ppm NAA and minimum acidity was also recorded with 40 ppm NAA
2	[14]	2016	Effect of Plant Growth Regulators on Fruit-set and Quality of Guava	The better response to fruit growth, TSS, ascorbic acid content was noticed under 200 ppm GA3 as compared to other treatment
3	[15]	2017	Effect of Plant Growth Regulator on Fruit Yield and Quality of Guava (<i>Psidium guajava</i> L.) cv. Allahabad Safeda	The quality of fruit in terms of TSS (11.47%), ascorbic acid (239.03 g/100g pulp), total sugar (7.43 %) and reduced acidity (0.20%) were higher with the NAA 200 ppm followed by 150 ppm NAA..
4	[16]	2017	Effect of Plant Growth Regulators on Physico-Chemical Changes in Guava Cultivars Under Ultra High Density Planting System	PGRs showed maximum plant height, plant spread, plant girth, number of fruit/plant fruit yield/plant and fruit yield/hectare. The average fruit weight, acidity, pH and TSS were also maximum with varieties Lalit
5	[17]	2017	Effect of Plant Growth Regulator on Yield and Quality of Guava cv. <i>Psidium guajava</i> L.) cv. Allahabad Safeda	The maximum yield (37.13 kg/plant), TSS (12.50 °B), ascorbic acid (135.30 mg/100g), total sugar (10.13%) and lowest acidity (0.16%) was recorded under 50 ppm GA3
6	[18]	2017	Effect of Growth Regulators on Yield and Quality of Winter Guava cv. Allahabad Safeda	The maximum yield (47.39 kg/tree), total sugars (10.46%), reducing (4.99%), non-reducing sugars (5.47%) and TSS (11.05 °B) was noticed with the foliar spray of 50 ppm 2,4-D
7	[19]	2017	Effect of Foliar Spray of Zinc Sulphate And Gibberellic Acid on Yield and Economics of Guava [<i>Psidium guajava</i> L.] Cv. G-27	The maximum no. of fruits per plant (814.36), fruit weight (210.40 g) and yield (74.76 kg) were resulted with ZnSO4 (0.40%) and GA3 90 ppm.
8	[20]	2018	Effect of Foliar application of plant growth regulators and boron on quality of guava (<i>Psidium guajava</i> L.) cv. 49	Maximum TSS:Acid ratio was observed under treatment of NAA 40 ppm at 4th day of storage and with CCC 500 at 6th day after storage
9	[21]	2018	Effect of Plant Growth Regulators on Flowering, Fruit Growth and Quality of Guava (<i>Psidium guajava</i> L.) cv Allahabad Safeda	Maximum fruit weight, TSS, total sugar, yield were recorded under T3 (200 ppm NAA)
10	[22]	2018	Effect of Crop Regulation Practices on Quality Attributes of Guava (<i>Psidium guajava</i> L.) cv G-27	Minimum titratable acidity and maximum ascorbic acid, total sugars, reducing sugars were maximum under NAA 800 ppm
11	[23]	2018	Effect of Plant Growth Regulators on Rooting and Sprouting of Different Stem Cuttings of Guava (<i>Psidium guajava</i> L.) cv. Lucknow-49 under Mist Chamber Condition	The higher rooting percentage was recorded in softwood cutting treated with IBA 4000 ppm. Softwood cutting treated with 4000 ppm IBA exhibit better rooting and sprouting performance as compared to NAA and IAA
12	[24]	2019	Role of plant growth regulators in guava (<i>Psidium guajava</i> L.) cultivation: A review	The growth regulators are also used to improve the seed germination by breaking seed dormancy, root initiation in cuttings and air layers, to regulate proper canopy, flowering and fruit set
13	[25]	2019	Effect of Pruning and Plant Growth Regulators on Fruit Quality of Guava (<i>Psidium guajava</i> L.) cv Allahabad Safeda	Minimum PLW (Physiological Loss in Weight), acidity and maximum TSS, total sugars, reducing sugars, non-reducing sugars and ascorbic acid were recorded with GA3 150 mg/l

14	[26]	2019	Studies on role of plant growth regulators and rooting media on rooting and survival of airtlayers of Guava (<i>Psidium guajava</i>) var. G-27	The maximum length (4.99 cm), diameter (3.286 mm) of primary root, number (34.08/layer), length (2.858 cm) of secondary root, rooting success (82.68 %) and survival percentage (74.39 %) was obtained maximum with the treatment combination (IBB, NAA 7500 ppm with moss grass and cocopeat)
15	[27]	2020	Effect of Pgr's on Rootand Shoot Parameters of Hard Wood Cuttings in Guava (<i>Psidium guajava</i> L.) Cv. Lucknow49	The various shoot parameters viz., days required for bud sprouting (14.08), the number of sprouts per cuttings (3.22), fresh weight of shoot (4.17g), dry weight of shoot (1.52g) and survival percentage of rooted cuttings (90.49%), length of shoot (11.15cm) were observed maximum in the hard wood cuttings treated with IBA @ 3000 ppm as compared to the control
16	[28]	2020	Effect of Foliar Spray of Plant Growth Regulators and Micronutrient on Guava (<i>Psidium guajava</i>)	The maximum fruit set (74.2%), yield (12.32 kg/plant) was noticed under SA 150 ppm

Research Objectives

1. To improve the quality standards of guava fruit.
2. To increase the shelf life or longevity of guava.
3. To reduce the spoilage losses after harvesting.
4. To give characteristics grade to fruit variety.
5. To acquire the knowledge about the best PGR for guava.

Conclusion

Guava is the stupendous fruit available thrice in a year because the climate of India is best suited for its cultivation. The winter guava is considered of excellent quality due to less incidence of fruit fly in winter as compared to other seasons. It has high nutritional value and immature fruit is rich in pectin content. The objective of this paper is to provide an overview of the research and development work. This paper basically summarized the study of guava, its common names, various species, nutritional status and various advances that comes from time to time. Every plant growth regulator has different impact on tree physiology, yield and fruit quality. From the above literature, it is concluded that GA₃, NAA and 2,4-D has foremost impact on the quality and yield of the guava. The use of plant growth regulators has assumed an integral part of modern fruit production to improve the quality and production of guava fruit and it has resulted in outstanding achievements in yield and quality [29]. This study can be further extended to investigate the impact of plant growth regulators

on yield and quality attributes of guava and researchers are able to take this factor into consideration for research in guava fruit.

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TINOSPORA CORDIFOLIA (GILOY) A MEDICINAL PLANT

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Abstract

Guduchi (*Tinospora cordifolia* (Willd.) Miers.) is a dioecious creeper, commonly known as “Giloe”, with significant medicinal importance in the traditional systems of medicine. The plant is dioecious, however, this aspect is not given due attention when harvesting the plant material for medicinal purposes. Minimal reports are available on male and female varieties of Guduchi and no published information on the comparative physicochemical analysis of these varieties is available so far. Considering this, the present research is intended to comparatively analyse the physicochemical profiles of male and female varieties of Guduchi. Both male and female varieties were obtained, authenticated and subjected to morphological/organoleptic sampling, specific physico-chemical criteria, qualitative checking for different functional groups, and quantitative estimate of total alkaloids, total starch and mucilage contents. The present research distinguished both male and female varieties in morphological and organoleptic characters. The values of water and alcohol soluble extractives were found comparatively higher in male variety, whereas the total alkaloid, total starch and total mucilage contents were higher in female variety. All functional groups were found to be same in both varieties; however, more detailed works on quantification of chemical constituents and secondary metabolites are needed.

Keywords: Guduchi, Dioecious, physicochemical evaluation, *Tinospora cordifolia*.

Introduction

Guduchi has been an unbelievably versatile vine in the Ayurvedic medicine system since ancient times. It is identified in Ayurveda as a Rasayana drug recommended to increase general body resistance and promote longevity and as antistress and adaptogen.[1,2] Several reports have already been published on its chemical constituents, medicinal properties, and validation of therapeutic claims.[3-5] *Tinospora cordifolia* (Willd.) Miers., which belongs to India, is the accepted botanical source of Guduchi throughout India. The genus *Tinospora* comes from the Latin word *tinnio*, meaning subglobose or ellipsoidal seed, and the Greek word 'spora.' The word *folia* means leaves with a cordial-heart shape in the species *Cordifolia*. Family: Menispermaceae means a drug with a seed in the form of a moon or crescent. A large glabrous, dioecious climber with succulent, corky, grooved stems is *Tinospora cordifolia*. The plant is dioecious, where male and female flowers are born on separate plants, but this factor is not generally taken into account when the plant is collected for medicinal purposes. The

phenomenon of dioecy in plants is more rare and is limited to about 7% of the known taxa, widely distributed in various orders and families.[7] It is noteworthy that almost twenty-five plant species with known dioecism are now traditionally used. There are few variations in different genders, such as growth rates, morphological and microscopic characters, and levels of phytoconstituents.[8,9] Recent reports indicate that female Guduchi has higher secondary metabolite concentrations and higher antioxidant potential than male varieties.[10] Another study also concluded that there are many morphological, genetic, microscopic, There is no knowledge on the comparative physicochemical profile of male and female varieties, notwithstanding various medicinal attributes, large usage in practice, and many recorded studies on the physicochemical profile of different dosage types of Guduchi, [12-14]. In view of this, the present task is to determine the physicochemical norms of Guduchi's two genders.

Distribution

The plant is distributed all over India's tropical and subtropical regions. The regions of India, Sri Lanka, China, Myanmar, Thailand, Philippines, Indonesia, Malaysia, Bangladesh, Vietnam and South Africa are indigenous.[15,16]. The plant occurs in tropical regions of India from kumaon to assam and Myanmar, bihar, konkan to Sri lanka. The species is endemic to India and at an altitude of 600 m is commoc in the tropical and sub-tropical zones.

Growth Requirement

The plant is very rigid and it can be grown in nearly all climates but prefer warm climate.

Planting is normally achieved during rainy season (July-August) [17]. It can be grown successfully in any number of soils. Medium black or red soil can be preferred for cultivation purposes.

Habitat and Morphological Description

As the classification explains, *T. Cordifolia* belongs to the family of Menispermaceae and the deciduous shrubaceous plant, which is about 1 foot in width and grows to about 3-4 feet in height. The climbing plant is seen to bear lots of slender

spreading branches that grab on to support the nearby objects. With petioles up to 15 cm in length, the leaves that are seen are simple, alternate, and exstipulate, bearing roundish and pulvinate leaves at the apex and basal region; the basal region is much longer and halfway around partly twisted. The flowers that are seen are small and unisexual; different plants show female and male flowers. The plants bear no leaves during the flowering season and the flowers bear a yellowish green colour and the flowers are located at the apex and terminal racemes. The gender differentiations are seen in the way where the male flowers are typically clustered and the female flowers are placed alone. The sepals and petals are 6 in number and 2 or 3 numbers are usually free or paired. The fruits are located with scarlet or orangish colouring in an aggregate of 1-3 drupes. In nature, the seeds are curved and pea size and are transverse dehiscent. In both underground and aerial forms, the roots present in this plant are seen.

History and Vedic References

The use of this medicinal plant has been described in detail manner in Vedic and ayurvedic scriptures. The plant is known as Guduchi or Amrita in Sanskrit which points to the nature of this plant in the rejuvenating and the retainment of youth and life span of the consumer. In other words, the fountain of life force is an apt title for this medicinal plant. The Caraka Samhita, Sushruta Samhita, Bhela Samitha, Kashyapa Samhita and Ashatanghrdayam are few of the noted works that have detailed description of the medicinal plants in the field of spiritual and health field of the biological system that they are introduced to. The influence of Persian, Arabic, folk medicines in the life style of man along with the Vedic and Ayurvedic practices has heavily influenced the normal household life along with the scientific know-hows in the molecular level with the biochemical and phytochemical composition of the plant and the plant compounds has done a great deal in the understanding of this miraculous plant. The traditional and folk medicine with no scientific basis has been strongly advocating the regular use of the medicinal plants in the dietary form or in supplementary form; this is credited to the observational knowledge and the

information which is passed from godly beings to the sages and to general bodies through Gurus (teachers). The abundant medicinal plants and the Vedic scriptures that point to the correct usage of these plant for the optimum beneficial effect has spiked the interest of the science bodies and the further research on these plants on the scientific platform has inevidently pointed to the same results that have been preached from time immemorial by the traditional forms of medicine.

Mode of Action of Medicinal Plants

Human have always relied on nature and her remedies to relieve himself of bodily and mental discomforts. The primary source of all natural drugs is traced to the medicinal plants and few microorganisms. From time immemorial, various traditional and folk forms of medicine have appreciated the medicinal plants for their miraculous therapeutic properties that have attracted the interest of the modern medicine and industries.[69] Upon extensive studies on the medicinal plants, it has been observed that the presence of low molecular weight compounds of wide structurally diversity found in almost all medicinal plants are responsible for the expression of medicinal properties. These compounds are termed as secondary metabolites and these compounds are very important for the survival and protection of the plant. The compounds are secreted in small amount compared to other compounds which are involved in the metabolic and physiological pathways; but their involvement in the protection aspect is of at most importance and these compounds are involved in many pathways like cellular signalling pathways, either directly or indirectly involved in processes like pollination, repelling insects or harmful organisms.[70] No matter what the build-up of the host, the plant or the structural diversity of the secondary metabolite, the general mode of working is that these secondary metabolites target the cell surface receptors that include ion channels, enzyme linked receptors, neuroreceptors, ion pumps or receptors linked to cytoskeleton structures. This process is rather explained in detailed manner using the selective process of evolutionary molecular modelling and how these structures evolve along the timeline of evolution and yet they maintain their therapeutic

properties. Upon closer analysis of the working of these compounds, it has seen that the optimum effect of these compounds is due to the synergic effect of the multiple biologically active phytocompounds and their interactions that are yet to correctly known and understood. The mediation of the biological activities can be attributed to the modifications that occur at the protein and DNA bases and these modifications are due to reactive group and side chains that the secondary metabolites contain. These groups and side chains that are responsible for such modifications include aldehydes, SH- groups, epoxides, double bonds with enon configuration, triple bonds and these side chains and biologically active groups either form covalent bonds with the amino acids residues of the protein or the DNA bases.[69] These bonds bring about conformational changes and thereby bringing about the biological process under physiological conditions. The modification at transcriptional and translational level is also observed to be the reason for the expression of the biological activities. The alterations at the genes involved in the transcription and translation process and the modification of the transcription factors are also seen to be involved in bringing about the desired change either by the up-regulation or down-regulation of the gene that undergo the modification. Upon the advent of the softwares and sequencing techniques using bioinformatics, it is evident that these secondary metabolites affect multiple proteins and genes mediating single or multiple processes. This is in favour to the complex process of epigenetics that is observed in human system and higher vertebrates.[71] These secondary metabolites have an affinity to the cellular membranes that maintain the cellular concentration, osmotic pressure and the influx-out flux of the cellular contents and alter their structural and functional being and thereby bringing about cell death or disability. The activity at the ion channel and pump systems is altered and thereby disturbing or altering the ionic and osmotic gradient in the cellular environment. Certain classes of secondary metabolites alter the polymerization and depolymerization of the compounds of the plasma membrane, the synthesis and activation of collagen and collagen related enzyme and thereby altering the cellular

density and elasticity. Certain secondary metabolites get involved in the metabolic pathways as a substituent compound to primary metabolites like acetic acid, fumeric acid, malic acid and furthermore.[69,72] Certain secondary metabolites of the class ergot alkaloids which are of microbial origin affect and modulate the activity of noradrenaline, serotonin and dopamine receptors and influence the agonistic and antagonistic behaviour of the cell which is either way responsible for the antimicrobial nature and process like muscle contraction and lactation are also mediated by this class of secondary metabolites.[73] These compounds have the ability to interfere with the telomere and telomerase activity which plays an effective role in the control of cancer. The control of cellular proliferation and block in the cell division by blocking important enzymes and transcription factors that are involved in the process are few of the pathways and factors that are targeted by the secondary metabolites in controlling and eliminating the cancer.[70] Though the rough outline of the various pathways and mechanisms that the secondary metabolite employs to bring about the necessary biological modifications and relief measures have been studied, the entire process of how these compounds bring about the wide array of characteristics is still not correctly brought to light and further research are solely conducted in finding new characteristics or behaviours of these medicinal plants and further knowledge on how these compounds work in a biological system and in what manner these compounds interact with other compounds in synergic manner to bring about the therapeutic behavior.[69,71]

Medicinal and Therapeutic Properties

The plant has been titled to many properties that have been used from time immemorial and few of them include curative properties against jaundice, fever, gout, urinary and upper respiratory infections and preventive measures against skin infections, chronic diarrhoea, bleeding piles, itching and erysipelas. The plant is known for its potent aphrodisiac nature and its rejuvenating nature.[58] The plant extract affects the secretion of bile liquids and is known to enrich the blood

constituents. The effect that the plant extract has in both adult and children systems is similar and this is the good factor in the administration of the plant drug irrelevant to the host age which is not the case in synthetic drugs which base the age of the consumer to be a major factor in drug administration.[57,59,60] The plants show antidiabetic properties due to the presence of tannins, alkaloids, flavonoids, glycosides, saponins and steroids. The plant has been seen to have an effect on both the sexual arousal and the sexual performance of the biological systems and these drugs have stimulatory effect on the copulatory behaviour and thereby entitled to aphrodisiac activity. The most admirable character of the plant extract is the impact it bears in the cognitive field. Its capacity to influence the learning and memory cortex of the human intelligence is an admirable trait and this trait has drawn the attention of numerous science and industrial bodies.

Anti-inflammatory, Anti-arthritic and Anti-osteoporotic Activities

T. cordifolia is mentioned to treat *vatarakta* (gouty arthritis) and *daha* (burning sensation) in various Ayurvedic texts. It is traditionally used in compound formulations for the treatment of rheumatoid arthritis.[73] The alcoholic extract of *T. cordifolia* has been found to exert anti-inflammatory actions in models of acute and subacute inflammation.[74] The water extract of the stem of neem-giloe [The *T. cordifolia* that grow on *Azadirachta indica* (neem)] significantly inhibited acute inflammatory response evoked by carrageenin in a dose of 50 mg/100 g given orally and intraperitoneally. A significant inhibition of primary and secondary phases of inflammation was observed in a model of adjuvant-induced arthritis. It also significantly inhibited antibody formation by typhoid "H" antigen. A mild analgesic effect of its own as well as potentiation of morphine analgesia has been reported.[75] In another study aqueous extract of *T. cordifolia* showed a significant anti-inflammatory effect in the cotton pellet granuloma and formalin induced arthritis model, its effect was comparable with indomethacin and its mode of action appeared to resemble that of nonsteroidal anti-inflammatory agent. The dried stem of *T. cordifolia* produced significant anti-inflammatory effect in both acute and

subacute models of inflammation. *T. cordifolia* was found to be more effective than acetylsalicylic acid in acute inflammation, although in subacute inflammation, the drug was inferior to phenylbutazone.[76] The aqueous extract of stem was reported to exert a significant anti-inflammatory effect in both cotton pellet-induced granuloma (1, 250 and 500 mg/kg given orally) and formalin-induced arthritis (1 mg/kg given orally) rat models.[77,78]

Anti-allergic Activity

T. cordifolia is used for the treatment of kasa (cough) and swasa (asthma), which is described in various texts of Ayurveda. *T. cordifolia* is traditionally used for the treatment of asthma, and the juice is also employed for the treatment of chronic coughs.[79] In a clinical study, 100% relief was reported from sneezing in 83% of the patients on treatment with *T. cordifolia*. Similarly, there was relief from nasal discharge was reported in 69%; from nasal obstructions 61% and from nasal pruritus, in 71%. In placebo group, there was relief from sneezing only in 21% patients; from nasal discharge, in 16.2%; from nasal obstruction, in 17%; and from nasal pruritus, in 12%. Thus, *T. cordifolia* significantly decreased all symptoms of allergic rhinitis and was well tolerated.[80] The anti-allergic and bronchodilator properties of an aqueous extract of the stem evaluated on histamine-induced bronchospasm in guinea pigs, capillary permeability in mice and mast cell disruption in rats showed that it significantly decreased bronchospasm induced by 5% histamine aerosol, decreased capillary permeability and reduced the number of disrupted mast cells.[81,82]

Antioxidant Activity

T. cordifolia is mentioned as vishaghni, vishahara and tridoshashamaka in various texts of Ayurveda. A significant increase in the concentration of thiobarbituric acid-reactive substances (TBARS) in brain, along with its decrease in heart, was observed in diabetic rats. *Tinospora cordifolia* treatment decreased the concentrations of glutathione reductase (GSH) and decreased activities of superoxide dismutase (SOD), catalase and glutathione peroxidase (GPx) in the tissues of diabetics rats. Alcoholic extract of the root of *T. cordifolia* (TCREt) administered at a

dose of 100 mg/kg orally to diabetic rats for 6 weeks normalized the antioxidant status of heart and brain. The effect of *T. cordifolia* root extract was better than glibenclamide (600 μ /kg) although Insulin (6 units/kg) restored all the parameters to normal status.[83,84] *T. cordifolia* has also been reported to elevate GSH levels, expression of the gamma-glutamylcysteine ligase and Cu-Zn SOD genes. The herb also exhibited strong free radical-scavenging properties against reactive oxygen and nitrogen species as studied by electron paramagnetic resonance spectroscopy.[85] Aqueous extract of *T. cordifolia* inhibited Fenton (FeSO_4) reaction and radiation - mediated 2-deoxyribose degradation in a dose-dependent fashion, with an IC₅₀ value of 700 μ /mL for both Fenton and radiation-mediated 2-DR degradation. Similarly, it showed a moderate but dose-dependent inhibition of chemically generated superoxide anion at 500 μ /mL concentration and above, with an IC₅₀ value of 2000 μ /mL.[86] In various studies, *T. cordifolia* was found effective in iron-mediated lipid damage and gamma-ray-induced protein damage,[87] amelioration of cyclophosphamide-induced toxicity,[88] alteration of lethal effects of gamma rays,[89] induction of enzymes of carcinogen/drug metabolism and inhibition of lipid peroxidation in mice,[90] free radical generation and lipid peroxidation during oxygen-glucose deprivation,[91] and nitric oxide scavenging effects.[92] The extract of *T. cordifolia* has demonstrated antioxidant action in the alloxan induced diabetes model as well.[93]

Antineoplastic and Radio-Protective Activity

Intraperitoneal injection of the alcoholic extract of *T. cordifolia* has been shown to Dalton's lymphoma (DL) bearing mice e stimulated macrophage functions like phagocytosis, antigen-presenting ability and secretion of Interleukin-1 (IL-1), tumour necrosis factor (TNF) and Reference Nutrient Intake (RNI) as well as slowed tumor growth and increased lifespan of the tumor-bearing host.[94] *T. cordifolia* has been shown effective in several other tumour models including Ehrlich ascites carcinoma (EAC) in mice.[95] It induces proliferation and myeloid differentiation of bone marrow precursor cells in a tumor-bearing host,[96] activates

tumor-associated macrophages-derived dendritic cells,[97] is effective against various cancers,[98] killing the cancer cells very effectively in vitro[99,100] inhibits skin carcinogenesis in mice,[101] and inhibits experimental metastasis.[102] *T. cordifolia* may offer an alternative treatment strategy for cancer in combination with gamma radiation.[103,104]

Antipyretic and Anti-Infective Activity

Traditionally *T. cordifolia* is known for its jwarahara activity (antipyretic activity), as mentioned in . The water-soluble fraction of 95% ethanolic extract of *T. cordifolia* plant has shown significant antipyretic activity.[105] In another experimental study, antipyretic effects have been reported in the hexane- and chloroform-soluble portions of *T. cordifolia* stems.[106] Various studies show remarkable anti-infective and antipyretic properties of *T. cordifolia*. [107,108] Pre-treatment with *T. cordifolia* was shown to impart protection against mortality induced by intra-abdominal sepsis following coecal ligation in rats and significantly reduced mortality from induced by *E. coli*-induced peritonitis in mice.[109]

Anti-hyperglycemic Activity

T. cordifolia is widely used in Ayurveda for treating diabetes mellitus.[83,88,93] Various studies demonstrate amelioration of experimental diabetic neuropathy and gastropathy in rats,[111] reduction of blood sugar in alloxan-induced hyperglycemic rats and rabbits,[111] significant reduction in blood glucose and brain lipids,[112] increase in glucose tolerance in rodents,[113,114] increase in glucose metabolism,[114] inhibitory effect on adrenaline-induced hyperglycemia by pyrrolidine derivative,[115,116] and significant hypoglycemic effect in normal and alloxan diabetic rabbits[117] following administration of *T. cordifolia*.

Immunomodulatory Activity

In Ayurveda *T. cordifolia* is believed to have rasayana (rejuvenating), balya (tonic), vayah-sthapana (anti-aging), aayushyaprada (increases the lifespan), vrishya (aphrodisiac) and chakshusya (useful in eye disorders) properties. The alcoholic and aqueous extracts of *T. cordifolia* are reported to have beneficial effects on the immune system[and have been tested successfully for their immunomodulatory activity.[118 -122]

The degradation of proteins due to photosensitization as assessed by Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) was effectively reduced by simultaneous treatment with G1-4A/PPI (partially purified immunomodulator) from *T. cordifolia* during photosensitization.[124]

Diuretic Activity

T. cordifolia has been described as useful in mutrakriccha (urinary trouble) separately and in the form of various formulations in Ayurveda, as mentioned in . In a scientific study on rats and human volunteers, *T. cordifolia* was found to have diuretic effects. It was also found effective in modulation of morphology and some gluconeogenic enzymes activity in diabetic rat kidney.

Cardioprotective Activity

Bhavprakash Nighantu and Shaligram Nighantu describe *T. cordifolia* to have hrudya (cardioprotective) properties and is useful in hridroga (cardiac disorders). A dose-dependent reduction in infarct size and in serum and heart lipid peroxide levels were observed with prior treatment with *T. cordifolia* in ischemia-reperfusion-induced myocardial infarction in rats. The stem extract has been normalize alterations in the lipid metabolism caused by diabetes mellitus in streptozotocin-induced diabetic rats indirectly benefiting the heart.[113] Administration of the extract of *T. cordifolia* roots (2.5 and 5.0 g/kg body weight) for 6 weeks resulted in a significant reduction in serum and tissue cholesterol, phospholipids and free fatty acids in alloxan diabetic rats.[122]

Use of *Tinospora Cordifolia* (Giloy) Against Covid19

This ayurvedic herb is a powerhouse of antioxidants that neutralize free radicals and prevent inflammation. Also, it purifies blood, boost immunity, flushes out toxins from the body and fight against bacteria and virus effectively. Consuming giloy juice can help you get rid of fever, which is one of the signs of covid19. Its anti-inflammatory properties help in tackling respiratory problems like cough, cold and breathing problems. These are also major signs of the novel corona virus infection.

The pharmacological actions attributed to *Tinospora cordifolia* in Ayurvedic texts have been validated by a remarkable body of modern evidence suggesting that this drug has immense potential in modern pharmacotherapeutics.

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BIOCOMPATIBLE NANOMATERIALS: A REVIEW ON CHEMISTRY AND USE OF GRAPHENE OXIDE IN BIOSENSING DEVICES

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Abstract

Biocompatible nanomaterials are used to replace or applied directly instead of natural materials to function or contact with the living systems. High degree of biocompatibility is achieved when a material interacts with the body without inducing unacceptable toxic, immunogenic, thermobogenic, and carcinogenic responses. Most nanoscaled materials are biocompatible, which permits them to act in direct contact with the environment as carriers of biological recognition elements for obtaining lower and lower detection limit. Carbon materials have received great attention in the last decades with the emergence of nanoscience area. The utilization of carbon nanomaterials also possibilities the increase on charge transfer in bioelectrochemical devices. These include the modification of electrodes with several kinds of carbon at nanometer range carbon powder, carbon nanotubes, graphene sheets and carbon capsules.

Keywords: Biocompatible nanomaterials, Graphene, Biofunctional nanomaterials, *Escherichia coli*.

Introduction

Nanotechnology has boomed recently because of the availability of new investigative tools, making possible to characterize chemical and mechanical properties at a single molecular level, discover novel phenomena and processes, and provide science with a wide range of tools, materials, devices, and systems with unique characteristics. The history of nanomaterials began immediately after the big bang when Nanostructures were formed in the early meteorites. Nature later evolved many other Nanostructures like seashells, skeletons etc. Nanoscaled smoke particles were formed during the use of fire by early humans. The scientific story of nanomaterials however began much later. It is not clear when humans first began to take advantage of nanosized materials. It is known that in the fourth-century A.D. Roman glassmakers were fabricating glasses containing nanosized metals. An artifact from this period called the Lycurgus cup resides in the British Museum in London. The cup, which depicts the death of King Lycurgus, is made from soda lime glass containing silver and gold nanoparticles. The color of the cup changes from green to a deep red when a light source is placed inside it. The great varieties of beautiful colors of the windows of medieval cathedrals are due to the presence of metal nanoparticles in the glass. Around 1883 the American inventor George Ehtman, who would later found the Koclak Corporation, produced a&nwnsisting of a long paper strip coated with an emulsion containing silver halides. He later developed this into a flexible film that could be rolled, which made photography accessible to many. So technology based on nanosizedmabials is realty not that new [1].

Nanosized amorphous silica particles have found large-scale applications in many every-day consumer products, ranging from non-dairy coffee creamer to automobile tires, optical fibers and catalyst supports. In the 1960s and 1970's metallic nanopowders for magnetic recording tapes were developed. In 1976, for the first time, nanocrystals produced by the now popular inert- gas evaporation technique was published by Granqvist and Buhrman. Today nanophase engineering expands in a rapidly growing number of structural and functional materials, both inorganic and organic, allowing manipulating mechanical, catalytic, electric, magnetic, optical and electronic functions. For instance, when ordinary glass is doped with quantized semiconductor "colloids," it becomes a high performance optical medium with potential applications in optical computing [2]. The two main reasons why materials at the nano scale can have different properties are increased relative surface area and new quantum effects. Nanomaterials have a much greater surface area to volume ratio than their conventional forms, which can lead to greater chemical reactivity and affect their strength. Also at the nano scale, quantum effects can become much more important in determining the materials properties and characteristics, leading to novel optical, electrical and magnetic behaviours. Nanomaterials are already in commercial use, with some having been available for several years or decades. Nanoparticles, magnetic nanoparticles, fluorescent silica nanoparticles, quantum dots, Carbon nanotubes, nanowires etc. are derived from nanomaterials. In nanoscale on the basis of dimension the nanomaterials are classified as;

1. One dimensional nanomaterials- Surface films,
2. Two dimensional nanomaterials- Strands or fibers,
3. Three dimensional nanomaterials- Particles.

Nanomaterials are of interest because at this scale unique optical, magnetic, electrical, and other properties emerge. Applications of nanomaterials have made their presence strongly felt in various areas like healthcare, implants, and prostheses; smart textiles, energy generation and conservation with energy generating materials and highly efficient batteries, defence, security, terrorism, and surveillance [3]. The biofunctional nanomaterials with the abilities of specific recognition and signal triggering can be employed as not only excellent

carriers, but also electronic and optical signal tags to amplify the detection signal. These advantages provide a new avenue to construct a sensitive and specific platform in nanobiosensing[4]. One general advantage of all nanomaterials is the high specific surface thus already enabling the immobilization of an enhanced amount of bioreceptor units. However, one of the constant challenges is the immobilization strategy used to conjugate intimately the bio-specific entity onto such nanomaterials [5].

Biocompatible Nanomaterials

Biocompatibility first drew the attention of researchers between 1940 and 1980 in the context of medical implants and their interaction, both harmful and beneficial, with the body. The biocompatibility of nanomaterials is defined as "the ability of a material to perform with an appropriate host response in a specific situation". The three dogma which play important roles in this definition are that a material has to perform its intended functions and not merely be present in the tissue, that the induced reaction has to be proper for the intended application, and that the nature of the reaction to a particular material and its suitability may be different from one context to another. Bionanomaterial's research has emerged as a new exciting field, recognized as a new interdisciplinary frontier in the field of life science and material science. Great advances in nanobiochip materials, nanoscale biomimetic materials, nanomotors, nanocomposite materials, interface biomaterials, nanobiosensors, and nano-drug-delivery systems have the enormous prospect in industrial, defense, and clinical medicine applications. Biomolecules assume the very important role in nanoscience and nanotechnology, for example, peptide nucleic acids (PNAs) replace DNA, act as a biomolecular tool/probe in the molecular genetics, diagnostics, cytogenetics, and have enormous potentials in pharmaceuticals for the development of biosensors. Biosensor consists of a biosensing material and a transducer that can be used for detection of biological and chemical agents. Biosensing materials, like enzymes, antibodies, nucleic acid probes, cells, tissues, and organelles, selectively recognize the target analytes, whereas transducers like electrochemical, optical,

piezoelectric, thermal, and magnetic devices can quantitatively monitor the biochemical reactions [6]. Biocompatibility in the context of drug delivery and defined biocompatibility as "an expression of the benignity of the relation between a material and its biological environment". In general; high degree of biocompatibility is achieved when a material interacts with the body without inducing unacceptable toxic, immunogenic, thrombogenic, and carcinogenic responses[7]. In general, high degree of biocompatibility is achieved when a material interacts with the body without inducing unacceptable toxic, immunogenic, thrombogenic, and carcinogenic responses. There are a number of relevant factors that should be considered for evaluation of biocompatibility. These are

1. Biocompatibility is highly anatomically reliant which leads to the fact that the reactions to particular materials are different from one location to another. For instance, biodegradable polymeric-based nano- and microspheres such as those based on poly(lactic-co-glycolic acid) (PLGA) in general make a well characterized, subjectively mild tissue reaction, whereas the same particles introduced in the loose connective tissue surrounding nerves cause fairly strong acute inflammations. Therefore, another fact that one must be cognizant of is that, if a biomaterial for a particular application can cause an adverse effect in a specific tissue type, it will not necessarily provoke the same response if used for a different application or in a different tissue type.
2. An interrelated perspective, the biomaterials' intrinsic characteristics exclusively will not determine whether that particular material is biocompatible or not. For instance, PLGA nanoparticles that have a rapid clearance from the body, do not usually cause peritoneal adhesion, whereas PLGA microparticles which stay longer in peritoneal cavity, do cause peritoneal adhesions. Therefore, the exposure half-life is another important factor that deserves consideration.
3. Biocompatibility is a relative matter that depends on the risk-benefit ratio, and relies on a subjective declaration since, in general, inflammation would totally vanish over time, and the neighboring tissues do not exemplify a good proof of damage. Last, but perhaps most important, the lack of adequate data regarding biological processes in response to foreign materials, as well as the insensitive nature of

the methods available for biocompatibility has limited the understanding of the biocompatibility of materials.

All this together highlights the necessity of biocompatibility evaluation of biomaterials in a case-by-case and tissue- and application-specific manner. Bringing all these together, we can conclude that biocompatibility of materials depends on their structure, formulation and many other factors as described above and can refer to a local or total effect on the organism. Accordingly, using biocompatible materials in an absolute sense would be misleading. Here, we will present some of the known data regarding biocompatibility and nanoparticles in the context of drug delivery [8].

Biocompatible nanomaterials are revolutionizing many aspects of preventive and therapeutic healthcare, which are already playing important roles in developing new medical devices, prostheses, bioassay technologies, tissue repair and replacement technologies, drug delivery systems, and diagnostic techniques. [9]. Biocompatible nanomaterials are used to replace or applied directly instead of natural materials to function or contact with the living systems. Bionanomaterial's research has emerged as a new exciting field, recognized as a new interdisciplinary frontier in the field of life science and material science. Biocompatibility of graphene oxide. They construct graphene oxide-based glucose biosensors. The biocompatibility of as-synthesized graphene oxide nanosheets with human cells, especially retinal pigment epithelium (RPE) cells was investigated. Microporous graphene oxide exhibits good biocompatibility and has potential advantages with respect to cell attachment and proliferation[10]. They carried out biocompatibility testing on the as-synthesized GO for the purpose of direct utilization of the resulting graphene oxide films as practical biodevices. Retinal pigment epithelium(RPE) is a neuroectodermal derivative that is essential to the survival of photoreceptors. In the present study, ARPE-19, a cell line derived from human RPE, was seeded onto the graphene oxide substrate. The cell nuclei were subsequently stained using 40, 6-diamidino-2-phenylindole (DAPI). DAPI is a fluorescent stain that binds strongly to DNA. The good adhesion and differentiation of ARPE-19 cells on the graphene oxide film is visualized after 72 h

of culture time in the fluorescence microscope, the results suggesting excellent biocompatibility of the as-prepared graphene oxide nanosheets.

Chemistry of Graphene and Graphene Oxide

Carbon materials have received great attention in the last decades with the emergence of nano science area. The utilization of carbon nanomaterials also possibilities the increase on charge transfer in bioelectrochemical devices. These include the modification of electrodes with several kinds of carbon at nanometer range carbon powder, carbon nanotubes, graphene sheets and carbon capsules. The intrinsic electronic properties of carbon materials can be explained based on the nature of carbon bonding in their allotropic forms. Graphite is the simplest form of carbon-carbon bond with sp^2 hybridization with weak bond energy between adjacent layers and bond with and out of plane of p orbitals [11]. During the last half decade, chemically modified graphene (CMG) has been studied in the context of many applications, such as polymer composites, energy-related materials, sensors, 'paper'-like materials, field-effect transistors (FET), and biomedical applications, due to its excellent electrical, mechanical, and thermal properties. Chemical modification of graphene oxide, which is generated from graphite oxide (GO) has been a promising route to achieve mass production of CMG platelets. Graphene oxide contains a range of reactive oxygen functional groups, which renders it a good candidate for use in the aforementioned applications (among others) through chemical functionalizations. The precise chemical structure of GO has been the subject of considerable debate over the years, and even to this day no unambiguous model exists. There are many reasons for this, but the primary contributors are the complexity of the material (including sample-to-sample variability) due to its amorphous, berthollide character (i.e. nonstoichiometric atomic composition) and the lack of precise analytical techniques for characterizing such materials (or mixtures of materials). Despite these obstacles, considerable effort has been directed toward understanding the structure of GO, much of it with great success. Many of the earliest structural models of GO proposed regular lattices composed of discrete repeat units. Hofmann and Holst's structure consisted of epoxy groups spread across the basal planes of graphite, with a net molecular formula of C_2O . Ruess proposed a variation of this model in 1946

which incorporated hydroxyl groups into the basal plane, accounting for the hydrogen content of GO. Ruess's model also altered the basal plane structure to an sp^3 hybridized system, rather than the sp^2 hybridized model of Hofmann and Holst. The most recent models of GO have rejected the latticebased model and have focused on a nonstoichiometric, amorphous alternative. Certainly the most well-known model is the one by Lerf and Klinowski (Fig. 1). Anton Lerf and Jacek Klinowski have published several papers on the structure and hydration behavior of GO, and these are the most widely cited in the contemporary literature. The initial studies done by Lerf and coworkers used solid state nuclear magnetic resonance (NMR) spectroscopy to characterize the material.²⁵ This was a first for the field as earlier models relied primarily on elemental composition, reactivity and X-ray diffraction studies. By preparing a series of GO derivatives, Lerf was also able to isolate structural features based on the material's reactivity [12].

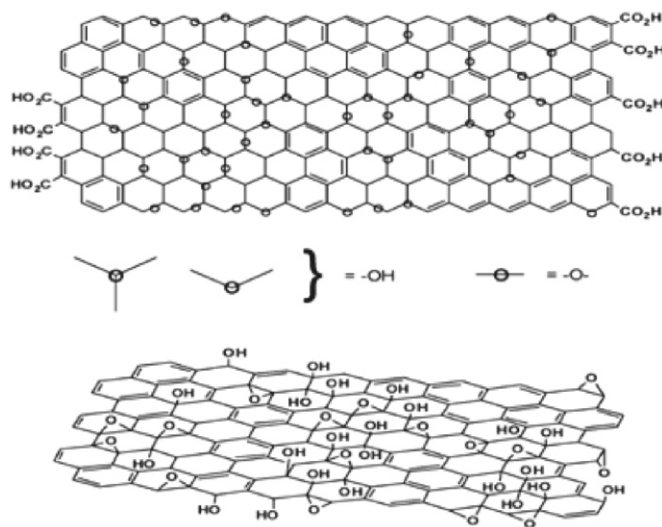


Figure-1 Variations of the Lerf-Klinowski model indicating ambiguity regarding the presence top, adapted from [13] or absence (bottom, adapted from HeH. et al., [14] of carboxylic acids on the periphery of the basal plane of the graphitic platelets of GO.

[15]describe the application of graphene for enzymatic biosensing, DNA sensing, and immunosensing. He compared different techniques and presents his views on the future development of the field. Graphene has potential application in a wide variety of biosensing schemes. It has been used as a transducer in bio-field-effect transistors, electrochemical

biosensors, impedance biosensors, electrochemiluminescence, and fluorescence biosensors, as well as biomolecular labels[15].

[16] have reported about good antibacterial activity of graphene oxide (GO), recommending its potential for drug delivery in ophthalmology application[16]. A year later, [17] showed that modified GO could be used for targeted drug delivery and controlled release in the tumor therapy[17]. Almost at the same time, [18] showed that GO-based composites decreased reticulo endothelial system accumulation and remarkably enhanced tumor passive targeting effects[18]. Recently, [19] investigated the in vitro and in vivo intraocular biocompatibility and cytotoxicity of graphene oxide know the fact that eye is a particular organ with the presence of the blood-ocular barrier which makes it important in targeted medical therapies such as ocular tumor-related treatments[19]. Therefore, they investigated novel drug delivery and controlled release systems in ophthalmology and reported that GO has favorable biocompatibility for retinal pigment epithelial cells with minimal adverse effects on cell viability and morphology in long-term cultures. Although there are studies that address the biocompatibility of graphene, GO and their modified versions, a great deal of research is still required in the near future prior to their application in the clinical settings[20].

Graphene has become most widely used and investigated nanomaterial since its discovery in 2004. Graphene, a single atom planer sheet of carbon atoms perfectly arranged in a honeycomb manner, finds great application in biosensing owing to its extra ordinary physical, electrochemical and optical properties. In recent years, a number of remarkable efforts have been made to develop graphene based electrochemical, electrical and optical biosensors for microbial detection with enhanced sensitivity [21].

Graphene-Based Biosensing Devices

The excellent electrochemical behaviors of graphene indicate graphene is a promising electrodematerial in electroanalysis. Several electrochemical sensors based on graphene and

graphene composites for bioanalysis and environmental analysis have been developed.

Electrochemical detection is highly sensitive to electroactive molecules. In addition to sensitivity it also offers detection selectivity as different molecules can be oxidized/reduced at different potentials. Graphene is an excellent conductor of electrical charge. Heterogeneous electron transfer (the transfer of electrons between graphene and the molecule in the solution necessary for the oxidation/reduction of said molecule) occurs at the edges of the graphene or at defects in the basal plane. Thus, the high surface area of graphene facilitates large amounts of defects and thus, electroactive sites. Graphene has also been used for electrochemical immunosensing. In immunosensing, the direct electrochemical detection of antibody antigen recognition is usually not possible and electrochemically active labels must typically be used. There are two strategies in which graphene can be used. First, graphene can be used as an electrode surface for sensitive detection of a label. This case was employed for the graphene-enhanced detection of -fetoprotein, which is a cancer biomarker. Graphene sheets were modified with antibodies, then the -fetoprotein was added and consequently secondary antibodies loaded with microspheres bearing horseradish peroxidase enzyme as a sensitive label. The second approach employs graphene as a label-bearing nanocarrier. More specifically, a gold nanoparticle electrode was modified with a probe antibody, to which phosphorylated protein p53 was entrapped. The secondary antibody was conjugated with graphene oxide and horseradish peroxidase to generate large amounts of electroactive molecules and thus a larger signal[22].

[23] reported the first graphene-based glucose biosensor with graphene/polyethylenimine-functionalized ionic liquid nanocomposites modified electrode which exhibits wide linear glucose response (2 to 14 mM, $R^2 = 0.994$), good reproducibility (relative standard deviation of the current response to 6 mM glucose at -0.5 V was 3.2% for 10 successive measurements), and high stability (response current $\geq 4.9\%$ after 1 week) [23]. [24] reported a glucose biosensor based on chemically reduced

graphene oxide (CR-GO). Graphene(CR-GO)-based biosensor exhibits substantially enhanced amperometric signals for sensing glucose: wide linear range (0.01 - 10 mM), high sensitivity (20.21 mA mM⁻¹ cm⁻²) and low detection limit of 2.00 mM (S/N¼3). The linear range for glucose detection is wider than that on other carbon materials-based electrodes, such as carbon nanotubes and carbon nanofibers. The detection limit for glucose at the GOD/CR-GO/GC electrode (2.00 mM at -0.20 V) is lower than that of some reported carbon materials-based biosensors, such as carbon nanotubes paste, carbon nanotubes nanoelectrode, carbon nanofiber, exfoliated graphite nanoplatelets and highly ordered mesoporous carbon[24]. Kang *et al.*, (2009) employed biocompatible chitosan to disperse graphene and construct glucose biosensors. It was found that chitosan helped to form a well-dispersed graphene suspension and immobilize the enzymemolecules, and the graphene-based enzyme sensor exhibited excellent sensitivity (37.93 mA M⁻¹ cm⁻²) and long-term stability for measuring glucose. Electrochemical DNA sensors offer high sensitivity, high selectivity and low cost for the detection of selected DNA sequences or mutated genes associated with human disease, and promise to provide a simple, accurate and inexpensive platform of patient diagnosis. Electrochemical DNA sensors also allow device miniaturization for samples with a very small volume [25]. [24] reported an electrochemical DNA sensor based on graphene (chemically reduced graphene oxide). The current signals of the four free bases of DNA (i.e., guanine (G), adenine (A), thymine (T), and cytosine (C)) on the CR-GO/GC electrode are all separated efficiently, indicating that CR-GO/GC can simultaneously detect four freebases, but neither graphite nor glassy carbon can. This is attributed to the antifouling properties and the high electron transfer kinetics for bases oxidation on CR-GO/GC electrode which results from high density of edge-plane-like defective sites and oxygen containing functional groups on CR-GO that provide many active sites and are beneficial for accelerating electron transfer between the electrode and species in solution. Graphene-based electrochemical sensors have

been developed for environmental analysis for the detection of heavy metal ions (Pb²⁺ and Cd²⁺)[26]. Li *et al.*, (2009) report that Nafion-graphene composite film based electrochemical sensors not only exhibits improved sensitivity for the metal ion (Pb²⁺ and Cd²⁺) detections, but also alleviates the interferences due to the synergistic effect of graphene nanosheets and Nafion. The stripping current signal is greatly enhanced on graphene electrodes. The enhanced performance is attributed to the unique properties of the graphene (nanosized graphene sheet, nano-scale thickness of these sheets and high conductivity), which endowed the capability to strongly adsorb target ions, enhanced the surface concentration, improved the sensitivity, and alleviates the fouling effect of surfactants[27]. Liu F. *et al.*, (2011) reported a graphene based biosensor system, presented for performing highly sensitive pathogenic virus detection. A free-standing conductive graphene film was prepared as a novel electrochemical sensor through two steps: synthesis of a graphene oxide (GO) film from GO colloidal suspensions by using a speed vacuum concentrator and thermal annealing process at 900°C with H₂/Ar flow to generate a reduced GO film. The resultant graphene film shows an excellent electron transfer property on the surface in the [Fe(CN)₆]^{3/4-} redox system and is used as a working electrode in the electrochemical biosensor. The surface of graphene is modified with pyrene derivatives, and then covalently linked with virus-specific antibodies. The target cell, rotavirus, is captured on the graphene film through antibody-antigen interaction, and the entire process was monitored by cyclic voltammetric responses. A 10⁵pfu/mL of input cells is detected with ca. 30.7% sensitivity, and ca. 1.3% sensitivity is measured with 103pfu/mL of input cells, demonstrating that graphene film based electrode can be applied for electrochemical biosensor[28]. Basu P. K. *et al.*, (2013) reported a low cost, reagent free; Escherichia coli sensor is demonstrated with graphene, on transparent flexible acetate substrate. Graphene is grown on 100 µm thick Cu foil, using CVD process and subsequently transferred on to a flexible acetate substrate. Gold electrodes are deposited on graphene to form a two terminal, interdigitated capacitor structure. Impedance spectroscopy (10

Hz to 100 kHz) is performed to characterize the change in impedance, as a function of *E. coli* concentration on graphene surface. The residual methyl groups on graphene, resulting from the transfer process, act as binding sites for *E. coli*. It has been observed that the resistance of graphene decreases with increasing *E. coli* concentration. This is due to the increased hole doping induced by negatively charged *E. coli*. A sensitivity of 60% is achieved for an *E. coli* concentration of 4.5×10^7 cfu/ml [29]. Mungali *et al.*, (2015) develop an electrochemical biosensor for the rapid detection of *E. coli* (DH5) OmpA antigen. Here, we utilize carbodiimide based strategies to crosslink antibodies on amine-functionalized platforms for diagnostic applications. The main objective of this study was to optimize the surface of nanoporous polycarbonate track etched membrane (PCTE) to provide efficient binding of anti-OmpA (mouse anti *Escherichia coli* 03 (NTCC 9003) antibody and to exploit sensing surface for the detection of OmpA antigen (*Escherichia coli* DH5 alpha (1652)), as an alternative diagnostic test. The PCTE membrane was characterized by infrared spectroscopy. The inferred spectra shows specific peak of functionalization of PCTE membrane by carbodiimide (EDC-NHS) by converting terminal carboxylic group to an active NHS ester to bind antibodies (Ab) (mouse anti *Escherichia coli* 03 (NTCC 9003)) at 1772 cm^{-1} (C=O vibrations), 1406 cm^{-1} and 1079 cm^{-1} (C-OH vibrations), and 766 cm^{-1} (OCN vibrations); while peaks on 3387 cm^{-1} (N-H stretch), 1639 cm^{-1} (C=O) and 1567 cm^{-1} (NH₂ wag) exhibits specific Ab-Ag (OmpA (*Escherichia coli* DH5 alpha (1652)) interaction. We used a specially designed electrochemical biosensor setup for impedance measurement to monitor Ab-Ag interaction. The limit of detection of constructed electrochemical biosensor was 10 ng / ml. [30].

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SYNTHESIS AND SPECTRAL STUDY OF MIXED LIGAND COMPLEXES OF CHROMIUM(III) DIBASIC TRIDENTATE SCHIFF SCHIFF BASES AS PRIMARY AND NAPHTHOIC ACID AS CO-LIGAND

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Abstract

The transition metal complexes of Schiff bases have been widely researched on account of their importance as biochemical, analytical and antimicrobial reagent. Herein, the transition metal ion complexes of Cr(III) with dibasic tridentate Schiff bases derived by condensation of thiosemicarbazide with acetoacetanilide as primary ligand and 1-hydroxy-2-naphthoic acid as co-ligand have been prepared. The mixed ligand complexes of the above mentioned metal ion were characterized by analytical, magnetic and electronic spectral study. The transition metal complexes were also evaluated for antifungal activity against *Drechslera tetramera*, *Fusarium-oxysporum* and *Macrophomia phaseoli* at different concentrations.

Keywords: tridentate Schiff base, mixed ligand, naphthoic acid, electronic spectral study, antifungal activity.

Introduction

The coordination chemistry of trivalent ions involving multidentate ligands have received limited attention. The Complexes of Cr(III) with p-dimethyl aminoaniline-3-penten-2-one have been prepared and characterized by Agrawal and Chandra[1]. The reaction of potassium hexathiocyanatochromate (III) with β -diketone and nitrogen donor ligand in ethanolic medium form complexes[2] of the type $[\text{Cr}(\text{bzbz})(-\text{pic})_2(\text{NCS})_2]$, $[\text{Cr}(\text{b}_z\text{b}_z)\text{L}(\text{NCS})_2]$, $[\text{Cr}(\text{b}_z\text{ac})(-\text{pic})_2(\text{NCS})_2]$ and $[\text{Cr}(\text{b}_z\text{ac})\text{L}(\text{NCS})_2]$ where b_zH = Dibenzoylmethane, b_zacH = benzoylacetone, $-\text{pic}$ = $-\text{picoline}$ and L = 2,2' bipyridine or o-phenanthroline. The complexes have been characterized on the basis of elemental analyses, molar conductance, room temperature magnetic moment, infrared and electronic spectral data. They are paramagnetic and non-electrolytic in nature, having octahedral geometries. Complexes of Cr(III) with 1-(2'-pyridyl) benzothiazole-2-thione have been studied by[3]. The [4] have made spectral, magnetic, Mossbauer and chemotherapeutical studies of Cr(III) complexes with various new derivatives of isonicotinic acid hydrazide. Complexes of the composition $\text{H}[\text{M}(\text{C}_{18}\text{H}_{31}\text{NO}_4)_2]$ $[\text{M}=\text{Cr}^{+3}]$ with N-4-methyl-7-hydroxy-8-acetocoumarinylidene-o-aminophenol (H_2MHACAP) have been prepared and characterised[5] on the basis of elemental analysis, conductivity, electronic, infrared, and magnetic measurements.

All these metal complexes have been found to exhibit octahedral geometry. Cr(III) complexes of the Schiff bases derived from salicylhydrazide and 6-methyl-4-hydroxy-3-acetyl-coumarin were reported in literature [6]. 3-Hydroxy-3-phenyl-1-o-hydroxyphenyl triazene has been used as a reagent for spectrophotometric determination of chromium [7].

The stability constant [8] Cr(III) complexes of N-(8-aceto-7-hydroxy-4-methyl coumarin)-o-phenylene diamine have been determined at 25°C and 0.1M (NaClO₄) in 75% (V/V) aqueous-dioxane medium at different M:L ratio (where M=metal ion and L= ligand). Synthesis and structural characterization of Cr(III) complexes with terephthalic acid hydrazide Schiff bases has been carried out by [9]. Octahedral complexes of Cr(III) with 2,5-dihydroxyacetophenone Schiff bases was studied [10]. Magnetic and spectral studies of octahedral complexes of Fe(III) with -phenylamino -2,4,2,5 dihydroxy propiophenone, -benzidiny-2,5 dihydroxy propiophenone and -benzidiny-2,3,4 -trihydroxy propiophenone have been carried out [11]. Synthesis and structural determination of Cr(III) compounds with N,O and S containing ligands was studied [12]. Mossbauer studies on Cr(III) complexes with some nitrogen donor ligands was carried out [13].

The coordination chemistry of transition metals and their derivatives has received much attention in the recent years mainly due to their biological importance [14-16]. The metal thiosemicarbazones compounds are emerging as a new class of experimental anticancer chemotherapeutic agent [17], which shows activity against most of the cancers through inhibition of a crucial enzyme obligatory for DNA biosynthesis and cell division [18,19]. The complexes of manganese play an important role in photo chemical reactions [20].

Nitrogen, oxygen and sulphur donor ligands possess a range of biological applications such as antitumor [21], antiviral [22], antibacterial [23], antimalarial [24] and antifungal activities [25]. Manganese ethylene bisdithiocarbamate is known to exhibit antifungal activity and successfully used against a wide variety of diseases [26] specially vegetables and fruits [27]. Manganese complexes of some thiosemicarbazones are potent antileukemic agents [28-29].

The survey of literature revealed that the mixed ligand complexes of Cr(III) with dibasic tridentate Schiff bases derived by the condensation of thiosemicarbazides with acetoacetanilide and o-chloro-acetoacetanilide as primary and 1-hydroxy-2-naphthoic acid and 3-hydroxy-2-naphthoic acid as co-ligands have not been studied so far. In the present studies, above mentioned complexes were synthesized. The newly synthesized complexes were characterized on the basis of their elemental analysis, magnetic, spectral and electrolytic conductance studies. Different ligand field parameters have also been calculated. These complexes were also screened for their fungicidal activity against *Drechlera-tetramera*, *Fusarium-oxysporum* and *Macrophomera-phaseoli* at different concentration viz. 100, 50 and 200 ppm.

Material and Method: all the chemicals used were of chemically pure analytical grade. The solvent were dried and distilled before use. Metal(III)chloride, thiosemicarbazide, acetoacetanilide, o-chloro-acetoacetanilide, 1-hydroxy-2-naphthoic acid and 3-hydroxy-2-naphthoic acid were procured from Fischer Scientific, India. Dimethyl formamide (DMF) and alcohol were purchased from Fischer Scientific, India.

The elemental analysis was performed at Central Drug Research Institute, India. Conductance of the metal complexes were measured in nitromethane at 25 C on Toshniwal conductivity bridge CL01/01 using dip type cell. The following accepted range of molar conductivity for water at concentration equal to M/1000 and temperature 25 C were taken to determine the number of ions present in solution. The standard range of molar conductivity in mhos of uni-divalent electrolyte is 215-273 mhos

Infrared spectra of the ligand and their metal complexes were recorded on Beckmann IR 120 Spectrophotometer and Perkin Elmer improved 137 spectrophotometer in Nujol mull and KBr in the range 200 to 400 cm⁻¹ and 400-4000 cm⁻¹ at room temperature. The electronic spectra of the complexes were recorded in ethanol at room temperature on CZ-specord UV-vis-spectrophotometer provided with an automatic recorder. The magnetic susceptibility at

room temperature was determined on Gouy's electromagnetic balance and corrected for diamagnetism.

Preparation of Primary Ligand(Schiff Bases)

Schiff bases were prepared by refluxing thiosemicarbazides with acetoacetanilide or o-chloro-acetoacetanilide in 1:1 molar ratio in alcohol for an hr. After refluxing it was concentrated on water bath upto half of its volume. The precipitate obtained after condensation were filtered and dried. The formation of Schiff bases were confirmed by elemental analysis and infrared spectral studies.

Preparation of Mixed Ligand Complexes

To a warm absolute ethanolic solution of anhydrous metal (III) chloride, hot ethanolic solution of Schiff base was added drop wise. The reaction mixture was thoroughly stirred and refluxed at 70-80 C for two hrs on water bath. Crystalline complexes separated out on cooling at room temperature. They were filtered off washed with ethanol and finally with ether and dried over phosphorous pentoxide .

The mixed ligand complexes were prepared by treating the ethanolic solution of binary complexes with the ethanolic solution of 1-hydroxy-2-naphthoic acid .The reaction mixture was refluxed over water bath for about four hours in each case and the reaction mixture was kept over night at room temperature. The precipitated compounds were filtered, washed with acetonitrile and dry ether to remove unreacted ligand if any. They were recrystallised from ethanol: chloroform mixture. The crystalline complexes were dried in vacuum.

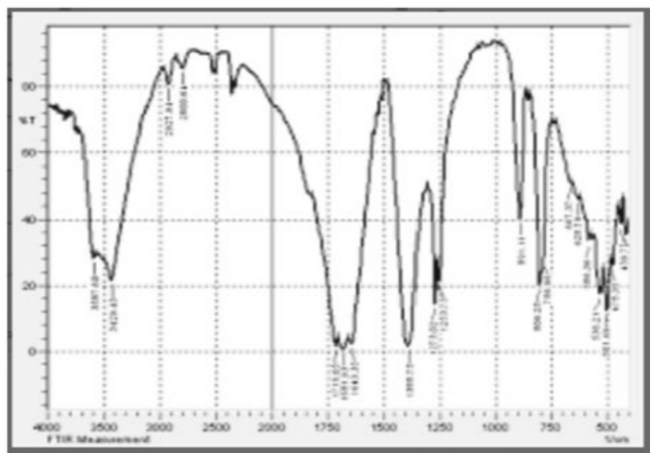
Result and Discussion

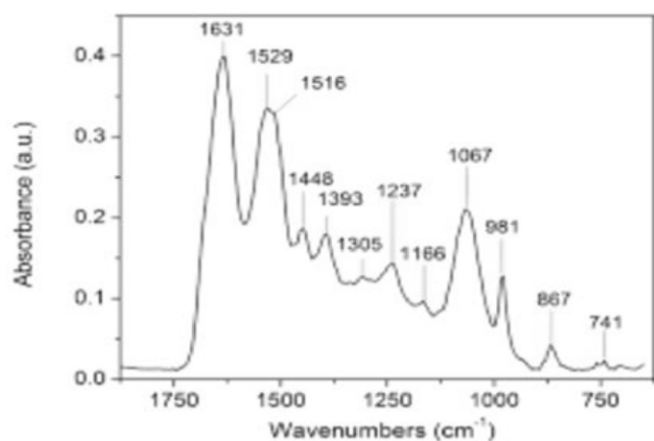
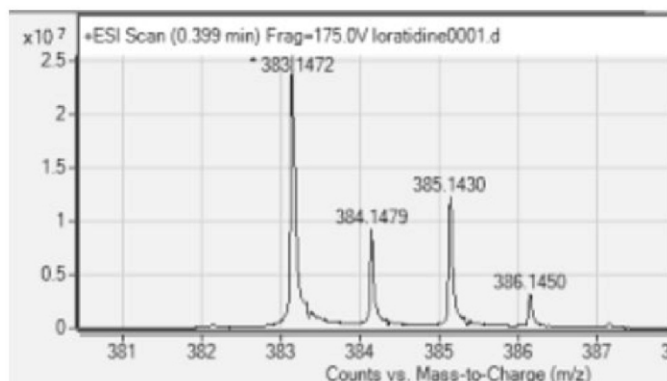
Analytical data of mixed ligand complexes suggest 1:1:1 (M:L:L'/L'') stoichiometry of isolated mixed ligand complexes (where $M = Cr^{3+}$ and $L = C_{11}H_{14}N_4SO$, $L' = C_{11}H_{13}N_4SOCl$, $L'' = C_{11}H_8O_3$, $L''' = C_{11}H_8O_3$). The compounds are stable upto 150 C showing that they are non-hygroscopic. All the complexes are soluble in common organic solvents. The conductance data shows that they are having non-electrolytic nature.

FTIR Study

On comparison of IR. spectra of free ligands with those of mixed ligand complexes confirm the coordination of thiosemicarbazone and naphthoic acid to the metal Cr(III). I.R. spectra of free thiosemicarbazone ligands display two bands around 3450 and 3300 cm^{-1} due to as and sym of terminal NH_2 group[30]. These bands remain practically unaltered in the corresponding metal complexes showing the non-involvement of this group on complexation. The absorption due to $C=N$ of the free ligand appearing in the region 1620 cm^{-1} undergoes a negative shift by 5-15 cm^{-1} in the spectra of complexes indicating coordination of azomethene nitrogen to the metal.

The bands of strong intensities in the spectra of primary ligand around 1650 cm^{-1} are due to $C=O$. In the spectra of complexes, this band is absent and a new band is observed around 1620 cm^{-1} which can be attributed to the enolisation and subsequent coordination through the deprotonated oxygen atom of $-CH_2-C=O$ group[31]. The band due to $C=S$ appears around 830 cm^{-1} in free primary ligand disappears on complexation and a new band appears around 720-750 cm^{-1} . These observations may be attributed to thioenolisation of the $NH-C-S$ group and subsequent coordination through the deprotonated sulphur[32]. From IR. spectral data, it is concluded that the thiosemicarbazones are potentially dibasic tridentate ligands and the coordination sites are the -nitrogen and thiolato sulphur and oxygen after deprotonation. The possibility of -nitrogen coordination is ruled out because of considerable strain[33].





The OH (of COOH group) observed as a broad intense band at 2650 cm^{-1} in naphthoic acid is not traceable in the spectra of mixed ligand complexes indicating that the carboxylic proton has been removed in complexation. The symmetrical and asymmetrical stretching vibrations of -COO of free ligand are observed at 1410 and 1630 cm^{-1} , respectively that shifted to $1440\text{-}1450\text{ cm}^{-1}$ and $1570\text{-}1580\text{ cm}^{-1}$ in the complexes indicating coordination of carboxylate oxygen to metal ion.

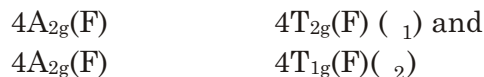
The broad band centred at 2960 cm^{-1} in the spectra of complexes indicating non-participation of phenolic-OH present in naphthoic acids.

Magnetic and Electronic, Spectral Studies

Cr(III) Mixed ligand complexes

Cr(III) complexes under study, showed magnetic moment of $3.80\text{-}3.84\text{ B.M.}$ corresponding to three unpaired electrons and sp^3d^2 hybridization. These values lie in the range

expected for octahedral stereochemistry. The electronic spectra of acetonic solution of Cr(III) compounds exhibit bands in the range $17200\text{-}17900\text{ cm}^{-1}$ and $23000\text{-}23400\text{ cm}^{-1}$ which may be assigned to the following transitions.



These transitions are characteristics of an octahedral Cr(III) ion. In addition, a low energy band in the range $12700\text{-}12950\text{ cm}^{-1}$ is also observed which may be due to spin-forbidden transition.

$4A_{2g}(\text{F})$ $2T_{2g}$, $2E_g$. The higher energy spin allowed 3 band corresponding to $4A_{2g}(\text{F})$ $4T_{1g}(\text{P})$ usually found above $30,000\text{ cm}^{-1}$ could however not be traced in the electronic spectra of Cr(III) mixed ligand complexes.

The spectral and magnetic moment values support the octahedral stereochemistry for the Cr(III) complexes.

Conclusion

It is to be concluded that in this work three mixed ligand complexes of Cr(III) have been successfully synthesized along with tridentate Schiff base derived by condensation of thiosemicarbazides with acetoacetanilide as primary ligand and 1-naphthoic acid as co-ligand. The transition metal complexes were characterized by FTIR, elemental analysis and electronic spectral study. The antifungal activity of the three compounds were performed with fungi, *Drechslera tetramera*, *Macrophomia phaseoli* and *Fusarium oxysporum* at different concentrations. The growth response and average % inhibition after 46 h of exposure to fungi strain was observed in relation to the ligand and its metal complexes. The spectral and magnetic moment values support the octahedral stereochemistry for the Cr(III)

Growth Responses Of *Drechslera Tetramera*, *Macrophomia Phaseoli* And *Fusarium Oxysporum* (After 96 Hours At $26\pm 1^\circ\text{C}$ On Czpeck's Dox Agar Medium) At Different Concentrations (In Ppm) In Relation To The Ligand And Its Metal Complexes

Table: Fungicidal Testing Of Ligand (Schiff Base+1-Hydroxy-2-Naphthoic Acid)And Its Metal Complexes

Test Sample	Average % inhibition after 96 hours								
	Drechslera tetramera			Macrophomia Phoseoli			Fusarium oxysporum		
	Concentration used in ppm								
	200	100	50	200	100	50	200	100	50
Ligand (Primary + Secondary)	65	52	35	64	51	34	64.5	50.5	33.8
[Cr (C ₁₁ H ₁₂ N ₄ SO) (C ₁₁ H ₇ O ₃) H ₂ O]	50	38	28	51.0	37	20.4	51.0	30	20.4
[Cr (C ₁₁ H ₁₁ N ₄ SOCl) (C ₁₁ H ₇ O ₃) H ₂ O]	51.0	37.8	27	50.8	26.8	20.3	50.8	29	20.6

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MEDICINAL BENEFITS OF ALOE VERA (*ALOE BARBADENSIS*)

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Introduction

Aloe vera is a succulent plant species of the genus Aloe. An evergreen perennial, it originates from the Arabian Peninsula, but grows wild in tropical, semi-tropical, and arid climates around the world. It is cultivated for agricultural and medicinal uses.

Classification

- **Scientific name:** Aloe vera
- **Higher classification:** Aloes
- **Rank:** Species
- **Family:** Asphodelaceae
- **Kingdom:** Plantae
- **Order:** Asparagales
- **Order:** Asparagales

The botanical name of Aloe vera is Aloe barbadensis miller. It belongs to Asphodelaceae (Liliaceae) family, and is a shrubby or arborescent, perennial, xerophytic, succulent, pea- green color plant. It grows mainly in the dry regions of Africa, Asia, Europe and America. In India, it is found in Rajasthan, Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu.

Harvesting of leaves starts after 7-8 months of planting. Sharp knife is used for harvesting. Proper harvesting is a labor-intensive process. Typically, the outermost 3-4 leaves are harvested by pulling each leaf away from the plant stalk and cutting at the white base. The leaves should be handled gently. Care should be taken to prevent damage to the outer rind and to maintain the seal at the base of the leaf in order to prevent introduction of bacteria. Leaves that show signs of tip necrosis should not be harvested, as these provide entry points for microbial contamination. Care also has to be taken to reduce the loss of juice from the cut portion. If harvesting is done once in a year, October - November are the best period for harvesting. Second year gives maximum yield and for about 4-5 years good yield could be harvested. After harvesting leaves are dried in shade and then in sun before storages. Flowers are collected in December - January and preserved after proper drying. Harvested leaves are carefully stacked and then transferred to a refrigeration or processing facility.

The plant has triangular, fleshy leaves with serrated edges, yellow tubular flowers and fruits that contain numerous seeds. Each leaf is composed of three layers:

1. An inner clear gel that contains 99% water and rest is made of glucomannans, amino acids, lipids, sterols and vitamins.
2. The middle layer of latex which is the bitter yellow sap and contains anthraquinones and glycosides.
3. The outer thick layer of 15-20 cells called as rind which has protective function and synthesizes carbohydrates and proteins. Inside the rind are vascular bundles responsible for transportation of substances such as water (xylem) and starch (phloem).³

Aloe is identified by the presence of succulent leaves, inflorescences in clusters or panicles, tubular flowers, the presence of secondary metabolic compounds as 1-methyl-8-hydroxyanthraquinone in roots and C-glycosides in leaves. Additionally, Aloe has a basic chromosome number $x=7$ (Reynolds 2004).

The Aloe vera plant has been known and used for centuries for its health, beauty, medicinal and skin care properties. The name Aloe vera derives from the Arabic word "Alloeh" meaning "shining bitter substance," while "vera" in Latin means "true." 2000 years ago, the Greek scientists regarded Aloe vera as the universal panacea. The Egyptians called Aloe "the plant of immortality." Today, the Aloe vera plant has been used for various purposes in dermatology. Aloe vera has been used for medicinal purposes in several cultures for millennia: Greece, Egypt, India, Mexico, Japan and China.¹ Egyptian queens Nefertiti and Cleopatra used it as part of their regular beauty regimes. Alexander the Great, and Christopher Columbus used it to treat soldiers' wounds. The first reference to Aloe vera in English was a translation by John Goodyew in A.D. 1655 of Dioscorides' Medical treatise *De Materia Medica*.² By the early 1800s, Aloe vera was in use as a laxative in the United States, but in the mid-1930s, a turning point occurred when it was successfully used to treat chronic and severe radiation dermatitis.²

Benefits of Aloe Vera

The medicinal claims made about Aloe vera, as with many herbs and plants, are endless. Some are backed by rigorous scientific studies while others are not. This article focuses mainly on those that are backed by research.

Teeth and Gums

A study published in *General Dentistry* reported that Aloe vera in tooth gels is as effective as toothpaste in fighting cavities. The researchers compared the germ-fighting ability of an Aloe vera tooth gel with two popular toothpastes. They found that the gel was just as good, and in some cases even better than the commercial toothpastes at controlling cavity-causing oral bacteria. The authors explain that Aloe latex contains anthraquinones, compounds that actively heal and reduce pain through natural anti-inflammatory effects.

The scientists warned that not all gels they analyzed contained the proper form of Aloe vera - they must contain the stabilized gel that exists in the center of the plant to be effective.

Constipation

Germany's regulatory agency for herbs - Commission E - approved the use of Aloe vera for the treatment of constipation. Dosages of 50-200 milligrams of Aloe latex are commonly taken in liquid or capsule form once daily for up to 10 days. The U.S. Food and Drug Administration (FDA) ruled in 2002 that there is not enough data on the safety and efficacy of Aloe products; so, in the U.S., they cannot be sold to treat constipation.

Diabetes-induced Foot Ulcers

A study carried out at the Sinhgad College of Pharmacy, India, and published in the *International Wound Journal* looked at Aloe's ability to treat ulcers. They reported that a "gel formed with carbopol 974p (1 percent) and Aloe vera promotes significant wound healing and closure in diabetic rats compared with the commercial product and provides a promising product to be used in diabetes-induced foot ulcers."

Antioxidant and Possible Antimicrobial Properties

Share on Pinterest Aloe vera may be used on skin conditions or superficial cuts for its antimicrobial and antioxidant properties. Researchers at the University of Las Palmas de Gran Canaria, Spain, published a study in the journal *Molecules*. The team set out to determine whether the methanol extract of leaf skins and flowers of Aloe vera might have beneficial effects on human health. The scientists focused on

the extract's possible antioxidant and antimycoplasmic activities. Mycoplasma is a type of bacteria that lack a cell wall; they are unaffected by many common antibiotics. Antimycoplasmic substances destroy these bacteria. They reported that both Aloe vera flower and leaf extracts had antioxidant properties, especially the leaf skin extract. The leaf skin extract also exhibited antimycoplasmic properties. The authors concluded that "A. Vera extracts from leaf skin and flowers can be considered as good natural antioxidant sources."

Protection from Ultraviolet (UV) Irradiation

Scientists at Kyung Hee University Global Campus, South Korea, wanted to determine whether baby Aloe shoot extract and adult Aloe shoot extract might have a protective effect on UVB-induced skin photoaging; in other words, whether they could protect the skin from the aging effects of sunlight. Baby Aloe shoot extract (BAE) comes from 1-month old shoots while adult Aloe shoot extract (AE) comes from 4-month old shoots. In an article published in *Phytotherapy Research*, the authors concluded: "Our results suggest that BAE may potentially protect the skin from UVB-induced damage more than AE."

Protection from Skin Damage After Radiation Therapy

A study carried out at the University of Naples, Italy, tested five different topical creams to see how effective they might be in protecting the skin of breast cancer patients receiving radiation therapy. One of these creams contained Aloe. They divided 100 patients into five groups of 20; each was prescribed a different topical treatment. They applied the creams twice daily, starting 15 days before radiation therapy treatment, and carried on for 1 month afterward. During the 6-week period, the participants underwent weekly skin assessments. In the journal *Radiation Oncology*, the scientists reported that the preventive use of the topical hydrating creams reduced the incidence of skin side effects in the women treated with radiation therapy for breast cancer, none performed significantly better.

"All moisturizing creams used in this study were equally valid in the treatment of skin damage induced by radiotherapy."

Depression, Learning, and Memory - an Animal Experiment

A study published in *Nutritional Neuroscience* found that Aloe vera reduced depression and improved memory in mice. After carrying out experiments on laboratory mice, they concluded: "Aloe vera enhances learning and memory, and also alleviates depression in mice." Further studies are needed to establish whether humans might also receive the same benefits.

Wounds from Second-degree Burns

A team of plastic surgeons compared Aloe vera gel to 1 percent silver sulphadiazine cream for the treatment of second-degree burn wounds.

They reported in the *Journal of Pakistan Medical Association* that the burn wounds among the patients treated with Aloe vera healed significantly quicker compared with those treated with 1 percent silver sulfadiazine (SSD). The researchers added that those in the Aloe vera group experienced significantly more and earlier pain relief than those in the SSD group. The authors wrote: "Thermal burns patients dressed with Aloe vera gel showed advantage compared to those dressed with SSD regarding early wound epithelialization, earlier pain relief, and cost-effectiveness."

Irritable bowel Syndrome (IBS)

A randomized, double-blind human trial carried out at St. George's Hospital Medical School, London, United Kingdom investigated Aloe and IBS. Their results were published in the *International Journal of Clinical Practice*. Participants with IBS were given either Aloe vera or a placebo.

Medicinal Use of Aloe Vera

Aloe vera is anthelmintic, aperients, carminative, deobstruent, depurative, diuretic, stomachic and emmenagogue. Juice is used in skin care medicine, dyspepsia, amenorrhea, burns, colic, hyperadenosis, hepatopathy, splenopathy, constipation, span menorrhea, abdominal tumors, dropsy carbuncles, sciatica, lumbago and flatulence. The elio, a product made by juice of this plant, is used for helminthiasis in children and is a purgative, anthelmintic & emmenagogue. A number of glycoprotein present in Aloe vera gel

have been reported to have antitumor and antiulcer effects and to increase proliferation of normal human dermal cells [1-3]. Gel is useful in ulcerative colitis and pressure ulcers, respectively [6,1]. Traditionally, Aloe vera gel is used both, topically (treatment of wounds, minor burns, and skin irritations) and internally to treat constipation, coughs, ulcers, diabetes, headaches, arthritis, immune-system deficiencies [4,2]. Aloe vera has been used for medicinal purposes in several cultures for millennia: Greece, Egypt, India, Mexico, Japan, and China [3]. The Egyptians used the Aloe vera to make papyrus like scrolls as well as for treatment of tuberculosis [4]. Nadkerni [5] stated various preparations of Aloe barbadensis like confection, lotion and juice, useful remedies for curing various diseases. Aloe contains mixture of glucosides collectively called aloin which is the active constituent of various drugs. Traditionally Aloe is extensively used in treating urine related problems, pimples and ulcers etc. It is also used in gerontology and rejuvenation of aging skin. The juice of Aloe vera leaves is used as stomachic tonic and purgative. Scientific evidence for the cosmetic and therapeutic effectiveness of Aloe vera is limited and when present is frequently contradictory [16,17]. Despite this, the cosmetic and alternative medicine industries regularly make claims regarding the soothing, moisturizing, and healing properties of Aloe vera, especially via internet advertising [18,19]. The bioactive compounds are used as astringent, haemostatic, antidiabetic, antiulcer, antiseptic, antibacterial, anti-inflammatory, antioxidant and anticancer agent also, effective in treating stomach ailments, gastrointestinal problems, skin diseases, constipation, radiation injury, wound healing, burns, dysentery, diarrhoea and in the treatment of skin diseases [7]. It is used in ayurvedic formulations as appetite-stimulant, purgative, emmenagogue and antihelminthic, for treating cough, colds, piles, debility, dyspnoea, asthma and jaundice [11].

Cosmetic & Skin Protection Application Aloin and its gel are used as skin tonic against pimples. Aloe vera is also used for soothing the skin, and keeping the skin moist to help avoid flaky scalp and skin in harsh and dry weather. The Aloe sugars are also used in moisturizing preparations

[72]. Mixed with selected essential oils, it makes an excellent skin smoothening moisturizer, sun block lotion plus a whole range of beauty products. Due to its soothing and cooling qualities, Maharishi Ayurveda recommends Aloe vera for a number of skin problems [71]. Representing the medicinal utilities of Aloe vera. Aloe vera extracts have antibacterial and antifungal activities, which may help in the treatment of minor skin infections, such as boils and benign skin cysts and have been shown to inhibit the growth of fungi that cause tinea [73]. Currently, the plant is widely used in skin care, cosmetics and nutraceuticals [74]. Aloe vera gel has been reported to have a protective effect against radiation damage to the skin [75,76]. Exact role is not known, but following the administration of Aloe vera gel, an antioxidant protein, metallothionein, is generated in the skin, which scavenges hydroxyl radicals and prevents suppression of superoxide dismutase and glutathione peroxidase in the skin. It reduces the production and release of skin keratinocyte derived immunosuppressive cytokines such as interleukin-10 (IL-10) and hence prevents UV-induced suppression of delayed type hypersensitivity [77]. Skin burns effect is reported and radiation dermatitis [78-80]. Some researcher has been reported the contact dermatitis and burning skin sensations following topical applications of Aloe vera gel to dermabraded skin. These reactions appeared to be associated with anthraquinone contaminants in this preparation [81,82].

Antiseptic: The antiseptic property of Aloe vera is due to presence of six antiseptic agents namely lupeol, salicylic acid, urea nitrogen, cinnamonic acid, phenols and sulphur. These compounds have inhibitory action on fungi, bacteria and viruses. Though most of these uses are interesting controlled trials are essential to determine its effectiveness in all diseases [13].

Anti-Diabetic: The five phytosterols of A. vera, lophenol, 24-methyllophenol, 24-ethyl-lophenol, cycloartanol and 24-methylenecycloartanol showed anti-diabetic effects in type-2 diabetic mice [14]. Aloe vera contains polysaccharides which increase the insulin level and show hypoglycemic properties

[5]. The beneficial effects of selective medicinal plant species such as *Allium cepa*, *Allium sativum*, *Aloe vera*, *Azadirachta indica*, *Gymnema sylvestre*, *Syzygium cumini* and *Pterocarpus marsupium*, and emphasize on the role of active biomolecules which possess anti-diabetic activity. The treatment of diabetes mellitus has been attempted with various indigenous plants and polyherbal formulations [7-9]. Encouraging results have been obtained from plant extracts with respect to antidiabetic activity, but still only a meager percentage of the plant world has been explored [9]. Medicinal plants like *Trigonella foenum-graecum*, *Allium sativum*, *Gymnema sylvestre*, *Syzygium cumini* and *Aloe vera* have been studied for treatment of diabetes mellitus [1]. Extracts of *Aloe* gum increases glucose tolerance in both normal and diabetic rats [2] and *Aloe vera* sap taken for 4 - 14 weeks has shown a significant hypoglycaemic effect both clinically and experimentally [3]. *Aloe vera* gel is used in reducing sugar in diabetes [7]. The five phytosterols of *A. vera*, lophenol, 24-methyl-lophenol, 24-ethyl-lophenol, cycloartanol and 24-methylenecycloartanol showed anti-diabetic effects in type-2 diabetic mice [4]. Traditional anti-diabetic plants might provide new oral anti-diabetic compounds, which can counter the high cost and poor availability of the current medicines for many rural populations in developing countries [8].

Anticancer Properties The role of *Aloe* in carcinogenicity has not been evaluated well. The chronic abuse of anthranoid-containing laxatives has been hypothesized to play a role in colorectal cancer, however, no causal relationship between anthranoid laxative abuse and colorectal cancer has been demonstrated and [1,8]. Report on cancer prevention is done by [4,5]. *Aloe vera* juice enables the body to heal itself from cancer and also from the damage caused by radio and chemotherapy that destroys healthy immune cells crucial for the recovery. *Aloe vera* emodin, an anthraquinone, has the ability to suppress or inhibit the growth of malignant cancer cells making it to have antineoplastic properties [9].

Stress *Aloe* juice is helpful in smooth functioning of the body machinery [7]. It reduces cell-damaging process during stress condition and minimizes biochemical and physiological changes

in the body [18]. Oxidative stress refers to chemical reactions in which compounds have their oxidative state changed. Some antioxidants are part of the body's natural regulating machinery while other dietary antioxidants are derived from diet sources.

Aloe vera is an excellent example of a functional food that plays a significant role in protection from oxidative stress [11,12, 19]. Adverse Reactions Abdominal spasms and pain may occur after even a single dose and overdose can lead to colicky abdominal spasms and pain, as well as the formation of thin, watery stools. Chronic abuse of anthraquinone stimulant laxatives can lead to hepatitis [10] and electrolyte disturbances (hypokalaemia, hypocalcaemia), metabolic acidosis, malabsorption, weight loss, albuminuria, and haematuria [10,12]. Weakness and orthostatic hypotension may be exacerbated in elderly patients when stimulant laxatives are repeatedly used [13]. Secondary aldosteronism may occur owing to renal tubular damage after aggravated use. Steatorrhoea and protein-losing gastroenteropathy with hypoalbuminaemia have also been observed, as have excessive excretion of calcium in the stools and osteomalacia of the vertebral column [14]. Melanotic pigmentation of the colonic mucosa (pseudomelanosis coli) has been observed in individuals taking anthraquinone laxatives for extended time periods. The pigmentation is clinically harmless and usually reversible within 4 to 12 months after the drug is discontinued [10]. *Aloe vera* contains polysaccharides which increase the insulin level and show hypoglycemic properties [15].

Aloe Vera as an Immunity Enhancer

Immuno-stimulants are widely used for health management in animals (Pugh et al., 2001). Some plant polysaccharides are well known to possess immunostimulatory effects (Pugh et al., 2001; Im et al., 2005; Qiu et al., 2000). *Aloe vera* possesses confirmed curative or healing actions. A total of 360 *A. vera* species (commonly known as *A. vera*) are grown in the dry regions of North America, Europe and Asia. It is consumed both as a vegetable and as a traditional Chinese medicine in single and compounded prescriptions for treating fever, constipation and ringworm. Some specially prepared *A. vera* extracts possess many biological activities

such as antiinflammation, anti-cancer, antioxidant, anti-diabetes and macrophage activation (Grover et al., 2002; Krishnan, 2006; Xiao et al., 2007; Xu et al., 2008). Polysaccharide with biological response modifiers derived from *A. vera* are mainly mannose polymers (Leung et al., 2004). *A. vera*'s role as a biologically active immunomodulator has been well documented for years. Especially, these products have been extensively studied for their immunological effects (Yates et al., 1992; Im et al., 2005). Administration of *A. vera* has been universally demonstrated to result in marked increase in phagocytic and proliferative activity of the reticuloendothelial system (Hanaue et al., 1989; Im et al., 2005). These products can modulate and stimulate both humoral and cellular immunity and also stimulate proliferation of murine pluripotent hematopoietic stem cells, granulocyte macrophage colony-forming cells, and cells forming myeloid and erythroid colonies (Egger et al., 1996; Im et al., 2005; Boudreau and Beland, 2006). It is demonstrated that immunomodulating and/or immunostimulating effects of these products are dependent on the activation of the innate immune cells (macrophages, neutrophils, lymphocytes and NK cells), synthesis and release of cytokines (TNF- α , IFN- γ , IFN- β , IL-1, IL-2, IL-6 and IL-8), generation of enhanced cell-mediated responses, and induction of nitric oxide production (Leung et al., 2004; Pugh et al., 2001; Im et al., 2005; Boudreau and Beland, 2006). Besides the role in cellular immunity, researchers also found that *A. vera* induces antibody responses. The 5226 Afr. J. Biotechnol. effects on antibody response were proved by the significant increase in the number of B lymphocytes forming both IgM and IgG antibodies (Yates et al., 1992). The aim of this study was to evaluate the effect of *A. vera* administration on cellular and humoral immune response in rabbits.

Aloe vera was evaluated on the mycelium development of *Rhizoctonia solani*, *Fusarium oxysporum*, and *Colletotrichum coccodes*, that showed an inhibitory effect of the pulp of *A. vera* on *F. oxysporum*

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BIOTECHNOLOGY AND HORTICULTURAL CROPS : A HELPFUL APPROACH FOR BETTERMENT

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Abstract

Biotechnology is considered one of the key means to the country to achieve the goals of development strategies. Nowadays, there are several research groups spread all over the country, and dedicated to projects in horticultural biotechnology, quite strategic in the short- and long-term runs, as follows: development of insect or disease resistant crops and tolerant to abiotic stresses; improvement of nutritional composition of edible crops; manipulation of secondary metabolite routes in plants; reduction of post-harvest storing losses, shorting juvenile cycles for rapid improvement of native and exotic forest and fruit trees, and reduction of lignin content in wood species.

Keywords: Biotechnology, Horticultural crops, genetic engineering, tissue culture, transgenic.

Introduction

In the past ten years, the scientific community developed a remarkable capacity to manipulate new biotechnology tools, as the emerging technologies of recombinant DNA, genomics and proteomics. However, public institutions generally do not have access to the full range of enabling technologies and trait genes, nor the resources to satisfy the regulatory and stewardship requirements needed to develop a commercial biotech variety, making public-private partnerships an attractive avenue for development. Major and exciting changes have taken place recently in various aspects of bio technology. Even more exciting is the prospect of major innovations that the entire field of biotechnology holds for plant growth in general. Regulatory trends to govern the safe use of biotechnology to date, include undertaking scientifically based, case-by-case, hazard identification and risk assessments; regulating the end product rather than the production process itself; developing a regulatory framework that builds on existing institutions rather than establishing new ones; and building in flexibility to reduce regulation of products after they have been demonstrated to be of low risk.[6]

The requirement of fruits and vegetables is increasing proportionally with the increasing population in the country. How do we keep horticultural production on par with the burgeoning population? Although conventional plant breeding techniques have made considerable progress in the development of improved varieties, they have not been able to keep pace with the increasing demand for vegetables and fruits in the developing countries. Therefore an immediate need is felt to integrate biotechnology to speed up the crop improvement programmes. Biotechnological tools have

revolutionized the entire crop improvement programmes by providing new strains of plants, supply of planting material, more efficient and selective pesticides and improved fertilizers. Many genetically modified fruits and vegetables are already in the market in developed countries. Modern biotechnology encompasses broad areas of biology from utilization of living organisms or substances from those organisms to make or to modify a product, to improve plant or animal or to develop micro-organisms for specific use. It is a new aspect of biological and agricultural science which provides new tools and strategies in the struggle against world's food production problem. [7]

Improvement of Horticultural Crops with Biotechnology

In vitro culture techniques have had numerous applications to fruit crops beginning nearly 60 years ago with embryo rescue techniques for stone fruits. Later on, the method has been applied successfully to produce commercially acceptable early-ripening peach and nectarine cultivars. [7] The methods have been adapted to other crops as well, e.g. in breeding programmes to produce both early-ripening and seedless grapes. Historically, the second application of in vitro culture methods to fruit crops was to eliminate disease causing viruses from strawberries. Meristem-tip culture has since become an integral part of virus-indexing programmes for a number of fruit crops, usually in conjunction with thermotherapy. In some cases, it has been necessary to micro-graft the meristem tip into an in vitro- grown seedling as is done for citrus.

Within the past 25 years, micro-propagation of fruit crops has become an important application of in vitro technology (Table 1). Strawberry was the first fruit crop for which the method was developed. Now many fruit crops are being micro-propagated commercially. More recent uses of in vitro culture emphasize application for genetic improvement of fruit crops. These applications include production of hybrid plants from fused protoplasts, somaclonal variation and mutagen-driven changes in regenerated plants, haploids plants from anther culture and transfer of specific genes via *Agrobacterium*-mediated transformation.

Temperate Fruit Crops	Tropical Fruit Crops
Strawberry (<i>Fragaria</i>)	Mulberry (<i>Morus alba</i>)
Rasp berry (<i>Rubus sp.</i>)	Cashew (<i>Anacardium occidentale</i>)
Peach (<i>Prunus presica</i>)	Pomegranate (<i>Prunicagranarum</i>)
Apple (<i>Malus</i>)	Guava (<i>Psidium guajava</i>)
Cherry, sour (<i>Prunus cerasus</i>)	Lime (<i>Citrus aurantifolia</i>)
Pear (<i>Pyrus communis</i>)	Banana (<i>Musa sp.</i>)
Grape (<i>Vitis vinifera</i>)	Date Palm (<i>Phoenix dactylifera</i>)
Cherry, sweet (<i>Prunus avium</i>)	Lemon (<i>Citrus limon</i>)
Black berry (<i>Rubus sp.</i>)	Kiwifruit (<i>Actinidia chinensis</i>)
	Papaya (<i>Carica papaya</i>)
	Pineapple (<i>Ananas cosmosus</i>)

Following methods are used to improve and multiply the horticultural crop plants.

1. Micro propagation
2. Virus elimination
3. Genetic improvement
4. Germplasm conservation
5. Haploid production

The above mentioned methods have been employed for fruit crops, plantation crops and vegetable crops. Examples of plantation crops are-Pineapple, palms, banana, cacao (*Theobroma cacao*), coffee (*Coffea sp.*), tea (*Camellia sp.*) rubber (*Hevea brasiliensis*), Vanilla (*Vanilla planifolia*), clove (*Syzygium sp.*) ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), cardamom (*Elleteria cardamomum*). Some of these plants are produced in millions by plant tissue culture industry.

In vegetable crops, major emphasis has been given on - cabbage (*Brassica oleracea*), mustard (*B. campestris*), artichoke (*Helianthus tuberosus*), garlic (*Allium sativum*), onion (*A. cepa*), tomato, carrot, melon (*Cucumis melo*), cucumber (*Cumissativus*) pepper (*Capsicum annum*), and watermelon (*Citrullus vulgaris*). Micro propagation of ornamental plants (foliage and flower plants) has become a major plant tissue culture based industry on developed and developing countries.

At the peak of the plant tissue culture era in the 1980s, in a relatively short time, many commercial laboratories were established around the world to capitalize on the potential of micropropagation for mass production of clonal

plants for the horticulture industry. Today plant tissue culture applications encompass much more than clonal. The range of routine technologies has expanded to include somatic embryogenesis, somatic hybridization, virus elimination as well as the application of bioreactors to mass propagation.

Impact of Plant Biotechnology in Crop Improvement

The major areas of biotechnology which can be adopted for improvement of horticultural crops are

Tissue Culture

Genetic Engineering

Molecular diagnostics and

Molecular markers

Development of Beneficial microbes

Tissue Culture

One of the widest applications of biotechnology has been in the area of tissue culture and micro propagation in particular. It is one of the most widely used techniques for rapid asexual in vitro propagation. This technique is economical in time and space affords greater output and provides disease free and elite propagules. It also facilitates safer and quarantined movements of germplasm across nations. When the traditional methods are unable to meet the demand for propagation material this technique can produce millions of uniformly flowering and yielding plants. Micropropagation of almost all the fruit crops and vegetables is possible now. Production of virus free planting material using meristem culture has been made possible in many horticultural crops. Plant organ, tissue and cell culture procedures have developed rapidly in the last half-century since the pioneering efforts of Gautheret, White and Nobecourt. The potential application of the methods of tissue culture are of special significance in crop improvement since conventional methods involve several difficulties, including heterozygosity and a long span between successive generations, hence many investigators are devising methods whereby tissue culture could be fully exploited to improve crop varieties. Embryo rescue is another area where plant breeders are able to rescue their crosses

which would otherwise abort. Culture of excised embryos of suitable stages of development can circumvent problems encountered in post zygotic incompatibility. This technique is highly significant in intractable and long duration horticultural species. Many of the dry land legume species have been successfully regenerated from cotyledons, hypocotyls, leaf, ovary, protoplast, petiole root, anthers, etc., Haploid generation through anther/pollen culture is recognized as another important area in crop improvement. It is useful in being rapid and economically feasible. Complete homozygosity of the offspring helps in phenotype selection for quantitative characters and particularly for qualitatively inherited characters making breeding much easier successful isolation, culture and fusion of plant protoplasts has been very useful in transferring cytoplasmic male sterility for obtaining hybrid vigour through mitochondrial recombination and for genetic transformation in plants.

In vitro germplasm conservation is of great significance in providing solutions and alternative approaches to overcoming constraints in management of genetic resources. In crops which are propagated vegetatively and which produce recalcitrant seeds and perennial crops which are highly heterozygous seed storage is not suitable. In such crops especially, in vitro storage is of great practical importance. These techniques have successfully been demonstrated in a number of horticultural crops and there are now various germplasm collection centers. In vitro germplasm also assures the exchange of pest and disease free material and helps in better quarantine.

Plant breeders are continually searching for new genetic variability that is potentially useful in cultivar improvement. A portion of plants regenerated by tissue culture often exhibits phenotypic variation atypical of the original phenotype. Such variation, termed somaclonal variation may be heritable i.e. genetically stable and passed on to the next generation. Alternatively, the variation may be epigenetic and disappear following sexual reproduction. These heritable variation are potentially useful to plant breeders.

Genetic Engineering of Plants

Genetic Engineering involves three major steps:

- (i) Identification and isolation of suitable genes for transfer.
- (ii) Delivery system to insert desired gene into recipient cells.
- (iii) Expression of new genetic information in recipient cells.

Using techniques of genetic engineering many useful genes have been introduced into plants and many transgenic plants have been developed in which the foreign DNA has been stably integrated and resulted in the synthesis of appropriate gene product. Transgenic plants have covered about 52.6 m hectares in the Industrial and developing countries upto 2001. Genes for the following traits have been introduced to the crop plants.

Herbicide Tolerance

Transgenic plants are developed that are resistant to herbicides allowing farmers to spray crops so as to kill only weeds but not their crops. Many herbicide tolerant plants have been developed in tomato, tobacco, potato, soybean, cotton, corn oilseed rape, petunia, etc. Glyphosate is one of the most potent broad spectrum environment friendly herbicide known, it is marketed under the trade name Round up. Glyphosate kills plants by blocking the action of an enzyme (5-enolpyruvyl shikimate-3-phosphate synthase) (EPSPS) an essential enzyme in the biosynthesis of aromatic amino acids, tyrosine, phenylalanine and tryptophan. Amino acids are building blocks of protein. Transgenic plants resistant to Glyphosate have been developed by transferring gene of EPSPS that over produce this enzyme thus inhibiting the effect of Glyphosate. A number of detoxifying enzymes have been identified in plants as well as in microbes. Some of these include glutathione-S-transferase or GST in maize and other plants which detoxifies the herbicide bromoxynil and phosphinothricin acetyl transferase (PAT) which detoxifies the herbicide PPT (L-phosphinothricine). Transgenic plants using bxn gene from *Klebsiella* and bar gene from *Streptomyces* have been obtained in potato, oilseed, sugarbeet, soybean, cotton and corn and are found to be herbicide resistance.

These transgenic plants reduce the use of weeding labour, farmers cost and increase yield.

Engineering pathogen resistance: Viruses are the major pests of crop plants which cause considerable yield losses. Many strategies have been applied to control virus infection using coat protein and satellite RNA. Viruses are submicroscopic pockets of nucleic acid (DNA or RNA) enclosed in a protein coat and can multiply within a host cell. Use of viral coat protein as a transgene for producing virus resistant plants is one of the most spectacular successes achieved in plant biotechnology. Coat protein gene from tobacco mosaic virus (TMV) classified as a positive strand RNA virus has been transferred to tobacco, making it nearly resistant against TMV. Using gene for nucleocapsid protein resistance has been introduced in crops like tomato, tobacco, lettuce, groundnut, pepper and in ornamentals like Impatiens, Ageratum and Crysanthemum against tomato spotted wilt virus. Use of satellite RNA (SATRNA) makes many transgenic plants resistant to Cucumber Mosaic Virus (CMV). Transgenic resistant plants have also been developed against alfalfa mosaic virus, potato virus X, Rice tungro virus, tobacco rattle virus and Papaya ring spot virus.

During the last decade many resistance genes whose products are involved in recognizing the invading pathogens have been identified and cloned. A number of signaling pathways which follow the pathogen infection have been dissected. Many of the antifungal compounds synthesized by plants which combat fungal infections have been identified. The major strategies for developing fungal resistance have been production of transgenic plants with antifungal molecules like proteins and toxins, and generation of hypersensitive response through R genes or by manipulating genes of SAR pathway. A chitinase gene from bean plants in tobacco and *Brassica napus* showed enhanced resistance to *Rhizoctonia solani*. In another case chitinase gene obtained from *Serratia marcescens* (soil bacterium) is introduced in tobacco making it resistant to *Alternaria longipes* which causes brown spot diseases. Acetyl transferase gene is introduced in tobacco making it resistant to *Pseudomonas syringae*, a causal agent of wild fire disease.

Stress Resistance

A number of genes responsible for providing resistance against stresses such as to water stress heat, cold, salt, heavy metals and phytohormones have been identified. Studies are also being conducted on metabolites like proteins and betains that have been implicated in stress tolerance. Resistance against chilling was introduced into tobacco plants by introducing gene for glycerol-1-phosphate acyl-transferase enzyme from *Arabidopsis*. Many plants respond to drought stress by synthesizing a group of sugar derivatives called polyols (Mannitol, Sorbitol and Sion). Plants that have more polyols are more resistant to stress. Using a bacterial gene capable of synthesizing mannitols it is possible to raise the level of mannitol very high making plants resistant to drought.

Fruit Quality

Tomatoes which ripen slowly are helpful in transportation process. Transgenic tomato with reduced pectin methyl esterase activity and increased level of soluble solids and higher pH increases processing quality. Tomatoes exhibiting delayed ripening have been produced either by using antisense RNA against enzymes involved in ethylene production (Eg ACC synthase) or by using gene for deaminase which degraded l-aminocyclopropane-l-carboxylic acid (ACC) an immediate precursor of ethylene. This increases the shelf life of tomatoes. These tomatoes can also stay on the plant long giving more time for accumulation of sugars and acids for improving flavour. It is produced at commercial level in European and American countries. Tomatoes with elevated sucrose and reduced starch could also be produced using sucrose phosphate synthase gene. Starch content in potatoes has been increased by 20-40% by using a bacterial ADP glucose pyrophosphorylase gene.

Pest Resistance

The insecticidal beta endotoxin gene (bt gene) has been isolated from *Bacillus thuringiensis* the commonly occurring soil bacteria and transferred to number of plants like cotton, tobacco, tomato, soybean, potato, etc. to make them resistant to attack by insects. These genes produce insecticidal crystal proteins which affect a range of

lepidopteran, coleopteran, dipteran insects. These crystals upon ingestion by the insect larva are solubilised in the highly alkaline midgut into individual protoxins which vary from 133 to 136 kDa in molecular weight. Insecticidal crystal protein produced during vegetative growth of the cells (VIP) are also found to be highly effective against insect control. Bt resistant plants are already in the market.

Male sterility and Fertility restoration: This is helpful in hybrid seed production. Transgenic plants with male sterility and fertility restoration genes have become available in *Brassica napus*. It facilitates production of hybrid seed without manual emasculation and controlled pollination as often done in maize. In 1990, Mariani and others from Belgium have successfully used a gene construct having another specific promoter from TA29 gene of tobacco and bacterial coding sequence for a ribonuclease gene from *Bacillus* Sp. (barnase gene) for production of transgenic plants in *Brassica napus*. Here the translated gene prevented normal pollen development leading to male sterility.

Molecular Diagnostics

Nucleic acid probes:- It is now possible to detect the plant diseases even before onset of symptoms by using cDNA probes. Probes are nucleic acid sequences of pathogen causing organisms labeled with certain markers. cDNA probes corresponding to specific regions of the pathogens can be generated using standard recombinant DNA technique.

Monoclonal antibodies (McAb): Immunochemical techniques are extremely useful for the rapid and accurate routine detection of plant pathogens and ultimately the diagnosis of plant disease and their relatedness. The introduction of hybridoma technology has provided methods for the production of homologous and biochemically defined immunological reagents of identical specificity which are produced by a single cell line and are directed against a unique epitope of the immunizing antigen. The great potential of McAbs in phytopathological diagnostics is essential because of homogeneous antibody preparations with defined activity and specificity can be

produced in large quantities over long periods. Even though hybridoma technology is a laborious and expensive enterprise compared to standard immunization procedures it is going to be widely used for large scale diagnosis.

Molecular Markers

The possibilities of using gene tags of molecular makers for selecting agronomic traits has made the job of breeder easier. It has been possible to score the plants for different traits or disease resistance at the seedling stage itself. The use of RFLP (Restriction Fragment Length polymorphism), RAPD (Random Amplified Polymorphic DNA), AFLP (Amplified Fragment Length Polymorphism) and isozyme markers in plant breeding are numerous. RFLPs are advantageous over morphological and isozyme markers primarily because their number is limited only by genome size and they are not environmentally or developmentally influenced. Molecular maps now exist for a number of crop plants including corn, tomato, potato, rice, lettuce, wheat, Brassica species and barley. RFLPs have wide ranging applications including cultivar finger printing, identification of quantitative trait loci, analysis of genome organization, germplasm introgression and map-based cloning. AFLP is becoming the tool of choice for fingerprinting because of its reproducibility compared to RAPD. Microsatellite or simple sequence repeats (SSRS) markers have also become the choice for a wide range of applications in genotyping, genome mapping and genome analysis.[5]

Development of Microbial Inoculum

Indiscriminate and injudicious use of chemical fertilizers and pesticides for the crop production and control of insect-pests has resulted in pollution of the environment deterioration of soil health and development of resistance by many insects and residue problems. Hence there is a great concern worldwide to use safer biofertilisers and biopesticides in the integrated nutrient management and pest management systems.

Biofertilizers are micro-organisms which fix atmospheric nitrogen or solubilise fixed

phosphorus in the soil and make more nutrients available to the plant. Some of the organisms providing major inputs are the biological nitrogen fixing organisms like *Rhizobium*, *Azotobacter*, *Azospirillum* and phosphate solubilising organisms like *Bacillus polymyxa*, *B. magisterium*, *Pseudomonas striata* and certain fungal species of *Aspergillus* and *Penicillium*.

The benefits of using micro-organisms as fertilizers are many fold. They are less expensive, nontoxic to plants, do not pollute the ground water nor render the soil acidic and unfit for growth of plants. *Rhizobium* forms nodules on the roots of leguminous plants and help in fixing nitrogen from the atmosphere to ammonium ions which get converted to amino acids in the plant system. Inoculation with this bacteria helps in reducing addition of nitrogenous fertilizers to the soil. *Azospirillum* is also found colonizing inter cellular spaces inside the root system. These bacteria also contribute substantially to the nitrogen requirement of the plant. Phosphate solubilising bacteria are another group of micro-organisms which solubilise the insoluble phosphorus in the soil and make them readily available to the crop. Mycorrhiza is the symbiotic association of the roots of crop plants with non-pathogenic fungus. They provide nutrients absorbed from deeper layers of soil to the plants. They help the plants in better plant establishment and growth when inoculated. Many fruit crops like papaya, mango, banana, citrus, pomegranate are found to be dependent on this association and are greatly benefited by its inoculation in procuring higher phosphate and other nutrient from the soil. These mycorrhizal associations help the plants in overcoming pathogen attack also. They improve soil characters too.

Genetic Modification of Microbes

By using DNA recombination technique it has been possible to genetically manipulate different strains of these bacteria suitable to different environmental conditions and to develop strains with traits with capacity for better competitiveness and nodulation.

Biopesticides are biological organisms which can be formulated as that of the pesticides for the control of pests. Biopesticides are gaining importance in agriculture, horticulture and in

public health programmes for the control of pests. The advantages of using biopesticides are many. They are specific to target pests and do not harm the non target organisms such as bees, butterflies and are safe to humans and live stocks, they do not disturb the food-chain nor leave behind toxic residues.

Some of the microbial pesticides used to control insect pests are *Bacillus thuringiensis* species to control various insect pests. Insecticidal property of these bacteria are due to crystals of insecticidal proteins produced during sporulation. These proteins are stomach poisons and are highly insect specific. Bt toxins could kill plant parasitic nematode too. Number of baculoviruses (BV) nuclear polyhedrosis virus (NPV) is being developed as microbial pesticides both nationally and internationally, A few examples of these are *Heliothis*, *Spodoptera*, *Plusia*, *Agrotis*, *Trichoplusia*, etc.

Biocontrol Agents

These are other microbes which are antagonistic to several pathogenic fungus and are good substitutes to fungicides or insecticide. These are *Bacillus* sps. *Pseudomonas fluorescens*, *Trichoderma*, *Verticillium* sp., *Streptomyces* sps. etc. These organisms are commercially available.

Applications of Biotechnology

The extent of commercial application of plant biotechnology is the important mark for measuring the vitality of this newly emerging technology. Small and marginal farmers can adopt less expensive technologies like the use of biofertilizers and biopesticides while capital intensive technologies can be adopted by rich farmers. Applications of biotechnology in

agriculture are in their infancy. Most current genetically-engineered plant varieties are modified only for a single trait, such as herbicide tolerance or pest resistance. The rapid progress being made in genomics may enhance plant breeding as more functional genes are identified. This may enable more successful breeding for complex traits such as drought and salt tolerance, which are controlled by many genes. This would be of great benefit to those farming in marginal lands worldwide, because breeding for such traits has had limited success with conventional breeding of the major staple food crops.

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DETERMINATION OF ASSIMILATE PARTITIONING AT DIFFERENT GROWTH STAGES OF POTATO PLANT UNDER WATER STRESS CONDITIONS

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Abstract

Timing of water stress relative to tuber initiation is critical in determining patterns of assimilate partitioning. Water stress early in the season (during stolon formation) reduces the number of stolons and subsequent initiation of tubers. Thus, severe and prolonged stress from early in the season constrains tuber formation causing assimilate to be partitioned to other organs. However, water stress imposed after stolon formation *i.e.* at the time of tuber initiation stage promoted the tuber initiation due to enhanced assimilate partitioning, consequently the number of tubers were increased at tuber initiation stage. It is also found that root and shoot growths are strongly affected by partitioning of dry matter to tubers during an early phase of tuber bulking [2]. An interesting finding was observed in number of tubers at different growth stages. Water stress imposed at tuber initiation stage (T2) caused 50% to 80% increase in number of tubers whereas tuber number was reduced when water stress was imposed at tuber enlargement and tuber maturity stages. Increase in number of tubers due to water stress at tuber initiation stage can be explained on the basis of assimilate partitioning to tubers.

Introduction

Many reports [1,3, 4, 5, 12, 13] indicated that during stolonisation and tuberisation potato plants are especially sensitive to drought, which then reduces the number of tubers [6,15, 16]. The availability of water during tuberisation determined the final number of tubers. [7], however, found that fewer tubers were initiated when there was drought during early tuberisation, but this negative effect was compensated for by less resorption of tubers during the bulking period. [8] found no effect of drought on tuber number when water was withheld at any time from tuber initiation onwards. [12,14] observed that although more tubers initiated when plants were exposed to water shortage during tuberisation, fewer were harvested because of an increase in the number of tubers or incipient tubers that were resorbed. [9] did not found varietal difference in tuber number when water stress was imposed at stolon initiation, tuber initiation, early tuber bulking and late bulking growth phases in three potato cultivars *i.e.* Kufri

Lauvkar, Kufri Chandramukhi and Kufri jyoti. However, the stress treatment effect was significant in reducing tuber number of different cultivars. Maximum reduction in tuber number was found in treatment where water stress imposed at stolon initiation stage.

[10] conducted trial to find the effects of 6, 12, and 18 days irrigation periods and three drought stages (i.e., from planting to emergence of seedlings, from emergence of seedlings to tuber setting and from tuber setting till maturation) on emergence time, tuber setting and maturation, they found significant reduction in tuber numbers due to water stress and reported that tuber setting stage was the most sensitive stage.

Materials and Method

The field experiments were conducted at Research Farm of CPRI Campus, Modipuram, Meerut (U.P.) during rabi season of Year-I and Year-II. Forty eight plots were used in a split plot design for accomodating 4 treatments .Field trials were conducted in split plots with three replicates employing the 4 varieties (i.e Kufri Chipsona-1, Kufri Pukhraj, Kufri Lauvkar and Desiree) having following treatments:

T₁ : Control (well watered plants)

T₂ : Water stress at- tuber initiation stage

T₃ : Water stress at -tuber enlargement stage

T₄ : Water stress at - tuber maturation stage

T1 control (well watered) plots were irrigated at 6 DAP (days after planting), 27 DAP, 42 DAP, 63 DAP and 80 DAP during the year Year-I and at 8 DAP, 25 DAP, 44 DAP, 67 DAP and 83 DAP during the year Year-II. The water stress was imposed by withholding water in T₂, T₃ and T₄ treatments at different growth stages. The growth stage was identified and confirmed by uprooting the plants and by examining the stage of tuber development. Experimental plots were dehaulmed at 90 DAP and harvesting was done 10-15 days after of dehauling so that tuber skin is matured.

Three plants per replication were uprooted, washed and observations of number of stolons and number of tubers were taken. The numbers were counted manually.

Results

Mean values of treatments showed that in well watered control (T₁) number of tubers increased with the age of crop. Water stress treatments caused reduction in number of tubers except when water stress was imposed at tuber initiation stage (T₂). Significantly higher number of tubers (3.0 and 3.5 during Year-I and Year-II respectively) was recorded when water stress was imposed at tuber initiation stage (T₂) in comparison with respective well irrigated control. Maximum percent increase (52% and 79% in respective years) also observed in T₂. Significant reduction in number of tubers (5.3 and 5.8 during Year-I and Year-II respectively) was recorded under water stress treatments at tuber enlargement stage (T₃) and tuber maturation stage (T₄) in comparison with well watered control.

The table 1 showed that cultivar Desiree recorded maximum number of tubers (6.0 and 6.8 during Year-I and Year-II respectively) under water stress treatment T2 (water stress at tuber initiation stage) whereas minimum number of tubers was recorded by Kufri Chipsona-1 (1.5 and 2.0 during Year-I and Year-II respectively). In T2, maximum percent increase in number of tubers was recorded by cultivar Kufri Lauvkar (71% and 82% in respective years) and minimum by Kufri Pukhraj (39 and 77% in respective years).

In T3 (water stress at tuber enlargement stage) maximum number of tubers was recorded by Kufri Chipsona-1 (6.1 and 7.0 during Year-I and Year-II respectively) and minimum by Desiree (4.8 and 5.2 during Year-I and Year-II respectively). In T3, maximum percent reduction in number of tubers was recorded by cultivar Desiree (31% and 27% in respective years) and minimum by Kufri Pukhraj (17% and 15% in respective years).

Under water stress at tuber maturation stage (T₄) maximum number of tubers was recorded by Kufri Lauvkar (16.1 and 16.2 during Year-I and Year-II respectively) and minimum by Desiree (9.0 and 9.2 during Year-I and Year-II respectively).

Table 1. Effect of water stress on number of tubers (No./plant) at various growth stages of potato cultivars

Treatments*	Year-I			Year-II		
	Growth stage**			Growth stage		
	TI	TE	TM	TI	TE	TM
Kufri Chipsona-1						
T1	1.0	8.7	14.0	1.1	9.0	15.2
T2	1.5 (+50%)***	6.4	9.3	2.0 (+82%)	6.2	10.1
T3	1.0	6.1 (-30%)	10.1	1.1	7.0 (-22%)	11.1
T4	1.0	8.6	13.0 (-7%)	1.1	9.0	14.0 (-8%)
Mean	1.1	7.4	11.6	1.3	7.8	12.6
Kufri Pukhraj						
T1	1.3	6.6	16.0	1.3	6.8	16.8
T2	1.8 (+39%)	5.2	8.1	2.3 (+77%)	5.4	9.1
T3	1.3	5.5 (-17%)	15.1	1.3	5.8 (-15%)	15.2
T4	1.3	6.3	15.3 (-4%)	1.3	6.7	15.3 (-9%)
Mean	1.4	5.9	13.6	1.6	6.2	14.1
Kufri Lauvkar						
T1	1.7	6.0	18.2	1.7	6.2	18.7
T2	2.9 (+71%)	4.4	13.2	3.2 (+82%)	4.9	12.9
T3	1.7	4.9 (-18%)	15.1	1.8	5.3 (-15%)	15.1
T4	1.7	6.1	16.1 (-12%)	1.8	6.4	16.2 (-14%)
Mean	2.0	5.4	15.6	2.1	5.7	15.7
Desiree						
T1	4.0	7.0	9.0	4.0	7.1	9.1
T2	6.0 (+50%)	4.4	6.0	6.8 (+70%)	4.9	6.3
T3	4.0	4.8 (-31%)	7.0	4.1	5.2 (-27%)	7.1
T4	4.1	6.9	9.0	4.2	7.2	9.2 (-1%)
Mean	4.5	5.8	7.8	4.8	6.1	7.9
Mean Values of Treatments						
T1	2.0	7.1	14.3	1.8	7.3	15.0
T2	3.0 (+52%)	5.1	9.2	3.5 (+79%)	5.3	9.6
T3	1.8	5.3 (-24%)	11.8	1.8	5.8 (-20%)	12.1
T4	1.8	7.0	13.3 (-6%)	1.9	7.3	13.7 (-7%)
CD at 5%						
Cultivar(C)	0.103	0.262	0.47	0.12	0.267	0.46
Treatment (T)	0.06	0.20	0.43	0.08	0.20	0.42
C × T	0.1	0.4	0.9	NS	0.4	0.8

***Treatments:** T1 = Control (well watered), T2 = water stress at tuber initiation, T3 = water stress at tuber enlargement and T4 = water stress at tuber maturation stage

****Growth stages:** TI = Tuber initiation, TE = Tuber enlargement and TM = Tuber maturation

*****Figures in parenthesis are percent (%)** change in number of tubers due to water stress treatment T2, T3 and T4 as compared with respective control

Discussion

An interesting finding was observed in number of tubers at different growth stages. Water stress imposed at tuber initiation stage (T2) caused 50% to 80% increase in number of tubers (Table 1) whereas tuber number was reduced when water stress was imposed at tuber enlargement and tuber maturity stages. Increase in number of

tubers due to water stress at tuber initiation stage can be explained on the basis of assimilate partitioning to tubers. Timing of water stress relative to tuber initiation is critical in determining patterns of assimilate partitioning. Water stress early in the season (during stolon formation) reduces the number of stolons and subsequent initiation of tubers [1, 11]. Thus, severe and prolonged stress from early in the

season constrains tuber formation causing assimilate to be partitioned to other organs. However, water stress imposed after stolon formation i.e. at the time of tuber initiation stage promoted the tuber initiation due to enhanced assimilate partitioning, consequently the number of tubers were increased at tuber initiation stage (Table 1). [2] also found that root and shoot growths are strongly affected by partitioning of dry matter to tubers during an early phase of tuber bulking.

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