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Research Opinion

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Protected cultivation in India: challenges and strategies

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ABSTRACT

Horticultural crop production is highly dependent on environment, and it is very difficult to get favourable climatic conditions for optimum crop growth and development along with protection against major biotic and abiotic stresses as per the crop requirements under open field conditions. The protected cultivation, also known as Controlled Environment Agriculture (CEA) or Modified Environment Agriculture (MEA) involves a series of techniques for modification of the natural environment around plants or crops, which totally or partially alter the microclimatic conditions, with the basic aims of improving their productivity, quality and their protection against major biotic and abiotic stresses.

Key Words: Protected cultivation, Abiotic stresses, Biotic stresses, Climatic condition, Modified environment

Protected cultivation in India was adopted from the western countries, and the initial structures made were mostly copy of the western models. The adopted design resulted in negligible profits, most of the enterprises across the nation failed due to lack of the understanding required for designs required as per the Indian conditions. The only success attained was in specific locations like Pune and Bangalore having mild climates which favoured the crop growth. Therefore, protected cultivation was more concentrated in these areas restricted to cultivation of only cut flowers (gerbera, carnation and Dutch roses) and Capsicum. These products were new in the Indian market and farmers used to get premium price, and no need was felt to take the risk to test performance of other crops (Singh *et al*., 2013b). Till the tail end of the 20th century, Maharashtra and Karnataka were the leaders in protected cultivation.

PROTECTED CULTIVATION IN INDIA

Although protected cultivation has an old history in India but practical application of protected cultivation in horticultural crops came into the picture only after 1990s. Time line of events happened in adoption of protected cultivation in India are:

- The first glasshouse made for growing flowers by Sultan Hyder Ali in Lal Bag, Bangalore, in 1760, as per the London's Crystal Palace Model
- Indo-American Hybrid Seeds Company (IAHS), Bangalore, was the first in the country to grow successful flower crops in greenhouses for seed production in 1966
- The IAHS developed the first hybrids of tomato and Capsicum in India and used their protected structures for seed production in 1973
- The Government of India gave support to establish several polyhouses at Bangalore, Pune, Hyderabad and Delhi in private sector and a few in other government agencies, i.e. Defence Agricultural Research Laboratory, Pithoragarh and DRDO, Chamoli, in 1990 for producing Capsicum, tomato, peas, brinjal etc.
- A pioneer starting in the country occurred by the launching of collaborative Indo-Israel Project on R & D in Hi-Tech Horticulture at IARI, New Delhi, in 1998
- Establishment of Centre for Protected Cultivation Technology (CPCT) at IARI, New Delhi, by renaming the Indo-Israel Project, simultaneously establishment of Horticulture Training Centre, Pune.The R & D work also started at College of Agriculture, Pune, under MPKV, Rahuri, and in other SAUs and allied agencies during 2000-2004
- Establishment of Centre of Excellence in various states; Research Centre/Programmes started at SAUs and various ICAR institutes, after 2005.

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PROTECTED CULTIVATION: INITIATIVES AND CONSTRAINTS

Initial research and developmental activities started in mid-1980s at IARI, New Delhi. But only modified designs suitable for northern plains for peak winter season were developed. In 1998, a pioneer starting of collaborative Indo-Israel Project on R & D in Hi-Tech Horticulture at IARI, New Delhi, helped to create a model infrastructural facility for various kinds of protected structures in 1.5 ha, this also made us to understand the research need as per the Indian conditions on commercial horticulture. After the end of the project, it was renamed as 'Centre for Protected Cultivation Technology (CPCT)'. The CPCT has now developed standardized permanent and temporary structures suiting different agroclimatic conditions to take up high scale commercial vegetable and flower cultivation in India and also identified potential areas for protected cultivation. Simultaneously, research on protected cultivation also started in a few State Agricultural Universities and in other Government agencies.

Popularity of protected cultivation in India came only after the launch of subsidy-based Government schemes in VIII and XI Plan during late 1990s and early years of 21st century. Plasticulture scheme launched in VIII Plan with earmarked amount of around ₹ 2.20 million helped in promotion of protected/greenhouse cultivation. National Horticulture Board also provided soft loans for export-oriented units for floriculture projects mostly around Bangalore and Pune. Under DAC scheme, nearly 400 ha area was developed under greenhouses in Leh and Laddakh, Maharashtra, Madhya Pradesh, Karnataka, Kerala and the North-Eastern states. In XI plan, naturally- ventilated greenhouses were also given preference. In 1999, a FAO assisted project entitled 'Greenhouse Floriculture Technology for Small-Scale Farmers' to demonstrate the simple cost-effective greenhouse technology to small-scale traditional flower growers, especifically for women was launched for Bangalore (Karnataka), Pune (Maharashtra) and Srinagar (Jammu and Kashmir). Under X Plan, 10,247 greenhouses of both 500 and 100 m^2 size and 13 Model Floriculture Centres were created in North- Eastern and Himalayan states. To an extent good efforts were also made under World Bank funded Projects like NATP and NAIP in strengthening research and development on protected cultivation.

In the XI Plan period, protected cultivation got a boost in the north Indian plains, with the concerted efforts under Government schemes and R & D support of CPCT, IARI, New Delhi, and other public sector agencies/institutions. Designs are being modified as per the requirements and crops and varieties are also being identified which can be raised well under protected conditions. But even after concerted efforts the national coverage of area under protected cultivation has only increased hardly up to 40,000 ha, which includes the use of plastic mulching, plastic low tunnels, walk-in-tunnels, insect-proof net houses, shade net houses, small- sized polyhouses, naturally-ventilated greenhouses, semi-climate controlled greenhouses having pad- and fan-system and climate-controlled greenhouses (at research institutions) have shown some impact in the country in recent years (Singh *et al*., 2012) which is summarized as under:

- Protected cultivation has now gained success in Maharashtra, Karnataka, North-East and Himalayan regions, Chhattisgarh, Odisha, tribal areas of Jharkhand, Punjab, and Haryana, and is increasing day- by- day in other regions. Mainly due to government promotional schemes and up to some extent by proper consultation of type of protected structures needed and crop to be grown
- The intervention of raised bed, drip fertigation along with plastic mulching is the key factor for success of protected vegetable cultivation in parts of Chhattisgarh, Jharkhand and adjoining belts under open fields.
- Low-cost temporary structures, like plastic low tunnels have proven rewarding in raising off-season vegetables in some parts of Haryana and Punjab.
- Naturally-ventilated greenhouses are most successful for growing cut flowers and vegetables in and around Bangalore, Himachal Pradesh, Uttarakhand, Jharkhand, Odisha, North-East region and other parts
- Plug tray nursery raising technology is now a huge business in the form of small-scale industries in and around Bangalore for supply of planting material of vegetables in the country
- Insect- proof net houses proved best to raise virus-free commercial vegetable crops, papaya and banana cultivation in southern parts, northern plains and several other parts of the country
- Shade nets equipped with foggers got huge success in North East regions to grow anturium and other flower crops
- Adoption of small polyhouses in temperate hilly tracks of Himachal Pradesh, Uttarakhand and Jammu and Kashmir for growing vegetables and flowers proved beneficial
- Initial adoption of protected cultivation under small areas are now getting expanded in the from of high scale commercial farms in many parts of the country.

Challenges

The Indian sub-continent has diverse agro-

ecological conditions and with respect to the changing climatic conditions and growing population. Huge changes have happened over the time in the farming systems of the country. We are far behind the developed nations in terms of productivity and quality of food we produce. Still, there is a lot to happen. Protected cultivation has changed the entire scenario across the world; China, the leading country in the world in protected cultivation, has understood the advantages of protected cultivation in horticultural crops and more specifically in commercial vegetable cultivation and their hybrid seed production, which has transformed agriculture into hi-tech enterprise. India can also visualise to become one of the major players in protected horticulture but there are numerous challenges (Singh *et al*., 2013a) before us to give a new line to national agricultural scenario:

- Lack of trained and skilled manpower for various areas, viz. fabrication, maintenance and renovation of protected structures.
- Proper guidance about region-specific designs of various protected structures.
- Fabrication of protected structure has come up as a big business, taking an opportunity that small industries are sacrificing with the quality of material to be used to gain more profit and also lack of understanding of the quality of basic steel and cladding materials used for fabrication of structures.
- These industries are also promoting similar designs of greenhouses and other protected structures irrespective of the climatic region needs. Most of the firms are fabricating the greenhouses with very poor ventilation specifically under semi-arid and arid conditions.
- A few of the firms are even fabricating the structures with the use of MS pipes and instead of using strong nut and bolt systems they are using welding as a tool for erecting the structures by sacrificing with the strength and life of the structures.
- The top and side ventilation screens are not of proper quality and mesh size which is the major cause for entry of several insect and pests inside the structures which ultimately creates high level of virus infestation in crops even under protected cultivation.
- In most of the structures, the entry gate is single door which does not provide proper protection against entry of insects and pests, rather it should be double door by leaving appropriate free space (waiting area) in between both the doors.
- In several states in fabrication of insect-proof net houses all side walls are erected with the use of insect-proof nets but the roof is covered with shade nets rather using the same insect-proof net, this reduces the light availability to the crop through the cropping season and also provides sufficient space for entry of different sucking pests inside the structures.
- Improper guidance and low availability of crop varieties and planting material specific to protected cultivation, its management practices etc. even the available planting material/seeds are too costly.
- For promotion of protected cultivation, the installing agencies are advising crops irrespective of climatic conditions suitable and even they bluff high to farmers showing huge gain in the crop which they are advising.
- Lack of demand driven cultivation without proper marketing strategy creates problem for proper disposal of high quality produce and farmers cannot get low premium price, therefore cluster approach for taking up protected cultivation as a whole is required.

Strategies

- Large-scale motivation and training of educated unemployed youths in various areas of protected cultivation.
- Government support must be extended for self-fabrication mode of temporary low-cost protected structures like insect-proof net houses, shade net houses, walk-in-tunnels and plastic low tunnels for large-scale production of vegetables and flowers.
- Large- scale production and distribution of healthy vegetable and flower seedlings to growers on nominal price.
- Government should support and promote protected cultivation in cluster approach, especially in peri-urban areas of the country.
- Government should promote to develop input hubs for protected cultivation in multilocations in PPP mode.
- The major ITIs in the country located in every state should have an integrated diploma course on designing, fabrication and maintenance of protected structures.
- The major SAUs located in various states should have an integrated diploma/degree course on production and management aspects of protected cultivation.
- Protected cultivation has hitherto been promoted from the view point of more and more construction of greenhouses by providing subsidy, however, there is a need to link such subsidies with production system, i.e. when protected cultivation produce is sold/auctioned by grower some of the subsidy may be realized to him at this level incentive as on.

- All the protected cultivation clusters must be mandatorily clubbed with rain water harvesting infrastructural facilities in various regions of the country.
- Most suitable crop sequences for different protected structures and seasons based on research data should be suggested.
- Large-scale promotion of low pressure drip irrigation system for low-cost small-scale protected cultivation in hilly states and plains, and for small farmers for open field vegetable and flower cultivation.
- Large-scale use of different reflective plastic mulches for different seasons clubbed with raised beds and drip fertigation system for vegetable and flower production under open field conditions and also to discourage expensive surface irrigation in various horticultural crops.
- Promotion of large-scale mechanization in vegetable and flower cultivation by using raised bed makers, plastic laying machines, plastic low tunnel making machines, pipe bending machines for making walk-in-tunnels, drip lateral laying and binding machines.
- To establish convergence and synergy among various ongoing and planned government programmes in the field of protected cultivation development.
- To ensure adequate, appropriate, time bound and concurrent attention to all links in production under protected conditions, post production on-farm value addition, processing and consumption chain.
- Use of solar energy for running pumps or drip system and up to some extent for running heating and cooling devices of the protected structures.

Looking to the increasing population, climate change, decreasing land holding, increasing pressure on natural resources (land and water) and high demand of quality horticultural fresh produce, we are forced to shift towards protected cultivation like China. As China started protected cultivation in mid 1990s along with India but today they are the world leader in vegetable production by converting around 3.4 million ha area under protected cultivation. Of which, around 95 % area is only under vegetable cultivation and hybrid seed production of vegetables. This shows the real potential of hi-tech technology, but a proper approach is needed to convert maximum area of the present 9.0 million ha under vegetables for increasing the national productivity. Similarly, this can be replicated for flowers, fruits and other suitable crops.

Promotion of protected cultivation will help in creation of huge self-employment for unemployed educated youths and will also raise the national economy by sale of high quality produce in domestic and international markets. Under the new era of FDI (Foreign Direct Investment) in retail, these kinds of models posses high potential for enhancing the income of farmers opting for quality and off-season vegetable and cut flower cultivation through protected cultivation. Production of vegetable and cut flower crops under protected conditions provides high water and nutrient-use efficiency under varied agroclimatic conditions of the country.

This technology has very good potential, especially in peri-urban areas adjoining to the major cities which is a fast growing market of country, since it can be profitably used for growing high-value vegetable crops like, tomato, cherry tomato, colour peppers, parthenocarpic cucumber, cut flowers like rose, gerbera, carnation, chrysanthemum etc. and virus-free seedlings in agri-entrepreneurial models. But protected cultivation technology requires careful planning, attention and details about timing of production and moreover, harvest time to coincide with high market prices, choice of varieties adopted to off-season environments, and able to produce economical yields of high quality produce etc.

Even though the application of chemicals for controlling biotic stresses is also low under protected structures which gives a high quality safe vegetables for human consumption. By using protected structures, it is also possible to raise off-season and long duration vegetable crops of high quality. Vegetable and cut flower farming in agri-entrepreneurial models targeting various niche markets of the big cities is inviting regular attention of the vegetable and flower growers for diversification from traditional ways of crop cultivation to the modern methods of crop production.

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Self- and cross-incompatibility relationship in rose (*Rosa hybrida*) varieties

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ABSTRACT

An experiment was conducted to find out the self-and cross-incompatibility relationship among varieties of rose (*Rosa hybrida* L.) during 2012-13 at the Research Farm of Division of Floriculture and Landscaping, Indian Agricultural Research Institute, New Delhi. The compatibility relationships among varieties help in designing the hybridization programme in roses efficiently. Self- and cross- incompatibility were widely prevalent in varieties of rose making the hybridization programme challenging. Among the 57 varieties studied, 12 were self-incompatible, while 30 were cross- incompatible. These cross- incompatible varieties cannot be used in breeding programme. It is recommended to use the 25 varieties (Delhi Princess, Dr Benjamin Pal, Soma, Pusa Pitamber, Pusa Abhishek, Sugandha, Jawani, Dr Bharat Ram, Mridula, Jantar Mantar, Dr S S Bhatnagar, Suchitra, Pusa Komal, Surabhi, Sadabahar, Shreyasi, Priyadarshini, Mrinalini, Mother Teresa, Arjun, Pink Montezuma, Pink Parfait, Shola, Homage and Raktima) that were cross-compatible in the breeding programme. Out of these varieties, 24 exhibited self- and cross-compatibility, while 9 were both self- and cross- incompatible.

Key Words: Gametophytic, Cross-incompatibility, Rose, Self- incompatibility, Varieties, Xenogamy

Rose (*Rosa hybrida* L.) is universally acclaimed as 'Queen of Flowers'. It occupies first position in the international trade. Rose is one of the most economically important ornamental species used as cut flower, potted and landscape plant in the world. Pollination in *Rosa* spp. and varieties has not been well studied experimentally (Mac Phail, 2007). The main mode of reproduction in this genus has been thought to be xenogamy, perhaps through operation of incompatibility systems (Ueda and Akimoto, 2001). There is also high variability in fruit and seed production within and between varieties. The most common way by which plants can avoid self- fertilization is through a physiological barrier, defined as self- incompatibility or the inability of a fertile hermaphrodite seed plant to produce zygotes after self-pollination (Barrett, 2003). Gametophytic incompatibility mechanisms, in which self- incompatibility phenotype of pollen-grains is determined by its own genotype, are well known in Rosaceae, including the genus Rosa (Barrett, 2003). Cross- and self-compatibility relationships are important for commercial hybridization in rose because commercial cultivars are highly inbred and often have low fertility (Shahare and Shastry, 1963; Zlesak, 2006). However, not all combinations in crossings are successful. The ways in which chromosomes pair and divide in meiosis may preclude fertility (Shahare and Shastry 1963; Jicinska 1976; Kevan, 2003). There is very little information on the self- and cross- incompatibility relationships of different varieties of rose. Therefore, an experiment was conducted to find out the self- and cross- incompatibility patterns in different varieties of rose.

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MATERIALS AND METHODS

The experiment was conducted during 2012-13 at the Research Farm of Division of Floriculture and Landscaping, Indian Agricultural Research Institute, New Delhi. The farm is situated at 77° 12 'E longitude, 28° 40' N latitude and an altitude of 228.16 m above mean sea-level. The climate is semi-arid, subtropical with hot summers and cold winters. The self- pollination was facilitated in varieties by bagging the flowers with butter paper bags from which corolla was removed. Five flowers were bagged for this purpose. The hip formation was observed a month later. The open- pollinated hip set was observed in all the varieties. The final hip set was observed during July-August.

RESULTS AND DISCUSSION

Of the 57 varieties studied, 12 varieties, viz. Ranjana, Deepak, Lalima, Prema, Dr B P Pal, Raja Surendra Singh of Nalagarh, Folklore, Pinata, Pusa Muskan,

Table 1. Hip set under selfing and open-pollination in rose varieties

Variety	No. of flowers self-pollinated	No. of hips set	Set in selfing (%)	Setter under open pollination
Delhi Princess	5	5	100	Yes
Dr S. S. Bhatnagar	5	5	100	Yes
Pink Parfait	5	5	100	Yes
Jadis	5	5	100	Yes
Surabhi	5	3	60	Yes
Priyadarshani	5	3	60	Yes
Mother Teresa	5	3	60	Yes
Surekha	5	3	60	No
Dr Benjamin Pal	5	2	40	Yes
Pusa Pitamber	5	2	40	Yes
Pusa Mohit	5	2	40	Yes
Dr Bharat Ram	5	2	40	Yes
Jantar Mantar	5	2	40	Yes
Suchitra	5	2	40	Yes
Pusa Komal	5	2	40	Yes
Sadabahar	5	2	40	Yes
Shreyasi	5	2	40	Yes
Pusa Gaurav	5	2	40	No
Pusa Garima	5	2	40	No
Raktagandha	5	2	40	No
Raja Ram Mohan Roy	5	2	40	No
Pusa Bahadur	5	2	40	No
Maharani	5	2	40	No
Krishna	5	2	40	No
Sailoz Mookherjea	5	2	40	No
Ganga	5	2	40	No
Soma	5	1	20	Yes
Pusa Abhisek	5	1	20	Yes
Sugandha	5	1	20	Yes
Jawani	5	1	20	Yes
Mridula	5	1	20	Yes
Mrinalini	5	1	20	Yes
Arjun	5	1	20	Yes
Pink Montezuma	5	1	20	Yes
Pusa Urmil	5	1	20	No
Dr M. S. Randhawa	5	1	20	No
Haseena	5	1	20	No
Pusa Priya	5	1	20	No
Suryakiran	5	1	20	No
Delhi Brightness	5	1	20	No
Pusa Arun	5	1	20	No
Sahasardhara	5	1	20	No
Abhisarika	5	1	20	No
Pusa Shatabdi	5	1	20	No
Surkhab	5	1	20	No
Shola	5	0	0	Yes
Homage	5	0	0	Yes
Raktima	5	0	0	Yes
Ranjana	5	0	0	No
Deepak	5	0	0	No
Lalima	5	0	0	No
Dr B. P. Pal	5	0	0	No
Prema	5	0	0	No
Raja Surendra Singh of Nalagarh	5	0	0	No
Folklore	5	0	0	No
Pinata	5	0	0	No
Pusa Muskan	5	0	0	No

Shola, Homage and Raktima were self- incompatible. The varieties, Shola, Homage and Raktima, were self-incompatible but cross-compatible(Table1). The varieties, Ranjana, Deepak, lalima, Prema, Dr B P Pal, Raja Surendra Singh of Nalagarh, Folklore, Pinata and Pusa Muskan were self- and cross- incompatible. The varieties, Delhi Princess, Dr Benjamin Pal, Soma, Pusa Pitamber, Pusa Mohit, Pusa Abhishek, Sugandha, Jawani, Dr Bharat Ram, Mridula, Jantar Mantar, Dr S S Bhatnagar, Suchitra, Pusa Komal, Surabhi, Sadabahar, Shreyasi, Priyadarshini, Mrinalini, Mother Teresa, Arjun, Pink Montezuma, Pink Parfait and Jadis were both self- and cross-compatible. The varieties, Pusa Urmil, Pusa Gaurav, Surekha, Pusa Garima, Raktagandha, Raja Ram Mohan Roy, Dr M S Randhawa, Haseena, Pusa Bahadur, Maharani, Pusa Priya, Suryakiran, Delhi Brightness, Krishna, Pusa Arun, Sahasradhara, Sailoz Mookherjea, Abhisarika, Ganga, Pusa Shatabdi and Surkhab were self- compatible but cross- incompatible. Majority of varieties were self- compatible (45 out of 57 varieties studied). Thirty varieties were cross-incompatible. Delhi Princess, Dr S S Bhatnagar, Pink Parfait and Jadis have shown 100% hip set on selfing.

In rose, studies on cross- and self-incompatibility have been conducted several times and self-incompatibility in diploid genotypes was frequently observed (Ueda and Akimoto, 2001). Some roses were essentially self- incompatible, but the incompatibility system may be overcome as the flower ages or if it is exposed to higher temperatures (Gudin, 2000; Zlesak, 2006). Low fertility of self- pollination is assumed to be caused by self- incompatibility in rose species (Cole and Melton, 1986; Ueda and Akimoto, 1996). The breakdown of self- incompatibility is at a higher ploidy level in the genus Rosa (Cole and Melton, 1986). Self-pollination appears to be more common at higher ploidy levels, possibly reflecting reduced influence of incompatibility genes and the competitive interaction of S-alleles in diploid and tetraploid pollen (Cole and Melton, 1986; Debener and Mattiesch, 1999; Ueda and Akimoto, 2001; Spethmann and Feuerhahn, 2003).

Delhi Princess, Dr Benjamin Pal, Soma, Pusa Pitamber, Pusa Mohit, Pusa Abhishek, Sugandha,

Jawani, Dr Bharat Ram, Mridula, Jantar Mantar, Dr S S Bhatnagar, Suchitra, Pusa Komal, Surabhi, Sadabahar, Shreyasi, Priyadarshini, Mrinalini, Mother Teresa, Arjun, Pink Montezuma, Pink Parfait and Jadis were self- and cross- compatible. Ranjana, Deepak, Lalima, Prema, Dr B P Pal, Raja Surendra Singh of Nalagarh, Folklore, Pinata and Pusa Muskan were self- and cross-incompatible.Of the varieties, Shola, Homage and Raktima were self- incompatible and cross-compatible.Varieties which were self- compatible but cross- incompatible were:Pusa Urmil, Pusa Gaurav, Surekha, Pusa Garima, Raktagandha, Raja Ram Mohan Roy, Dr M S Randhawa, Haseena, Pusa Bahadur, Maharani, Pusa Priya, Suryakiran, Delhi Brightness, Krishna, Pusa Arun, Sahasradhara, Sailoz Mookherjea, Abhisarika, Ganga, Pusa Shatabdi and Surkhab.

The cross- incompatible varieties cannot be used in breeding programme. Therfore, it is recommended to use the 25 varieties (Delhi Princess, Dr Benjamin Pal, Soma, Pusa Pitamber, Pusa Abhishek, Sugandha, Jawani, Dr Bharat Ram, Mridula, Jantar Mantar, Dr S S Bhatnagar, Suchitra, Pusa Komal, Surabhi, Sadabahar, Shreyasi, Priyadarshini, Mrinalini, Mother Teresa, Arjun, Pink Montezuma, Pink Parfait, Shola, Homage and Raktima) which were cross-compatible in the breeding programme.

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Combining ability analysis in okra (*Abelmoschus esculenta*)

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ABSTRACT

An experiment was conducted to analyse the combining ability effect on okra [*Abelmoschus esculenta* (L.) Moench] during the *zaid* season of 2012 at the Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. All the homozygous parents were sown and maintained by applying the standardized cultural practices. All the morphological characters of the landraces were studied. The experiment was conducted with 21 F_1s and F_2s developed through diallel hybridization technique excluding reciprocals along with seven parents in a randomized block design with three replications. Okra varieties, KS-387, FB-10 and Azad Krishna, showed good general combining ability(GCA) for yield which appeared to be worthy for exploitation in future hybrid development. It was recommended that the population involving these lines may be developed through multiple crossing isolating high-yielding varieties. The specific combining ability (SCA) effects indicated that choice of parents could be based on the *per se* performance. The selection in okra crop can be based on the combination of two characters, i e length of first fruiting node with length of fruit and length of fruit with width of fruit, and number of fruits/ plant for higher yield over straight selection. The cross combinations of KS-401 × Azad Krishna showed high SCA effects as well as *per se* performance in F_1 and F_2 generations.

Key Words: Analysis of variance, General combining ability, Specific combining ability, Diallel cross

India is the largest producer of okra [*Abelmoschus esculenta* (L.) Moench] in the world with a total area of 0.43 million ha and production of 4.53 million tonnes (70% of the total world production) of green pods, whereas its productivity is 10.5 tonnes/ha (FAO STAT 2009). Among vegetables, contribution of rainy and summer season cultivated okra is 5.4 % in area and 3.5 % share in total production (NHB, 2009; Solankey *et al.*, 2013). It is predominantly a self-fertilized crop but there is natural crossing of 6.75% (Purewal and Randhawa, 1947). It is an interesting crop to breeders and the geneticists, owing to its monoadelphous condition of the stamens and large flowers which are amenable to easy emasculation. Morever, its capsule bears a large number of seeds. The combining ability refers to the ability of a genotype to transient superior performance to its ceases, the GCA variance provides and estimate to additive genetic variance, which is required for the estimation of narrow sense heritability (Sanwal *et al.*, 2012). It also provides information about the gene action involved in the expression of various quantitative characters and thus, helps in deciding the breeding procedure for genetic improvement of such traits (Koundinya *et al.*, 2013).

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MATERIALS AND METHODS

The materials for the experiment comprised seven genotypes of okra, *viz.* KS-312, KS-387, KS-401, Fb-10, KS410, Parbhani Kranti and Azad Krishna, collected from the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh). The collected germplasm stock maintained at the Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, for standardized cultural practices to keep the crop in a good condition. All the homozygous parents were sown during the *zaid* season. All the possible 21 F_1 crosses, excluding reciprocals were made among these seven parents. For building up of the F_2 population of these F_1 crosses, all the 21 F_1s were sown during the next *kharif* season. All these F_1s were selfed for procuring the F_2 seeds. The parents were also maintained through selfing.

All the 21 F_1s and F_2s along with seven parents were sown in a randomized block design with three replications during *kharif* season. The parents and F_1s were sown in single rows, while F_2s in double rows,

with 10 plants in each row. The rows were 5 m long and spaced 50 cm apart. The plant- to- plant spacing was maintained at 50 cm. The observations were recorded on randomly selected five plants in each parent and F_1, and 10 plants in each F_2 population from each replication. The selected plants were tagged and properly labelled before flowering for recording the data on days to flowering, plant height, number of branches/plant, length of first fruiting node, length of fruit, width of fruit, number of fruits/plant and yield/ plant. The combining ability analysis was carried out as per the procedure (Griffing, 1956). The experimental Method-II and Model-I (Robinson 1966; Robinson 1965) was taken to be the most appropriate for the material under study.

RESULTS AND DISCUSSION

All the diverse genotypes of okra, viz. KS-312, KS-387, KS-401, Fb-10, KS410, Parbhani Kranti and Azad Krishna, were grown by following standardized cultural practices. The data were recorded on days to flowering, plant height, number of branches/plant, length of first fruiting node, length of fruit, width of fruit, number of fruits/plant and yield/plant.The analysis of variance for combining ability was carried out separately for all the eight attributes in F_1 and F_2 generations and the results are presented in Table 1. Highly significant variances were observed for general and specific combining ability both in F_1 and F_2 generations for all the characters except width of fruit. However, relative magnitude of GCA variance indicating thereby that the additive component was important in the expression of all the characters in each generation except width of fruit in F_2 which was found to be under the control of equal proportion of genes. These findings are in agreement with those of Kulkarni *et al*. (1976) and Singh *et al.* (2001) for number of fruits/ plant and Rao and Sathyavathi (1977) for days to flower and yield under such situation where both additive and non- additive, maximum production may be attained with a system that can exploit additive and non-additive genetic effects simultaneously.

The compression of GCA effects with mean performance revealed that parents, KS-312 for days to flower; Azad Krishna for plant height; FB-10 for number of branches/plant; KS-387, Parbhani Kranti and KS-312 for length of first fruiting node; FB-10 for fruit length; Azad Krishna for width of fruit; KS-387 for number of fruits/ plant and KS-387, FB-10 and Azad Krishna for yield/ plant were common under both the criteria (Table 2), indicating a correspondence between GCA in both F_1 and F_2 generations and *per se* performance of the parents. The similar findings were observed by Kulkarni *et al.* (1976). Consistent GCA effects over F_1 and F_2 may prove advantageous while evaluating varieties for combining ability. Bhullar *et al.* (1981) suggested that the grass might be studied for combining ability in F_2 instead of F_1 when the objectives are to breed pure varieties.

However, this suggestion still needs substantiation before it could be adopted for practical utilization. Further varieties showing good, particular component may be used in component breeding for bringing improvement in a particular component, thereby effecting improvement in yield. Varieties, KS-387, FB-10 and Azad Krishna, showing good GCA for yield appear to be worthy for exploitation in practical plant breeding. It is suggested that population involving these lines

Table 1. Analysis of variance for combining ability for eight characters in seven-parent diallel cross of F_1 and F_2 generations in okra

Source of variation	Generation	d. f.	Mean sum of squares for different characters							
			Days to flowering	Plant height(cm)	No. of braches/ plant	First fruiting node length	Fruit length	Fruit width	No. of fruits/ plant	Yield/ plant
GCA	F_1	6	21.999**	555.088**	0.988**	20.025**	6.150**	0.011	11.000**	2206.433**
	F_2	6	18.554**	290.668**	0.440**	31.066**	7.275**	0.006	08.023**	20.695**
SCA	F_1	20	07.847**	199.773**	0.499**	07.033**	1.998**	0.008	05.478**	1199.995**
	F_2	20	04.558**	190.105**	0.355**	9.994**	1.888**	0.005	03.456**	711.228**
Error	F_1	52	0.888	7.964	0.089	0.850	0.299	0.005	0.278	19.889
	F_2	52	0.822	3.200	0.060	0.555	0.270	0.003	0.215	12.775
GCNSCA	F_1	-	3.025	2.882	2.000	2895	2.999	1.455	1.999	1.793
	F_2	-	4.288	1.569	1.663	3.000	3.998	0.716	2.486	2.968

**Significant at 1% level.

Table 2. Ranking of the best parents for general combining ability effects and *per se* performance for character under 7×7 parental diallel mating design in okra

Character	*Perse* perfor-mance	GCA effects F_1	F_2	Common parent
Days to flowering	KS-312 KS-387 KS-410	KS-312 A. Krishna FB-10	KS-312 KS-387	KS-312
Plant height	A.Krishna KS-401 FB-10	A.Krishna KS-387 KS-387	A.Krishna FB-10	A.Krishna
No. of branches/ plant	FB-10 P. Kranti KS-312	FB-10 KS-387	FB-10	FB-10
First fruit node length	KS-387 P. Kranti KS-312	KS-387 P. Kranti KS-312	P. Kranti KS-387 KS-312	KS-387 P. Kranti KS-312
Fruit length	FB-10 A. Krishna	FB-10 A. Krishna	FB-10 KS-401	FB-10 KS-401
Fruit width	A.Krishna FB-10 KS-410	A.Krishna - -	A.Krishna -	A.Krishna .
No. of fruits/ plant	KS-387 KS-312 A.Krishna	KS-387 - - - -	A.Krishna KS-387 KS-312	KS-387
Fruit yield/ plant	KS-387 FB-10 A.Krishna	KS-387 A. Krishna FB-10	A.Krishna KS-387 FB-10	KS-387 FB-10 A.Krishna

A, Azad; P., Prabhani

may be developed through multiple crossing isolating high-yielding varieties. Similar results were observed by Kulkarni *et al.* (1976), Singh *et al.* (2001), and Shekhawat *et al.* (2005).The SCA effects represent dominance and epistemic component of variation, which are non-fixable, and hence SCA studies would not contribute to the improvement in self-pollinated crops except in cases where commercial exploitation of heterosis is feasible. However, in the production of homozygous lines, breeders' interest usually rests upon transgressive.

The SCA effects and *per se* performance of crosses are presented in Table 3. To confirm whether the crosses selected on the basis of SCA effects were really the best performer ones, the bests three crosses on the basis of mean performance and SCA effects were selected. It was observed that in F_1 out of three best crosses KS-410 × Azad Krishna for days to flowering; FB-10, Azad Krishna for plant height, KS-401 × Azad Krishna for number of branches/ plant; KS-387 × FB-10 for length of first fruiting node; KS-401 × Azad Krishna for fruit length; KS-312 × Parbhani Kranti for width of fruit; FB-10 × Azad Krishna for number of fruits/plant and KS-401 × Azad Krishna for yield/plant also showed high SCA effects as well as *per se* performance. The crosses are showing high SCA effects and *per se* performance for yield/plant suggested that these hybrids may be exploited in heterosis breeding programme. These findings are in agreement with those of Rao and Ramu (1978) and Singh *et al.* (2001).

In F_2 out of five best crosses, Parbhani Kranti × Azad Krishna for days to flowering; KS-401 × FB-10 for plant height; KS-401 × FB-10 for number of branches/ plant; FB-10 × Azad Krishna for length of first fruiting node; KS-387 × FB-10 for length of fruit; Parbhani Kranti × Azad Krishna for width of fruit, number of fruits/ plant and yield/plant showed high SCA effects and good *per s*e performance. Similar findings were observed by Bhullar *et al.* (1981), Singh *et al*. (2001) and Shekhawat *et al*. (2005).

It is a general observation that good cross combinations are obtained between high × high and poor ones between low × low general combiners in present study. Best cross combinations involved high × high, high × low, high × moderate, moderate × moderate, moderate × low and low × low general combiners for the characters under study (Table 4). This has suggested that good cross combinations be not always obtained between high general combiners. Shekhawat *et al.* (2005) also found crossed with SCA effects emanating from low × low general combiners.

The crosses showing high SCA involved both parents, which were good general combiners. They could be exploited in breeding. In case, the crosses showing high SCA involved one good combiner and other moderate combiner, such a combination may through up desirable transgressive segregates, if the additive genetic system is present in good combiner and complementary epistatic effect if present in the cross, act in the same direction so as to maximize the desirable plant attributes. Breeding for homozygous lines by routine pedigree method could mean only partial exploitation of additive genetic variance, in order to exploit different types of gene actions in a population. It is suggested that a breeding procedure which may accumulate the fixable type of gene effects and at the same time maintains considerable heterozygosity for exploiting the dominance gene effects might prove most beneficial in improving the populations under study.

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Table 3. Best crosses on the basis of mean value and SCA effects for character under 7 × 7 parental diallel mating design in okra

Character	Best crosses on the basis of mean values	
	F_1	F_2
Days to flowering	KS-410 × Azad Krishna	P. Kranti × A. Krishna
	KS-312 × FB-10	KS-312 × KS-387
	KS-312 × KS-387	KS-312 × FB-10
Plant height	FB-10 × Azad Krishna	KS-401 × FB-10
	KS-387 × Azad Krishna	KS-410 × Azad Krishna
	KS-401 × Azad Krishna	KS-312 × KS-410
Number of branches/plant	KS-387 × Azad Krishna	KS-401 × FB-10
	KS-387 × Azad Krishna	KS-387 × KS-410
	KS-387 × Azad Krishna	KS-401 × Azad Krishna
Length of first fruiting node	KS-387 × FB-10	FB-10 × Azad Krishna
	KS-312 × KS-387	P. Kranti × Azad Krishna
	KS-312 × KS-410	KS-410 × Parbhani Kranti
Length of fruit	KS-401 × Azad Krishna	FB-10 × Azad Krishna
	FB-10 × Azad Krishna	KS-387 × Azad Krishna
	KS-401 × KS-410	KS-401 × KS 410
Width of fruit	KS-312 × Parbhani Kranti	P. Kranti × Azad Krishna
	KS-387 × Parbhani Kranti	KS-410 × Parbhani Kranti
	KS-387 × Azad Krishna	KS-410 × Azad Krishna
Number if fruits/plant	FB-10 × Azad Krishna	P. Kranti × Azad Krishna
	KS-401 × Azad Krishna	KS-312 × Azad Krishna
	KS-387 × KS-410	KS-410 × KS-387
Fruits yield/plant	KS-401 × Azad Krishna	P. Kranti × Azad Krishna
Days to flowering	FB-10 × KS-410	KS-312 × FB-10
	KS-401 × KS-410	KS-387 × FB-10
Days to flowering	KS-410 × Azad Krishna	P. Kranti × Azad Krishna
	KS-312 × FB-10	KS-401 × Prabhani Kranti
	KS-312 × KS-387	FB-10 × Prabhani Kranti
Plant height	FB-10 × Azad Krishna	KS-401 × FB-10
	KS-410 × Prabhani Kranti	KS-312 × Prabhani Kranti
	KS-387 × Azad Krishna	KS-312 × KS-410
Number of branches/plant	KS-401 × Azad Krishna	KS-401 × FB-10
	KS-387 × Prabhani Kranti	KS-387 × KS-410
	FB-10 × Prabhani Kranti	FB-10 × Azad Krishna
Length of first fruiting node	KS-387 × FB-10	FB-10 × Azad Krishna
	P. Kranti × Azad Krishna	KS-312 × FB-10
	KS-312 × FB-10	P. Kranti × Azad Krishna
Length of fruit	KS-401 × Azad Krishna	KS-387 × FB-10
	KS-312 × KS-387	KS-312 × KS-410
	FB-10 × Azad Krishna	KS-401 × FB-10
Width of fruit	KS-312 × Prabhani Kranti	P. Kranti × Azad Krishna
	KS-312 × KS-410	KS-312 × FB-10
	P. Kranti × Azad Krishna	FB-10 × KS-410
Number of fruits/plant	FB-10 × Azad Krishna	P. Kranti × Azad Krishna
	KS-401 × Azad Krishna	KS-410 × Prabhani Kranti
	FB-10 × KS-410	KS-387 × Azad Krishna
Fruits yield/plant	KS-401 × Azad Krishna	P. Kranti × Azad Krishna
	KS-410 × Prabhani Kranti	KS-312 × FB-10
	KS-387 × Azad Krishna	KS-312 × KS-410

Table 4. Relationship of SCA of cross combinations with gca effect of the parents in okra

Character	Cross combinations with maximum SCA effect in F_1	GCA effect of parents
Days to flowering	KS-410 × Azad Krishna	Moderate × High
	KS-312 × FB-10	High × Low
	KS-312 × KS-387	High × Low
Plant height	FB-10 × Azad Krishna	Moderate × High
	KS-410 × Prabhani Kranti	Low × Low
	KS-387 × Azad Krishna	High × High
Number of branches/plant	KS-401 × Azad Krishna	High × Low
	KS-387 × Prabhani Kranti	High × Low
	FB-10 × Prabhani Kranti	High × Low
Length of first fruiting node	KS-387 × KS-410	High × Low
	P. Kranti × Azad Krishna	High × Low
	KS-312 × FB-10	High × Low
Length of fruit	KS-401 × Azad Krishna	Moderate × High
	KS-312 × KS-387	Low × Low
	FB-10 × Azad Krishna	High × High
Width of fruit	KS-312 × Parbhani Kranti	Low × Low
	KS-387 × KS-387	Low × Low
	P. Kranti × Azad Krishna	Low × Moderate
Number if fruits/plant	FB-10 × Azad Krishna	Low × Moderate
	KS-401 × Azad Krishna	Low × Moderate
	FB-10 × KS-410	Low × Low
Fruits yield/plant	KS-387 × KS-410	High × Moderate
	KS-401 × Azad Krishna	Low × High
	FB-10 × KS-410	High × Low
Days to flowering	P. Kranti × Azad Krishna	Moderate × Mode rage
	KS-401 × Prabhani Kranti	Low × Moderage
	FB-10 × Prabhani Kranti	Moderaw × Moderate
Plant height	KS-312 × Prabhani Kranti	Low × Low
	KS-401 × FB-10	Low × High
	KS-387 × Azad Krishna	Low × Low
Number of branches/plant	KS-401 × FB-10	Moderate × Low
	KS-387 × KS-410	Moderate × Low
	FB-10 × Prabhani Kranti	Low × Low
Length of first fruiting node	FB-10 × Azad Krishna	Low × Low
	KS-312 × FB-10	High × Low
	P. Kranti × Azad Krishna	High × Low
Length of fruit	KS-312 × KS-410	Low × Low
	KS-387 × FB-10	Low × Low
	KS-401 × FB-10	High × High
Width of fruit	P. Kranti × Azad Krishna	Moderate × High
	KS-312 × KS-410	Moderate × Moderate
	KS-387 × FB-10	Low × Low
Number if fruits/plant	P. Kranti × Azad Krishna	Low × High
	KS-410 × Prabhani Kranti	Low × Low
	KS-387 × Azad Krishna	High × High
Fruit yield/plant	P. Kranti × Azad Krishna	Low × High
	KS-312 × KS-401	Moderate × Low
	KS-312 × KS-410	Moderate × High

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Evaluation of gladiolus (*Gladiolus hybrida*) cultivars for flower and corm production under Pasighat (Arunachal Pradesh) condition

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ABSTRACT

Evaluation of gladiolus (*Gladiolus hybrida* L.) cultivars to identify the suitable variety for successful cultivation, flower and corm production under agroclimatic condition of Pasighat, East Siang district, Arunachal Pradesh, was carried out during winter season (November 2011 to February 2013). Ten varieties, Jester, Candyman, Poppy Tears, Summer Sunshine, Wedding Bouquet, Hunting Song, Pacifica, American Beauty, Red Ginger and White Prosperity, were selected for evaluation. Uniform size of gladiolus corms (3.00-4.00 cm diameter) were planted on raised beds. The experiment was laid out in a randomized block design with three replications. Uniform package of practices were followed throughout the experiment to grow a healthy crop. Significant response in vegetative, flowering and corm characters was observed in cultivar Candyman, followed by Poppy Tears, Red Ginger, Hunting Song, Wedding Bouquet, Pacifica and American Beauty. Sprouting of corms were advanced in cultivars Poppy Tears, Candyman, Summer Sunshine, Wedding Bouquet, Hunting Song and Pacifica, while delayed in cultivars Jester, American Beauty, Red Ginger and White Prosperity. Highest plant height (71.20cm) in cultivar Red Ginger, number of leaves/plant (10.67) in Candyman, length of leaf (53.67cm) in Pacifica, breadth of leaf (4.97cm) in Poppy Tears and number of tillers/plant (2.67) in American Beauty and Red Ginger was recorded, however, earliness in spike emergence after corm sprouting (60.00 days) in Jester, days to first flowering after spike emergence (9.33 days) in Candyman and maximum spike length (109.83cm) in Red Ginger, rachis length (66.23cm) in Pacifica, florets/spike (18.33) in Red Ginger and diameter of flower stalk (10.05mm) in Hunting Song were observed. Enhanced field life (20.33 days) and vase-life of cut gladiolus flowers under tap water (12.00 days) was observed in cultivar Red Ginger. However, maximum corm weight (74.30g) was noticed with cultivar Hunting Song, followed by Candyman (68.70g), Red Ginger (64,20g) and Poppy Tears (57.50g).

Key Words: Gladiolus, Evaluation, Variety, Climate, Field life, Vase-life, Corm, Spike, Florets

Gladiolus (*Gladiolus hybrida* L.) is one of the most popular cut flowers in international and domestic markets. It prefers cool and dry conditions and temperature plays a major role in its growth and flowering. This crop is grown commercially under open field conditions all over the country. There are excellent varieties of gladiolus with magnificent inflorescence in exhaustive range of colours, different shades, varying number of florets, arrangement of florets, spike length, post-harvest life and adaptability to different seasons. Gladiolus cultivation has gained popularity among farmers due to ease in cultivation and good profit. However, its production is just confined to winter season (November-February).

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Hence, it is very much necessary to evaluate the varieties suitable for the specific region. There are few reports about the suitable gladiolus varieties being grown in North-Eastern region, but scientific information is not available on gladiolus for commercial cultivation in East Siang district. Therefore, present study was carried out to evaluate various gladiolus cultivars, best suited to this region.

MATERIALS AND METHODS

An experiment was conducted at Instructional Farm, Department of Floriculture, College of Horticulture and Forestry, Central Agricultural University, Pasighat, during winter season (November 2011 to February 2013). The day temperature prevailing during crop period ranged from 18-29°C and night temperature from 9-16°C, respectively. The relative humidity ranged from 60 to 75%. The average rainfall during the crop period was 600mm. The experiment was laid out in a

randomized block design with 10 treatments and three replications. Ten varieties namely, Jester, Candyman, Poppy Tears, Summer Sunshine, Wedding Bouquet, Hunting Song, Pacifica, American Beauty, Red Ginger and White Prosperity, were selected for their evaluation.

Uniformly sized gladiolus corms (3.00-4.00 cm diameter) were planted on raised bed at a spacing of 30cm × 30cm under irrigated condition during second fortnight of November. Uniform package of practices were followed throughout the experiment to grow a healthy crop. Plant height was measured at the time of spikes emergence. Spikes were harvested at bud stage when the first bud was about to open by retaining four leaves on the plant to study the vase-life of different gladiolus varieties. Observations were made on various vegetative growth, flowering parameters, corm characters as well as vase-life under tap water. The data collected were pooled and analyzed using statistical methods as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Significant differences were observed in vegetative, flowering, quality, corm and cormel characters among the cultivars. There were significant differences among varieties in respect to vegetative parameters (Table 1). Sprouting of corms was advanced in cultivar Poppy Tears (16.00 days) while it was delayed in cultivar Jester (65.67days). Cultivar Red Ginger showed highest plant height (71.20cm), followed by cultivar Pacifica (66.23cm) which was on a par with Candyman (65.33cm). However, plant height measured in cultivar White Prosperity was found to be the minimum (53.47cm). Pandey *et al.* (2010) assessed the performance of twelve gladiolus cultivars in Jammu region and observed significant response among the cultivars in respect of their morphological characters which corroborates with present findings. The number of leaves/plant was significantly higher in cultivar Candyman (10.67) which was on a par with Poppy Tears (10.33), Hunting Song (10.33) and Summer Sunshine (10.00), whereas the least was observed in cultivar American Beauty (8.67) and White Prosperity (8.67).

Difference in vegetative characters of different cultivars of gladiolus may be due to varied growth rates and their genetic capability resulted in variation in phenotypic expression. Similar results for vegetative characters in gladiolus were observed by Lepcha *et al.* (2007). Increased length of leaf (53.67cm) was shown by cultivar Pacifica, followed by cultivar Red Ginger (44.73cm). The cultivar Pacifica in respect of length of leaf (53.67cm) was on a par with cultivar Wedding Bouquet (50.63cm), whereas cultivar American Beauty had minimum length of leaf (39.30cm). Breadth of leaf (4.97cm) was significantly higher in cultivar Poppy Tears followed by cultivar Jester (4.10cm) and Candyman (3.67cm), while minimum breadth of leaf was associated with cultivar Wedding Bouquet (3.57cm) and White Prosperity (3.57cm).

Increased number of tillers/plant was noticed in cultivar American Beauty (2.67) and Red Ginger (2.67), followed by Candyman (2.00), Poppy Tears (2.00), Wedding Bouquet (2.00) and Pacifica (2.00) which was on a par with each other. Different cultivars showed variable responses for vegetative characteristics. Cultivars under study were given same soil and climatic conditions but variations occurred. This might be due to their genetic composition which interacts differently to the soil and climatic condition of this area. Safiullah and Ahmed (2001) also confirmed these results after observing variation in vegetative and floral characteristics for gladiolus cultivars.

Gladiolus cultivars varied significantly for quality and flowering parameters (Table 2). One can observe variations among floral characteristics for different cultivars. These variations among floral characteristics

Table 1. Performance of gladiolus cultivars for growth parameters

Variety	Days for sprouting of corms	Plant height (cm)	Number of leaves /plant	Length of leaf (cm)	Breadth of leaf (cm)	Number of tillers/plant
Jester	65.67	55.67	9.00	44.20	4.10	1.00
Candyman	24.00	65.33	10.67	43.37	3.67	2.00
Poppy Tears	16.00	59.40	10.33	40.67	4.97	2.00
Summer Sunshine	25.33	59.87	10.00	41.77	4.70	1.33
Wedding Bouquet	27.67	64.97	9.67	50.63	3.57	2.00
Hunting Song	28.67	63.93	10.33	41.60	4.80	1.67
Pacifica	24.67	66.23	9.67	53.67	4.53	2.00
American Beauty	36.33	59.97	8.67	39.30	4.83	2.67
Red Ginger	36.33	71.20	9.00	44.73	4.73	2.67
White Prosperity	35.00	53.47	8.67	42.37	3.57	1.00
CD (P = 0.05)	4.38	6.42	1.15	5.01	0.57	0.20
CV (%)	7.99	6.03	6.97	6.61	7.58	6.27

of gladiolus cultivars have also been observed by Lal *et al*. (1984). Mahanta and Paswan (1995) compared various cultivars and observed similar differences among cultivars for floral characteristics.

Spike emergence after sprouting was advanced in cultivar Jester (60.00 days), followed by Poppy Tears (75.33 days) and Hunting Song (79.00 days) which was on a par with cultivar Candyman (82.33 days), whereas it was delayed in Pacifica (89.00 days). Leena Ravidas *et al.* (1993) reported similar observations in gladiolus under climatic conditions of Kerala and Horo *et al.* (2009) under climatic conditions of Jharkhand. Long days and slightly higher temperature during January-February at Pasighat might have prolonged the vegetative phase along with the time required for flowering. The findings of the present study also agrees with the result of Nagraju and Parthsarathy (2001) and Mohanty (2006) as they recorded the early spike emergence in various genotypes of gladiolus, *viz.* Meera, Beauty Spot, Yellow Mix, Dhavantari and Bindya These variations were due to the differences in geographical locations, genotypes, cultural management and growing seasons.

Days to flowering after spike emergence was significantly advanced by cultivar Candyman (9.33 days) which was on a par with cultivar Jester (10.33 days), Summer Sunshine (10.67 days) and Wedding Bouquet (10.33 days), Pacifica (10.33 days) and White Prosperity (10.67 days). However, it was delayed in Poppy Tears (15.00 days). Similar variation in early and late cultivars of gladiolus has been reported by Aswath and Parthsarthy (1996) and Kumar and Yadav (2005). Earliness for first floret open after colour break was noticed in cultivar Summer Sunshine (2.00 days), Hunting Song (2.00 days) and Pacifica (2.00 days) which was on a par with cultivars Poppy Tears (2.33 days), Wedding Bouquet (2.33 days) and White Prosperity (2.33 days). While, maximum days taken for first floret open after colour break was observed with Candyman (3.00 days) and American Beauty (3.00 days). Advanced spike initiation, delay in floret opening and colour break in several cultivars of gladiolus signifies the good quality of spike which may regulate the market based on prevailing climatic conditions of Pasighat.

In the present study, first floret bud separation was earlier mostly due to the influences of different genotypic and climatic conditions. Spike development of mid and late flowering cultivars was delayed by cool weather in the middle of December. Mild warm and dry weather in February and March accelerated the maturation of flower spikes. Spike length, which is synonymous with quality in current commercial grading system, was highly variable among the cultivars. Maximum spike length was observed in cultivar Red Ginger (109.83cm), followed by cultivar White

Table 2. Performance of gladiolus cultivars for flowering parameters

Variety	Days taken for spike emergence after sprouting	Days taken to flowering after spike emergence	Days to first floret open after colour break	Spike length (cm)	Rachis length (cm)	Number of florets/ spike	Diameter of 2nd floret (cm)	Diameter of flower stalk (mm)	Fresh weight of spike (g)	Field life (days)	Vase-life (days)
Jester	60.00	10.33	2.00	105.50	65.07	18.00	10.90	9.15	88.10	15.00	12.33
Candyman	82.33	9.33	3.00	99.83	47.57	12.00	10.97	9.48	64.57	11.50	10.67
Poppy Tears	75.33	15.00	2.33	100.00	56.67	14.00	11.10	8.82	55.63	12.33	11.33
Summer Sunshine	86.67	10.67	2.00	91.33	45.83	10.00	10.73	8.64	43.07	14.00	11.00
Wedding Bouquet	88.00	10.33	2.33	93.33	55.57	17.67	11.07	8.54	43.37	16.33	10.00
Hunting Song	79.00	12.00	2.00	89.67	50.30	17.00	10.73	10.05	57.53	17.33	10.67
Pacifica	89.00	10.33	2.00	109.50	66.23	16.00	9.70	8.98	52.20	23.67	11.33
American Beauty	80.33	13.67	3.00	104.80	62.37	16.33	11.27	8.99	38.40	17.67	12.00
Red Ginger	83.33	11.67	2.67	109.83	57.03	18.33	10.97	9.12	51.47	20.33	12.00
White Prosperity	88.67	10.67	2.33	93.67	52.87	17.00	11.23	8.11	39.30	12.00	9.67
CD (P=0.05)	5.69	1.78	0.29	14.16	7.61	2.31	0.54	0.73	7.88	2.12	1.50
CV (%)	4.08	6.02	7.39	8.27	7.93	8.60	2.88	4.76	8.61	7.70	7.89

Prosperity (93.67cm) and Summer Sunshine (91.33cm). No significant differences were observed among cultivars, Pacifica (109.50cm), Jester (105.50cm), American Beauty (104.80cm), Poppy Tears (100.00cm), Candyman (99.83cm) and Red Ginger (109.83cm), whereas cultivar Hunting Song produced shortest spike (89.67cm) as compared to other varieties.

Contrarily, rachis length was significantly higher in cultivar Pacifica (66.23cm), followed by Red Ginger (57.03cm) and Poppy Tears (56.67cm), whereas Jester (65.07cm) and American Beauty (62.37cm) were on a par with Pacifica (66.23cm). However, Summer Sunshine showed lowest rachis length (45.83cm) among all the genotypes . The cultivar Red Ginger significantly produced highest number of florets/spike (18.33), followed by Pacifica, (16.00), Poppy Tears (14.00) and Candyman (12.00). While, cultivars Red Ginger (18.33), Jester (18.00), Wedding Bouquet (17.67), Hunting Song (17.00), White Prosperity (17.00) and American Beauty (16.33) showed non-significant differences in number of florets/spike among each other, whereas the lowest number of florets/spike was counted in Summer Sunshine (10.00).

Number of florets/spike obtained in all varieties was markedly superior due to better vegetative growth. Similar findings were observed by Leena Ravidas *et al.* (1993) and Mukhopadhyay and Banker (1987). Uppal and Arora (1994) also noticed significant differences in number of florets per spike in different cultivars. Significant response in diameter of second floret and flower stalk was observed among the gladiolus varieties. The maximum diameter of second floret (11.27cm) was recorded in American Beauty. However, Pacifica showed lowest diameter of second floret (9.70cm).

The cultivars American Beauty (11.27cm), Jester (10.90cm), Candyman (10.97cm), Poppy Tears (11.10cm), Summer Sunshine (10.73), Wedding Bouquet (11.07cm), Hunting Song (10.73cm), Red Ginger (10.97cm) and White Prosperity (11.23cm) were non-significant with each other. Spike girth is a crucial character, since it determines the sturdiness of cut flowers. Mahanta and Paswan (1994) recognized sturdiness of the cut flower as one of important characters. Spike girth should be more to have sturdy cut flowers. The maximum diameter of flower stalk (10.05mm) was recorded in cultivar Hunting Song followed by Jester (9.15mm) and American Beauty (8.99mm). Whereas, Candyman (9.48mm) and Red Ginger (9.12mm) were on a par with Hunting Song (10.05mm). The cultivar White Prosperity showed lowest diameter of flower stalk (8.11mm). A significant difference in fresh weight of spike was noticed among the cultivars. The highest fresh weight (88.10g) was associated with cultivar Jester, followed by Candyman (64.57g) and Hunting Song (57.53g). While, cultivar White Prosperity registered to lowest fresh weight (39.30g).

The cultivar Pacifica showed the enhanced field life (23.67 days), followed by Red Ginger (20.33 days) and American Beauty (17.67 days). Whereas, increased vase-life of cut gladiolus spike under tap water was observed in cultivar Red Ginger (12.00 days), while lowest vase-life was noticed in White Prosperity (9.67 days). However, Red Ginger (12.00 days), Jester (12.33 days), Candyman (10.67 days), Poppy Tears (11.33 days), Summer Sunshine (11.00 days), Hunting Song (10.67 days), Pacifica (11.33 days) and American Beauty (12.00 days) were on par with each other. Variation in vase-life may be attributed to differential accumulation of carbohydrates due to varied leaf production, sensitivity of cultivars to ethylene and genetical framework of the plant. Kumar and Yadav (2005) reported similar results in variation of vase-life of cut gladiolus spikes. Maximum vase-life period may be attributed to its longer spike length and more number of florets/spike which help the spike to retain attractiveness for a longer period. These results are in accordance with the findings recorded by Pasannavar (1994) and Sidhu and Arora (2000) where they reported a vase-life of 7.6 – 11.6 days, respectively.

Close observation of the corm and cormel characteristics showed variable responses for the cultivars under study. Different cultivars responded or interact with given soil and climatic conditions depending upon their genetic composition. Mahanta and Paswan (1995) compared different cultivars of gladiolus and observed highly significant differences among the cultivars for corm and cormel characteristics. In present study, there were significant differences among the varieties in respect to corm parameters (Table 3). Maximum corm weight (74.30g) was observed in cultivar Hunting Song, followed, by Candyman (68.70g), Red Ginger (64.20g) and Poppy Tears (57.50g), while cultivar White Prosperity recorded least corm weight (39.57g). However, highest cormel weight (14.20g) was noticed with cultivar Poppy Tears, followed by Candyman (9.10g) and Hunting Song (8.93g). Lowest cormel weight (3.00g) was found in cultivar White Prosperity. This was also observed by Singh and Singh (1987) under Delhi conditions. However, Arora and Khanna (1985) under Ludhiana conditions reported less cormels production in Friendship, Happy End, Snow Princess and Sylvia. A significant differences in polar and equatorial diameter of corm was also noticed among the cultivars.

The highest polar diameter of corm (33.30mm) was observed in cultivar Candyman, which was on a par with Hunting Song (32.45mm), Poppy tears (30.70mm), Red Ginger (30.60mm) and Pacifica (28.67mm), whereas cultivar White Prosperity recorded lowest equatorial diameter of corm (44.85mm), followed by American

Table 3. Performance of gladiolus cultivars for corm parameters

Variety	Corm weight (g)	Cormel weight (g)	Polar diameter of corm (mm)	Equatorial diameter of corm (mm)	Cormel diameter (mm)
Jester	57.30	6.13	28.26	55.74	10.43
Candyman	68.70	9.10	33.30	64.33	12.85
Poppy Tears	57.50	14.20	30.70	62.02	13.15
Summer Sunshine	54.17	7.97	27.78	60.29	14.14
Wedding Bouquet	42.83	4.03	28.08	45.82	10.45
Hunting Song	74.30	8.93	32.45	68.23	12.35
Pacifica	44.57	6.47	28.67	54.03	12.36
American Beauty	46.63	6.67	27.94	53.76	10.44
Red Ginger	64.20	6.07	30.60	60.46	13.17
White Prosperity	39.57	3.00	23.54	44.85	10.64
CD (P=0.05)	4.23	0.95	4.47	6.27	1.19
CV (%)	4.48	7.63	8.95	6.13	5.81

Beauty (53.76mm), Pacifica (54.03mm) and Jester (55.74mm) which differed non-significantly among each other. The maximum cormel diameter (14.14mm) was observed in cultivar Summer Sunshine, followed by Candyman (12.85mm) and Pacifica (12.36mm), while lowest cormel diameter was recorded with cultivar Jester 10.43mm). Pragya *et al.* (2010) also noticed significant differences in corm and cormel characters among the cultivars.

Candyman, Poppy Tears, Red Ginger, Hunting Song, Wedding Bouquet, Pacifica, American Beauty and Summer Sunshine showed better performance for vegetative, flowering, quality and corm characters under climatic conditions of Pasighat, East Siang district, Arunachal Pradesh and can be recommended for commercial cultivation.

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Evaluation of nutritional qualities of mulberry (*Morus alba*)-based yoghurt

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ABSTRACT

An experiment was conducted to enhance the nutritional qualities of yoghurt by fortification with mulberry (*Morus alba* L.), which is a rich source of anthocyanins, potassium and calcium. The yoghurt, a fermented dairy product having ample probiotic values, was prepared by mixing milk and pulp of mulberry. The fruits of mulberry accession, MI497, were taken in different ratio, *viz.* 10, 15, 20, 25 and 30%. The mixture was inoculated with curd @5% and incubated at 45 ± 2°C for five hours. The final product obtained had attractive pink colour, pleasant taste and flavour, and good consistency. During sensory evaluation on the basis of colour, consistency, flavour and taste, mulberry yoghurt prepared from T_1 (90% of milk and 10% of mulberry pulp) was found to be best, obtaining a score of 8.5 out of 10. It had anthocyanin content as high as 10.9% mg and dietary fibre 0.16%. On the basis of probiotic, nutritional and sensory properties, mulberry fortified yoghurt may find good acceptance among consumers and has vast market potential.

Key Words: Fruit yoghurt, Mulberry, Sensory, Physical and chemical properties, Microbial quality

Yoghurt is prepared by lactic acid fermentation of milk. It is a rich source of probiotics in addition to protein, calcium, riboflavin, vitamin B6 and vitamin B12. Probiotics are gut-friendly beneficial micro-organisms belonging to *Streptococcus* and *Lactobacillus* spp. and exert health benefit. Recently, popularity of yoghurt has increased because of awareness among consumers about healthy foods. There are reports that intake of one cup of yoghurt a day can help fast recovery as well as prevents high blood pressure, cold and help in maintaining weight loss (http://www.fitness magazine.com/recipes/healthy-eating/nutrition/health-benefits-of-yoghurt/?page = 2).

Prebiotic are dietary fibre that trigger the growth of probiotics. These are abundantly present in fruits and vegetables. Thus, fruit yoghurt has added advantage over plain yoghurt. Hamilton (1999) reported that fruits and flavouring essences can be used to create exciting new taste and texture in yoghurt dessert. Moreover, fruit yoghurt has been found to be more attractive organoleptically due to masking partially the excessive acetaldehyde flavour in plain yoghurt (Barnes *et al.* 1991). Mulberry (*Morus alba* L.) is known as new superfood for battling diabetes, cholesterol and heart disease. These super berries can even help to loose weight by blocking sugar. A serving of mulberry contains significant amount of vitamin C, dietary fibre, iron, and protein. In addition, mulberries contain anthocyanins, a group of antioxidants known for their anti-inflammatory and possible anti-cancer properties and reservatrol, an antioxidant also found in red wine and peanuts. Therefore, an experiment was conducted with an objective to develop mulberry-based fruit yoghurt and its nutritional plain yoghurt.

MATERIALS AND METHODS

During March-April, fruits of mulberry accession, MI-497, were collected from the experimental farm of Central Institute for Subtropical Horticulture, Lucknow. Diseased and damaged fruits were sorted out, and healthy ones were washed thoroughly under the tap water. The fruits were crushed to get a homogenous paste.

Fresh milk was pasteurized at 85°C for 10 min, adding skim milk powder (5%) and sugar (10%). The pasteurized milk was transferred in containers. The mixture was blended with mulberry pulp in different ratios.

T_1 : 90% of milk and 10% of mulberry pulp
T_2 : 85% of milk and 15% of mulberry pulp
T_3 : 80% of milk and 20% of mulberry pulp
T_4 : 75% of milk and 25% of mulberry pulp
T_5 : 70% of milk and 30 % of mulberry pulp

The curd inoculum was added @ 5% and incubated at 45±2 °C for three hours.

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The total soluble solids of the samples were determined using a hand refractometer and expressed in ^{0}Brix. Titratable acidity and total anthocyanin content were estimated as per the methods described by Ranganna (1986). Dietary fibre was analyzed as per the method of AOAC (2000). Reducing sugar and total sugar in the yoghurt were determined as per the methods of Lane and Eynon (1923). Protein content was estimated as per the method of Lowry *et al.* (1951). Organoleptic evaluation was done on the basis of colour, consistency, taste and acceptability by a panel of 10 semi-skilled judges using a nine point hedonic scale (Ogden, 1993).

The samples were aseptically weighed and homogenized. From each sample, appropriate dilutions in peptone water were plated, in duplicate, on MRS agars (Speck, 1985). The plates were incubated at the appropriate temperatures (35 ± 5°C) for 2-3 days under aerobic and anaerobic conditions (Kalavrouzioti *et al*. 2005). Total count or enumeration of coliforms yeast and mold determination were done according to standard methods using the Plate Count Agar (PCA), Eosine Methylene Blue (EMB) and Potato Dextrose Agar (PDA) respectively (Zekai, 2003).

RESULTS AND DISCUSSION

Yoghurt is a well-known fermented product of milk which has acceptability throughout the world. Fruit yoghurt is prepared by adding fruits and their nectars, jams, marmalade, fruit jellies, fruit drinks, fruit syrups and concentrated fruit drinks to yoghurt or cultured pasteurized milk (Vahedi *et al*. 2008). Decreased immunity, infections, heart diseases, vision defects, ageing, diabetes, atherosclerosis and cancer are quickly becoming an epidemic in India. The increased incidence of these problems has been attributed to diets characterized by malnutrition, coupled with low potassium, anthocyanin, anti-oxidants and vitamin C intake. Mulberry fruits have medicinal properties and delicious taste when consumed fresh. Mulberry fruits have been reported to exhibit a variety of biological activities, such as anti-thrombotic (Yamamoto *et al*., 2006), antioxidant (Kim *et al*. 1999; Naderi *et al.* 2004), antimicrobial (Takasugi *et al.* 1979), anti-inflammation (Kim and Park, 2006) and neuron-protective effects (Kang *et al*., 2006). These activities are generated by anthocyanins, which are a group of naturally occurring phenolic compounds that are responsible for the red colour of mulberries. Analysis of mulberry fruit pulp is shown in Table 1.

Sensory evaluation of yoghurt prepared from various milk and mulberry pulp blends indicated that treatment T_1 (blend 9:1) was found better for yoghurt

Table 1. Nutritional composition of mulberry pulp

Total soluble solids (^{0}Brix)	5.10
Acidity (%)	0.26
Calcium (mg/100ml)	35.6
Potassium (g/100ml)	2.40
Ascorbic acid (%)	4.10
Anthocyanin (mg/100ml)	68.5
Phenolics (mg/100ml)	207
Total sugar (%)	4.40
Reducing sugar (%)	0.53
Pectin (%)	0.42
Protein (%)	0.18
Fibre	5.3

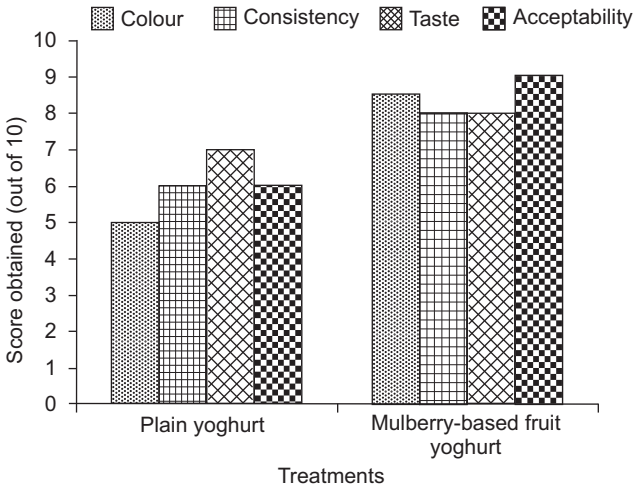

Fig. 1. Sensory evaluation of plain and mulberry supplemented yoghurt

preparation in terms of colour, consistency, taste and acceptability (Fig. 1 and Plate 1). Biochemical analyses of T_1 indicated that the yoghurt was enriched with anthocyanins and dietary fibre. But there was no difference in the TSS, acidity and sugars (Table 2). The lactic acid bacterial counts were also same, i.e. 10^7 cells per ml. It is reported that the addition of fruit flavour has no significant effect on total bacterial counts. It has been also reported that fruit-flavored yoghurts, made using 0 day old yoghurt as a starter culture, could be stored for up to 7 days without losing its desired flavour

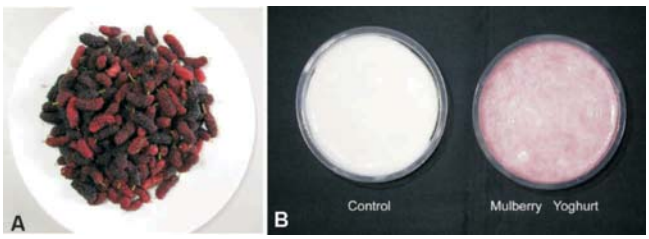

Plate 1: A. Mulberry fruits **B.** plain and mulberry yoghurt

Table 2. Comparative study of plain and mulberry supplemented yoghurt

	Plain yoghurt	Mulberry- based fruit yoghurt
TSS (^{0}Brix)	20	20
Acidity (as lactic acid %)	1.12	1.12
Protein (%)	1.99	1.97
Anthocyanins (mg/100ml)	0.0	10.9
Total sugar (g %)	0.161	.163
Reducing sugar (g %)	0.031	0.037
Dietary fibre (g%)	0.0	0.16

qualities (Zekai, 2003). In plates with mulberry yoghurt, yeast colonies increased 10^3 until 4th day of storage and then decreased to 10^2. No *E. coli*, or mould or coli form could be isolated from the tested samples. Frazier (1995) and Jai (1990) reported that competition with lactic acid bacteria causes difficult situation for coliforms' activity.

Mulberry supplemented yoghurt was found to have good acceptability as well as nutritional and microbiological quality. It may find great potential in market because of its probiotic, probiotic and nutritional properties.

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Effect of NAA and mulching on fruit drop in mango (*Mangifera indica*) cv. Kesar in semi-arid ecosystem

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ABSTRACT

An experiment was conducted to find out the effect of NAA and mulching on fruit drop in mango (*Mangifera indica* L.) cv. Kesar under semi-arid ecosystem at Krishi Vigya Kendra, Panchmahals, Central Institute of Arid Horticulture, Vejalpur-Godhra, Gujarat, during 2010-11 and 2011-12. The causes of fruit drop are non- pollination and fertilization, competition between developing fruits and hormonal imbalance. The application of irrigation, NAA and grass mulching alone or in combination reduced the fruit drop in mango considerably. The maximum number of panicles (174.28/ plant), hermaphrodite flowers/ panicle (28.24), initial fruits set per panicle (5.10), number of fruits/ panicle at harvesting (0.95) and yield/ plant(27.25 kg) were recorded in T_3 (irrigation at 15-20 days interval + two sprays of NAA@ 20 ppm at first week of February and first week of April + grass mulching).

Key Words: Mango, Fruit drop, NAA, Mulching, Auxin, Hormonal imblance

Mango *(Mangifera indica* L.) , the choicest fruit of India, is rightly titled as the "King of fruits" because of its wide adaptability, high nutritive value, richness in varieties, delicious taste, excellent flavour, attractive appearance and popularity among the masses. However, performance of its varieties is not found similar under varied agroclimatic conditions (Singh, 1978). Among several factors affecting the yield, the number of perfect flowers, extent of fruit drop, nutrient deficiency, competition between developing fruitlets, drought or lack of irrigation, unfavourable climatic conditions during fruit development period (wind and hailstorms), incidence of serious diseases like powdery mildew and anthracnose, and pest like hopper and mealy bug are very important (Majumdar and Sharma, 1990). Under arid and semi-arid regions, excessive fruit drop and low fruit retention are important factors that determine the yield of mango. In these areas, drought or scarcity of water and nutrient imbalance in soil are major factors associated with fruit drop. Hence, an attempt to control fruit drop in mango was done at five farmers' orchards in four villages of Panchmahals district of Gujarat.

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Naturally- occurring hormones play a major role in fruit growth and fruit drop of mango (Ram, 1992). Deficiency of auxins, gibberellins and cytokinins coupled with a high level of growth inhibiters, i.e. abscissic acid and ethylene cause fruit drops (Ram, 1983). An increase in auxin level corresponds with a period of growth, while a high level of inhibiter corresponds with high rate of fruit drop (Parkash and Ram 1984; Murti and Upreti 1995). In fact, when the concentration of abscissic acid and ethylene increase in panicles. As a result abscission layer formed at the attachment, and leads to fruit drop. The exogenous applications of NAA increase the concentration of auxin in panicles and antagonise the adverse effects of endogenous inhibiters. The mulching with paddy straw/grasses is directly related to conserve soil moisture which is the most important factor in production of mango in semi-arid ecosystem. Therefore, an experiment was conducted to control the fruit drop in mango through the application of NAA and mulching.

MATERIALS AND METHODS

The experiment was conducted on 8-10 years old mango cv. Kesar orchard at five farmers' orchards of Panchmahals district in Gujarat under on-farm testing during 2010-11 and 2011-12. All the plants were fertilized with recommended dose of manures and fertilizers.

Table 1. Effect of NAA and grass mulching on fruit drop and yield of mango cv. Kesar.

Treat-ment	Year	No. of panicles/ plant	Hermaph-rodite flowers (%)	No. of fruits/panicle			At harvest 1st week of June	Fruit drop (%) from IInd week of March to 1st week of June	No. of fruits/ plant	Yield/ plant (kg)	Average fruit weight (g)
				IInd week of March	IInd week of April	IInd week of May					
T_1	2010-11	160.50	24.80	4.45	1.70	0.80	0.40	91.01	64.20	11.04	172
	2011-12	162.60	24.90	4.50	1.75	0.85	0.38	88.54	66.10	11.40	170
	Pooled	161.55	24.85	4.47	1.725	0.825	0.39	89.775	65.15	11.22	171
T_2	2010-11	171.30	25.20	4.70	2.8	1.9	0.83	82.34	142.20	24.70	175
	2011-12	174.20	27.30	4.90	3.10	2.15	0.95	80.61	147.10	25.80	178
	Pooled	172.75	26.25	4.80	2.95	2.025	0.89	81.475	144.65	25.25	176.5
T_3	2010-11	174.30	28.25	5.10	3.20	2.20	0.86	83.14	149.90	26.80	179
	2011-12	179.50	30.60	5.65	3.35	2.35	0.95	83.19	152.80	27.25	182
	Pooled	176.9	29.42	5.37	3.275	2.275	0.905	83.165	151.35	27.025	180.5
T_4	2010-11	172.20	26.00	4.55	2.40	0.52	0.80	82.41	137.70	23.10	168
	2011-12	177.30	28.20	4.75	2.55	0.75	0.85	82.10	141.80	23.90	173
	Pooled	174.75	27.10	4.65	2.475	0.635	0.825	82.255	139.75	23.5	170.5
SEm+	2.085	0.341	0.076	0.067	0.035	0.020	1.619	2.203	0.999		2.281
CV	2.747	2.818	3.539	5.808	5.548	5.991	4.989	6.788	3.080		7.029
CD(-5%)	6.428	1.051	0.236	1.378	0.110	0.06	4.303	3.934	10.27		2.923

The experiment was laid out by four treatments, *viz.* T_1 (control, farmers practices), T_2 (irrigation at 15-20 days interval), T_3 (irrigation at 15-20 days interval + two spray of NAA@ 20 ppm during first week of February and first week of April + grass mulching), T_4 (mulching + two spray of NAA@ 20 ppm during first week of February and first week of April) were set off with five replications in a randomized block design. The data on number of fruits/panicle at harvesting stage (first week of June), per cent fruit drop, number of fruits/ plant, yield/plant (kg), yield/ha and average fruit weight (g) were recorded. The statistical analysis of pooled data of two years was done (Table 1).

RESULTS AND DISCUSSION

All the treatments had significant effect on fruit drop in mango. The flowering started during December-January in all the treatments. The maximum number of panicles (176.90) / plant was recorded in T_3, followed by T_4 (174.75), T_2 (172.75) and the control (161.55). The range of per cent hermaphrodite flowers varied from 24.85 to 29.42 / panicle, maximum being in treatment T_3 and minimum in the control (Table 1). The number of fruits/ panicle was recorded minimum (0.39) in the control at harvesting stage, whereas there were very less differences (0.82 - 0.90) in T_2, T_3 and T_4. The data on fruit drop was taken fortnightly. The initial fruit setting ranged from 4.47 (in the control) to 5.37 (T_3) fruits/ panicle (Table 1).

The maximum fruit drop was recorded during the initial 15 days after fruit setting. During this period, fruit drop may be due to poor pollination, fertilization and incompletely fertilized ovules had opined that the first two weeks were the most important for fruit shedding in mango (Naik and Rao, 1943). According to Thimmappaiah and Suman (1987) fruit setting at 15th days ultimately determined the yield and was significantly correlated with retention and yield. During the course of development, there was a gradual reduction in fruit drop and it ceased by 45th day. There was a significant difference between the first, second and third fortnights after fruit seting in terms of fruit drop. The number of fruits on plant at the time of harvesting is main contributing factor of yield.

There was a great difference among the treatments. It ranged from 65.15 to 151.35, maximum being in T_3, followed by T_2 (144.65) and T_4 (139.75) and minimum in the control (65.15). It is may be due to combined effect of irrigation and mulching due to conservation of soil moisture. During the rapid period of fruit growth, the level of inhibitors decreased and that of promoters increased. However, in maturation and slow fruit growth period, the levels of both the growth promoters and inhibitors were low. Thus, all the growth promoters played their role in the growth of fruits. Deficiency of auxins, gibberellins and cytokinins coupled with high level of inhibitors appear to cause fruit drop in mango.

Similar results have been reported by (Chattha *et*

al., 1999; Sharma *et al*. 1990) (Rawash *et al*. 1983) in mango. The application of NAA helped in reduction of concentration of inhibitors like as absesic acid in fruit petioles which help in retaining of fruits. The similar findings were also reported by (Ram, 1983) and (Singh and Ram, 1983) in mango. The fruit yield per plant was maximum in T_3 (27.02 kg), followed by in T_2 (25.25 kg) and minimum was recorded in the control. It might be due to reduction in fruit drop in the treatment. The average fruit weight in all treatments did not have significant difference, it ranged from 171 to 180.50 maximum being in T_3, followed by T_2 and minimum in the control.

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Evaluation of efficacy of zero energy cool chamber on storage of banana (*Musa paradisiaca*) and tomato (*Solanum lycopersicum*) in peak summer season

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ABSTRACT

A low-cost structure, zero energy cool chamber (ZECC), developed by the IARI, New Delhi, was utilized for testing the storage life, ripening days and colour development in banana (*Musa paradisiaca* L.) and tomato (*Solanum lycopersicum* L.), important summer horticultural commodities. Both are highly perishable, summer-sensitive and become soft, and shrivelled due to high temperature and low humidity. In banana, colour retention is the problem, while in tomato colour formation is the problem. As a result, banana becomes soggy and shrivelled and tomato remains yellow. Fully mature fruits were purchased from the market and stored in plastic crates both in ZECC and the control. The ZECC maintained a uniform temperature range of 22-33°C and a high relative humidity (90 %). Banana fruits showed a shelf-life of 6 days. They were firm, fully yellow in colour, with a pulp temperature of 27.2° C, while the control banana fruits started losing their firmness from day 1 to 2. Tomato was stored at three different stages; full colour (bright red), indicating complete ripening which took place at day 10 in green stage, day 7 in turning stage and day 5 in half ripe stage. The tomatoes were firm, with a lower pulp temperature (26.5° C) and marketable even after 14 days of storage period, while tomatoes kept in the control started showing deterioration as early as day 4 in half ripe stage and turning stage and from day 8 in green stage.

Key Words: Bamboo, Banana, Colour retention, Firm, Perishable, Storage, Tomato, Zero energy cool chamber

Fruits and vegetables are highly prone to perishability, especially in the summer season. Storage of fresh horticultural produce after harvesting is one of the most pressing problems in our country. Due to their high moisture content fruits and vegetables have very short shelf-life and are liable to spoilage. The low-cost, low- energy input cool chamber developed by the IARI, New Delhi, is good for storage of fruits and vegetables (Roy 1985; Roy and Pal 1991). The structure is made out of locally-available cheap raw materials such as bricks, sand, bamboo, dry grass and jute cloth. The floor of the storage space is made with a single layer of bricks, while the side walls with double layer of bricks. The space between the walls is filled with riverbed sand. This is made under a temporary shade made out of locally-available bamboo and *sirki*. This chamber is most beneficial for the retailers as after purchasing the fruits and vegetables they can keep and market them when the availability of a particular commodity is low in the market instead of going for the distress sale.

Banana (*Musa paradisiaca* L.) is rich in potassium and calcium and is a quick source of nutrition especially for children. Bananas are reported to be very sensitive to changes in temperature during the ripening process. Fully mature banana tend to spoil very fast due to the production of ethylene, which indirectly affects the flavour. Retailers normally cover the banana with gunny bags and sprinkle water on them which may fool the customer that they are fresh but actually do more harm to the fruits. Banana fruits are consumable for only a day or two in the summer months after which spoiling sets in. The perishability of banana fruits is attributed to adverse physiological changes, viz. loss of weight due to respiration and transpiration, softening of flesh and loss of resistance to microbial attack.

Tomato (*Solanum lycopersicum* L.) is an everyday commodity required as an essential ingredient in most of the dishes, as raw and as drink form. They contain lycopene, vitamin C, vitamin A and anthocyanin. The most important maturity index in tomato is the colour which is temperature sensitive with better plastid conversion occurring above 12°C and below 30°C (Thai *et al.*, 1990). It is reported that increased temperature affected the final colour and speed of ripening, while the optimum colour resulted at temperatures between 23°C and 25°C and no further colour development above 30°C. As destruction of chlorophyll progresses during ripening, different shades of colour such as green yellow,

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yellow orange with some traces of green, orange yellow, orange red develop in sequence.

In summer months when temperature is very high non-uniform colour development takes place, lycopene development is hampered and they remain yellow instead of reaching to the complete development stage. The best colour development in tomato takes place at 20°C. The spring summer tomato which is the main crop in northern India, is generally harvested when the day temperature is around 35°C or more. This temperature condition is more detrimental to the colour development in fruits as no colour development takes place above 30°C.

MATERIALS AND METHODS

A small chamber of 400-kg capacity based on ZECC model of IARI, New Delhi, was constructed with brick and sand inside a shaded structure on the organic farm, at the Amity University, Noida, Uttar Pradesh. The chamber constructed was above the ground, double-walled structure made of bricks. The cavity of the double wall was filled with riverbed sand. The lid was made by using dry grass/straw on a bamboo frame. The rise in relative humidity (90% or more) and fall in temperature (10–15°C) from the ambient was achieved by watering the chamber twice a day.

The experiments were conducted in May and June. During these months, fruits and vegetables suffer with the problem of softening, lack of colour development, shrivelling and rot. Banana and tomato were selected to test the efficacy of ZECC in enhancing the shelf- life, colour development and marketability of both the commodities for small-scale farmers and retailers in the peak summer of May-June when outside temperature is quite high (above 40°C) and the outside relative humidity is around 28-42 % which is detrimental for both.

Freshly harvested fully mature fruits of banana were purchased from the market and kept in the plastic crates inside the chamber and in the control conditions. For tomato, three stages, viz. green, turning stage and half ripe stage were used. Banana fruits of different stages were purchased from the market and equal number of fruits were kept in chamber and the control.

Data were collected on physiological loss in weight, shelf-life, pulp temperature, texture and colour. Temperature was recorded with minimum, maximum thermometer, relative humidity with wet bulb and dry bulb thermometer, physiological loss in weight with electronic weighing balance, and pulp temperature with pulp thermometer, firmness/texture were determined with feel in correspondence with a prepared scale. The fruits and vegetables were kept in plastic crates and the experiment was set up in the morning hours.

For firmness measurement scale of 1-5 was used, which is classified as: 5, very firm; 4, firm; 3, less firm; 2, soft; and 1,very soft. Ripeness rating of banana was measured as: 5, full colour; 4,light yellow; 3, yellowish-green; 2,light green; and 1, dark green. Colour measurement in tomato was based on colour chart which is classified as 1-5, where 1, green; 2, yellow; 3, light red; 4, red (except on the apical portion); and 5, bright red (full).

RESULTS AND DISCUSSION

The ZECC keeps the lower temperature range and maintains a high humidity level for storage of fruits and vegetables. There was difference in maximum temperature in the control and ZECC condition (9-19°C). Even when the atmospheric temperature was 44ºC, the temperature in the ZECC was only 25°C. The difference between maximum and minimum temperatures was also quite less in ZECC which gives a uniform temperature to fruits and vegetables throughout the storage period (Sing *et al*., 2009). The relative humidity during the experiment period in the control ranged from 28 to 56 %, while in the ZECC it varied from 86 to 92%. The major advantage of cool chamber storage was the maintenance of fruit firmness by lowering the physiological loss in weight (PLW) and other metabolic processes.

Banana which is a temperature sensitive commodity reported a weight loss of 54 % in the control (30- 40°C and RH 36%), while inside the ZECC (22-27°C and RH 89-92%) the weight loss was only 8 % at the end of six-day storage period (Waskar, 1989). In general, PLW increased with increasing in the ripening period. When the weight loss is 10%, banana fruits become unfit for marketing and consumption and even if they are sold the profit margin reduced as retailers get lower price for the produce. In the control, at the end of first day storage, the weight loss was 24.92%. The average pulp temperature of banana was about 2°C lower than the bananas kept in the control. It was noticed that the pulp temperature of banana stabilized at 27.2°C after three days of storage period (Tables 1 and 2).

In terms of firmness rating banana started deteriorating from day 2 and were completely unmarketable from day 3 in the control, and reduced to rating 1 at the end of 24-hour period, while the ZECC bananas were marketable and consumable at the end of 6-day storage period as they were firm and uniformly coloured (Figs 1 and 2). Thus, results show a firm, ripe and uniformally coloured banana at the end of 6 days of storage period which can be quite beneficial for the retailers and to fetch them appropriate price.

The fruit quality in store of tomatoes can be affected by many factors including genetic, environmental, pre-

Table 1. Temperature and relative humidity in the control and ZECC condition

Day	Ambient temperature (°C)		ZECC temperature (°C)		Temperature differential (°C)		Relative humidity (%)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Ambient	ZECC
Day 1	27	40	25	29.5	2	10.5	37	90
Day 2	29	44	22	25	7	19	35	89
Day 3	29	40	23	27	6	13	36	87
Day 4	31.5	40	22.5	27	9	13	36	91
Day 5	31.5	40	22.5	27	9	13	36	89
Day 6	22	39	22	25	0	14	36	90
Day 7	25	38	24	29	1	9	49	90
Day 8	24	38	23	28	1	10	52	89
Day 9	28	41	26	30	2	11	56	96
Day 10	27	40	25	31	2	9	56	96
Day 11	29	44	22	25	7	19	31	86
Day 12	29	40	23	27	6	13	28	86
Day 13	28	41	26	30	2	11	42	90
Day 14	33	42	26	31	7	11	36	91
Day 15	31.5	40	22.5	27	9	13	33	92

Table 2. Comparison of banana storage in ZECC and control

Weight loss (%)	Weight loss (%)		Pulp temperature (°C)		Firmness rating	
	ZECC	Control	ZECC	Control	ZECC	Control
Day 1	0.00	0.00	30.8	30.8	5	5
Day 2	2.59	24.92	30.8	31.6	5	3
Day 3	6.63	21.31	29.1	31.6	5	1
Day 4	7.93	25.13	27.2	30.6	4	1
Day 5	8.21	53.17	27.2	30.6	4	1
Day 6	8.50	53.77	27.2	30.6	4	1

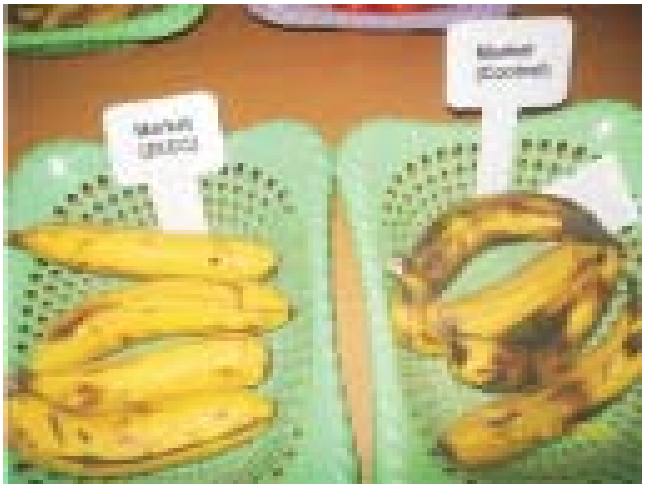

Fig. 1. Fruits in ZECC and the control

harvest and post-harvest factors. Their storage at room temperature favours decay, weight loss, softening, wilting, and off-flavour development (Table 3). There

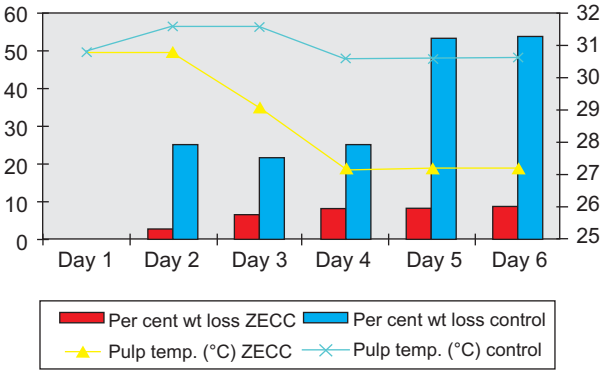

Fig. 2. Comparison of percent weight loss and pulp temperature in banana in ZECC and control

was physiological loss (PLW) (5%) in weight at mature green stage at the end of 14 day of storage period as compared to tomatoes kept in the control which lost their turgidity after 6th day, while after 14 day the loss in weight was 30.05%, for turning stage. Even the tomato in turning stage showed 9.56 % loss in weight in ZECC, and only 10 % in half ripe stage. The PLW of stored untreated tomato (TC) was 5.4% after 7 days at normal room temperature condition, while it was 5.15% after 17 days at ZECC. But PLW of hot water treated tomato T_1 and T_2 inside the ZECC was 4.41% and 3.03 % after 13 and 29 days of storage, respectively (Islam *et al.*, 2012).

The pulp temperature of tomato after fluctuating for a few days stabilized at 26.5°C after 6 days of storage in all tomatoes irrespective of the stage. A higher temperature was seen in the control, compared to the

Table 3. Comparison of tomato storage in ZECC and Control at different stages of maturity

	Green stage						Turning stage						Half ripe stage					
	Weight loss (% PLW)		Firmness rating (5-1)		Colour/ ripeness rating (5-1)		Weight loss (%)		Firmness rating (5-1)		Colour/ripeness rating (5-1)		Weight loss (%, PLW)		Firmness rating (5-1)		Colour/ ripeness rating (1-5)	
	ZECC	Ct	ZECC	Ct	ZECC	Ct	ZECC	Ct	ZECC	Ct	ZECC	Ct	ZECC	Ct	ZECC	Ct	ZECC	Ct
Day 1	0	0	5	5	1	1	0	0	5	5	1	1	0	0	5	5	1	1
Day 2	1.02	2	5	5	1	1	1.05	5.05	5	4	2	2	2.02	5.04	5	4	2	2
Day 3	1.30	3.5	5	5	2	2	1.50	7.08	5	4	3	3	3.03	6.84	5	3	3	3
Day 4	2.05	5	5	4	2	2	2.03	8.08	5	3	3	3	3.54	7.52	5	2	4	1
Day 5	2.48	7.1	5	4	3	3	3.03	8.54	5	2	4	3	4.08	8.05	5	1	5	1
Day 6	3.07	9	5	4	3	3	4.04	9.02	5	2	4	2	4.52	9.45	5	1	5	1
Day 7	3.78	11	5	3	3	3	5.05	10.04	5	1	5	2	5.02	10	5	1	5	1
Day 8	4.28	15	5	2	4	2	6.84	12.04	5	1	5	1	6.03	15.3	5	1	5	1
Day 9	4.79	21	5	2	4	2	7.10	17.04	5	1	5	1	7.08	24.4	5	1	5	1
Day 10	4.79	23	5	1	5	1	8.20	19.34	5	1	5	1	7.56	32	4	1	5	1
Day 11	5.14	26	5	1	5	1	8.94	20.03	5	1	5	1	8.08	35.5	4	1	5	1
Day 12	5.64	27	5	1	5	1	9.84	25.06	5	1	5	1	8.52	36	4	1	5	1
Day 13	5.82	28	5	1	5	1	9.30	36.16	5	1	5	1	9.06	40.3	4	1	5	1
Day 14	5.99	30	5	1	5	1	9.56	40.48	5	1	5	1	10	45.9	1	1	5	1

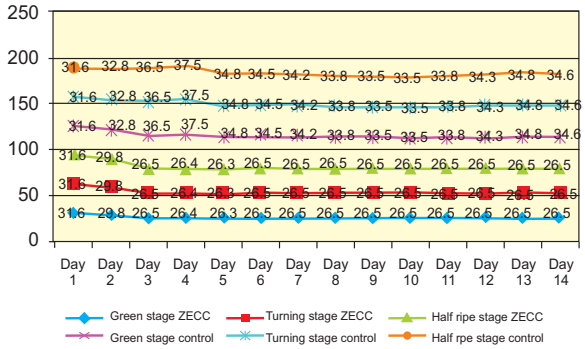

Fig. 3. Pulp temperature of tomato at different stages kept in ZECC and the control

Fig. 4. Comparison of tomato after 14 days in the control and ZECC

ZECC which showed a higher rate of deterioration. There was a uniform colour development in ZECC as moderate temperature between 22-30ºC and high relative humidity favoured uniform colour development and the tomatoes reached the full ripening stage at day 10 in green stage, day 7 in turning stage and day 5 in half ripe stage (Figs 3 and 4).

In ZECC, tomatoes in all the stages were firm, uniformly coloured after 14 days of storage period and marketable at a higher price, while tomatoes kept in the control never reached to full colour development stage and lost their firmness after day 4 in mature green stage, day 3 in turning stage and day 1 in half ripe stage which made them unmarketable (Singh 1981).

CONCLUSION

Banana and tomato fruits show a higher shelf-life in ZECC owing to their exposure to uniform temperature range and high relative humidity. Bananas which loses their life in 1-2 days in the control were firm, yellow, marketable and fit for consumption till 5 days of storage period. In tomato, the colour development takes place in the temperature range of 25-30°C at about 90% relative humidity which is the exact atmospheric condition provided by the ZECC. The tomato harvested and stored at three different stages reached full

colour development stage at day 10 in green stage, day 7 in turning stage and day 5 in half ripe stage and were firm, with a lower pulp temperature (26.5°C) and marketable even after 14 days of storage period, while tomatoes kept in the control started showing deterioration as early as day 3 in half ripe stage and tuning stage and from day 4 in green stage. They never reached the full colour development stage so were rendered unsuitable for marketing.

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Biology and feeding potential of green lacewing {*Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae)} on different hosts

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ABSTRACT

An experiment was conducted to find out the effects of different hosts on biology of green lacewing {*Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) } and their feeding potential of prey under laboratory conditions at 26±2°C and 65±5% relative humidity (RH) during 2010-11.The results indicated that the incubation period of eggs of *C. carnea* females feeding on different hosts as larvae was different on different host from each other. The biology of *C. carnea* was completed in 26 days on *Aphis craccivora,* followed by *Aphis gossypii* (31 days) and *Corcyra cephalonica* (45 days). A single larva of *C. carnea* consumed *A. gossypii* and 97.33 eggs of *Corcyra cephalonica,* followed by *A. gossypii* (80.0±2.65 nymphs/adults) and *A. craccivora* (64.33±0.67 nymphs/adults) per day. However, all the three larval instars of *C. carnea* consumed 369.00±6.11 eggs of *C. cephalonica,* followed by *A. gossypii* (277.67±4.37 nymphs/adults) and *A. craccivora* (206.67±1.86 nymphs/adults) during the whole larval period.

Key Words: Biology, Feeding potential, *Chrysoperla carnea*, Aphids, Green lacewing, Hosts

The genus *Chrysoperla* contains several important species of predatory insects, of which the common green lacewing, *Chrysoperla carnea* (Stephens) has been recorded as an effective generalist predator of aphids, coccids, mites and mealy bugs (Singh and Manoj 2000; Zaki and Gesraha 2001). Larvae of *C. carnea* are voracious and efficient biological control agents for various phytophagous arthropods (McEwen *et al*., 2001). One larvae may devour as many as 500 aphids in its life and there is no doubt that they play an important part in the natural control of many small homopterous pests (Michaud, 2001).

It has significant potential for commercialization and use against a variety of crop pests in combination with other insect pest management tactics. It is estimated that possibly up to one- third of the successful biological insect pest control programmes are attributable to the introduction of *C. carnea* and release of insect predators (Williamson and Smith, 1994). The knowledge of biology plays an important role in mass production and its utilization in pest management programme. To insight the information on description and duration of different stages of C. *carnea* and start a biological programme using *C. carnea*; mass-rearing techniques which are economical as well as posses higher biological efficiency need to be worked out.

MATERIALS AND METHODS

Biology of *Chrysoperla carnea* on three natural hosts was studied in Bio-control Laboratory, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh), India. Experiment was designed in a Complete Randomized Block Design (CRD) during 2010-11, replicated thrice each having 10 pairs of adult *C. carnea*. These adults were confined in a glass jar (15 cm diameter). The upper open end of glass jar was covered with black muslin cloth and tightened with rubber band. The adults were provided with nutritional diet containing equal volume of proteinex, honey and powdered yeast dissolved in little quantity of distilled water inside the glass jar with the help of small of plexi glass strips. The diet was provided at an interval of 24 hours.

Female green lacewing laid eggs on the walls of chimney and muslin cloth. The eggs were harvested with the help a of sharp razor and were placed singly in test tube (7.5-10 cm diameter) with the help of camel hairbrush and test tubes were covered with cotton swab. After hatching the newly- hatched larvae were fed on eggs of *C. cephalonica* (0.2 g/tube) that were provided at an interval of fours days. The process was continued

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until the formation of cocoons. The cocoons formed were removed gently and shifted to other empty glass chimneys for recording the emergence of adults.

Daily observations were made on the fecundity (number of eggs laid by a female), larval period, pupal period and adult longevity. The data recorded were analyzed by a computer software package. The natural hosts were cotton aphids, *Aphis gossypii* (Glov.), *A. craccivora* (nymphs/adults) and rice meal moth, *Corcyra cephalonica* (eggs). The first two hosts were collected from field. However, the eggs of *C. cephalonica* taken from laboratory culture, maintained for this purpose, were provided to the larvae of *C. carnea*. Each treatment consisted of 50 individuals and replicated thrice at 27±2ºC and 60±5 % RH.

RESULTS AND DISCUSSION

The present investigation shows that incubation period of eggs of 4.33±0.33, 3.33±0.33 and 3.33±0.33 days on *A. gossypii*, *A. craccivora* and *C. cephalonica*, respectively (Table 1). The results are in close conformity with those of Sattar *et al*. (2011) who found incubation period 2.25, 2.28, 2.36, 3.85, 2.25 and 2.80 days on *A. gossypii*, *P. solenopsis*, *S. cerealella*, *H. armigera*, *P. gossypiella* and mixed host diet, respectively.The duration of first instar maggot was completed in 2.67±0.33, 2.00±0.00 and 2.33±0.33 days on *A. gossypii*, *A. craccivora* and *C. cephalonica*, respectively. The second instar larvae completed in 3.67±0.33, 3.33±0.33 and 4.00±0.58 days on *A. gossypii*, *A. craccivora* and *C. cephalonica*, respectively.

However, third and final instar larvae completed in 5.00±0.57, 4.33±0.33 and 4.33±0.33 days on *A. gossypii*, *A. craccivora* and *C. cephalonica*, respectively (Table 1). The total larval period completed in 11.33±1.20, 9.67±0.33 and 10.67±0.67 days on *A. gossypii*, *A. craccivora* and *C. cephalonica*, respectively. These findings support to those of Sattar *et al*. (2011) who observed the complete larval developmental period was 8.50, 9.50, 12.37, 11.37, 8.25 and 11.00 days on *A. gossypii*, *P. solenopsis*, *H. armigera*, *P. gossypiella*, *S. cerealella*, and mixed host diet, respectively. The shortest and longest larval period of *C. carnea* were recorded as 8.25 and 12.37 days on *S. cereallela* and *H. armigera* eggs, respectively.

Table 1. Biology of lacewing, *Chrysoperla carnea*

Developmental period	*A. gossypii*	*A. craccivora*	*C. cephalonica*
Incubation period	4.33±0.33	3.33±0.33	3.33±0.33
1st instar	2.67±0.33	2.00±0.00	2.33±0.33
2nd instar	3.67±0.33	3.33±0.33	4.00±0.58
3rd instar	5.00±0.57	4.33±0.33	4.33±0.33
Total larval period	11.33±1.20	9.67±0.33	10.67±0.67
Prepupal period	1.33±0.33	1.00±0.00	1.33±0.33
Pupal period	8.33±0.33	8.67±0.33	11.00±0.58
Developmental period	25.33±1.67	22.67±0.33	26.33±0.67
Longevity Male	19.67±0.88	17.67±0.88	32.33±0.88
Female	31.00±1.00	26.00±1.53	45.00±0.58

The present investigation showed that pre-pupal period of *C. carnea* lasted for 1.33±0.33, 1.00±0.00 and 1.33±0.33 days on *A. gossypii*, *A. craccivora* and *C. cephalonica*, respectively (Table 1). However, newly formed pupa was silver in colour, which became shining silver with the advancement of time. The pupa appeared like round in shape. The pupal period lasted for 8.33±0.33, 8.67±0.33 and 11.00±0.58 days on *A. gossypii*, *A. craccivora* and *C. cephalonica*, respectively (Table 1). These results are similar to those of Sattar *et al*. (2011) who found the cocoon period of *C. carnea* was 7.75, 7.75, 8.37, 8.50, 7.37 and 8.25 days fed on *A. gossypii*, *P. solenopsis*, *H. armigera*, *P. gossypiella*, *S. cerealella*, and mixed host diet, respectively.

Bansod and Sarode (2000) studied biology and feeding potential of *C. carnea* on different hosts and noted developmental period of *C. carnea* ranged from 18.6 days on *Aphis cracivora* to 22.7 days on *H. armigera* neonate larvae. The duration of development of *C. carnea* was significantly different on three aphid species. Liu and Chen (2001) determined the development, survival and predation of *C. carnea* on three aphid species, *A. gossypii*, *M. persicae* and *L. erysimi*. Survival was significantly different on aphid species; when larvae were fed on *A. gossypii* and *M. persicae*, 94.4 and 87.6% individuals developed to adult stage, respectively; whereas only 14.9% when fed *L. erysimi*.

Duration of development was significantly short (19.8 d) when fed *A. gossypii,* followed by *M. persicae* (22.8 d) and *L. erysimi* (25.5 d). The adult lacewing was more or less spherical in shape with green coloured transparent wing. The males were smaller than the females in general. The longevity of male *C. carnea* was 19.67±0.88, 17.67±0.88 and 32.33±0.88 on *A. gossypii*, *A. craccivora* and *C. cephalonica.* However, female have 31.00±1.00, 26.00±1.53 and 45.00±0.58, respectively (Table 1). These results were similar to those of Sattar *et al*. (2011) who found male longevity 21.75±0.49, 20.25±0.25, 19.75±0.25, 19.62±0.32, 23.62±0.42 and 20.00±0.46 and female longevity was 38.00±0.65, 32.25±0.72, 30.87±0.39, 30.87±0.35, 38.62±0.62 and 31.25±0.99 on *A. gossypii*, *P. solenopsis*, *H. armigera*, *P. gossypiella*, *S. cerealella*, and mixed host diet, respectively.

For studying feeding potential of C. *carnea*, the observations were recorded at temperature 27±2°C and 60±5 % RH. The data indicates that the rate of feeding among different larval instars varied greatly. First instar

Table 2(a). Feeding potential of *C. carnea* on daily basis

Stages of larvae	*A. gossypii*	*A. craccivora*	*C. cephalonica*
1st instar	14.00± 0.58	15.67±1.76	18.00±0.58
2nd instar	20.33±0.33	26.67±0.88	34.00±0.58
3rd instar	30.00±0.58	37.67±0.88	45.333±1.20
Total consumption	64.33±0.67	80.00±2.65	97.33±1.20

* Mean of three replications

Table 2(b). Feeding potential of *C. carnea* during their life

Stages of larvae	*A. gossypii*	*A. craccivora*	*C. cephalonica*
1st instar	41.67±0.88	30.67±2.40	38.00±0.58
2nd instar	60.67±1.20	53.00±1.16	118.33±6.36
3rd instar	175.33±3.84	123.00±3.79	212.67±3.48
Total consumption	277.67±4.37	206.66±1.86	369.00±6.11

*Mean of three replications

maggot consumed an average of 14.00±0.58 *A. craccivora* and 15.67±1.76 *L. erysimi* and 18.00±0.58 eggs of *C. cephalonica*, respectively (Tables 2 a and b). The second instar maggot consumed an average 20.33±0.33, 26.67±0.88 and 34.00±0.58 on *A. gossypii*, *A. craccivora* (nymphs/adults) and eggs of *C. cephalonica*, respectively. The third instar maggot consumed an average of 30.00±0.58, 37.67±0.88 and 45.333±1.20, respectively. The total number of aphid consumed during whole larval duration varied from 64.33±0.67, 80.00±2.65 and 97.33±1.20 respectively on *A. gossypii*, *A. craccivora* (nymphs/adults) and eggs of *C. cephalonica* (Tables 2a and b).

These findings were supported by those of Saminathan *et al*. (1999) and Sattar *et al*. (2011). The gradual increase in the feeding rate of older instars with increase in the sizes of *C. carnea* explains increased requirements of food. These findings are similar to those of Liu and Chen (2001). *C. carnea* consumed more *A. gossypii* (292.4) and *M. persicae* (272.6) than *L. erysimi* (166.4). Zheng *et al*. (1993) found a highly significant positive correlation between prey consumed during larval stage and adult body weight of *C. carnea*.

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Evaluation of antimicrobial properties of Indian spices and commonly found weeds for development of new antibiotics

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ABSTRACT

The sensitivity of two gram positive bacteria (*Bacillus subtilis* and *Staphylococcus aureus*) and one gram negative bacteria (*Escherichia coli*) was tested against crude extract of different plant parts, e.g. buds, seeds, bark and leaves of different spices, viz. clove (S*yzygium aromaticum* L.), fenugreek or *methi (Trigonella foenum-graecum* L.), coriander(*Coriandrum sativum* L.) and cinnamon *(Cinnamonum aromaticum)* and weeds, *Argemone mexicana* and *Eclipta alba*. The plant extracts produced inhibition zones ranging from 6 to 38 mm against test microorganisms. The ethanol extract of the test plants was more effective in producing inhibition zones against the microorganisms compared to water or methanol extract.

Key Words: Antibiotics, Antimicrobial properties, Gram positive bacteria, Gram negative bacteria, Indian spices, Weeds

In the nineteen century, scientists began to purify the active extracts from medicinal plants. Friedrich Serturner first isolate morphine from the opium poppy (*Papaver somniferum*) in 1806. According to WHO (Santos *et al.,* 1995), medicinal plants would be the best source for obtaining a variety of drugs. Therefore, to evaluate the antimicrobial activities of some spices,viz. clove (*Syzygium aromaticum* L.), fenugreek *(Trigonella foenum-graecum* L.), coriander (*Coriandrum sativum* L.), cinnamon (*Cinnamonum aromaticum*) and medicinal plants, bhrangraj (*Eclipta alba*) and prickly poppy (*Argemone mexicana*) on one gram negative bacteria *(E.coli*) and two gram positive bacteria (*B.subtilis* and *S.aureus*).

Clove is used for teeth disorders, coughs, cholera, asthma, earache, muscular cramps and headaches. Fenugreek affects on blood sugar level it also helps to reduce kidney stones and colon cancer. It cures arthritis and eczema irritation, while fresh juice of *methi* leaves prevents hair fall and helps to get rid of dandruff. It is also used to relief in muscular aches and gout pain. Coriander is internally used for minor digestive problems and externally for hemorrhoids and painful joints. Cinnamon is medicinally used for diarrhoea, cold, influenza, fevers, arthritic and rheumatic complaints (Ross, 1999).

Seeds of *A. mexicana* are considered as an antidote to snake venom. The smokes of the seeds are used to relieve toothache. Fresh yellow, milky seeds extract contains protein dissolving substances, is effective in the treatment of warts, cold sores, cutaneous infections, skin diseases, itches, dropsy and jaundice (Chopra *et al*., 1986). *E. alba* is medicinally useful in spleen enlargement, jaundice, skin diseases, hairfall, inflammation, minor cuts and burns. It is also useful in ear and eye infection and upper respiratory infections (Sawant *et al*., L 2004). The use of these plant extracts and phytochemicals with known antimicrobial properties may have immersed importance in therapeutic treatments, hence studies were carried out to find out animicrobial characters of spieces and weeds commonly found for the development of antibiotics.

MATERIALS AND METHODS

The plant material used in this study included clove buds, fenugreek seeds, coriander seeds, cinnamon bark, *Argemone mexicana* seeds and leaves of *Eclipta alba*), collected from different sources. Initially, all the plant material was rinsed with distilled water and dried on paper towel in laboratory at room temperature.

Three sets (6 beakers each) of beakers were taken. About 10g of plant material was weighed for each set. In first set, 50 ml of water was added. Similarly, 50 ml each of ethanol and methanol were added in another set. These beakers were covered and left undisturbed for 24 hr. After 24 hr, these extract were filtered after 24

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Table 1. Antimicrobial sensitivity assay of aqueous, methanolic and ethanolic extracts of plants

	Fenugreek			Clove			Coriander			Cinnamon			*A.mexicana*			*E.alba*		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
E.coli	10	16	13	6	14	6	-	-	-	6	8	8	10	23	10	-	10	10
B.subtilis	9	18	23	10	18	32	-	-	-	10	10	16	12	25	22	6	20	30
S.aureus	-	-	-	12	27	36	-	-	-	10	11	18	7	19	25	6	21	36

A, Aqueous extract; B, methanolic extact; C, ethanolic extract

hr using sterile Whattman filter paper. The water extract was kept within an oven at 70°C for two days. It was dried properly. About 10 mg of each plant extract was weighed and 1 ml of autoclaved distilled water was added to it in a sterile eppen dorf tube, this procedure was done under laminar hood. These extracts were kept at 4°C.

The antibacterial tests of the plant extracts were tested on the test microorganisms using the agar-gel diffusion inhibition test (Perez *et al*., 1990), 0.2 ml of a 24hr broth culture of each test organisms was aseptically introduced and evenly spread using bent sterile glass rod on the surface of Muller- Hinton agar plates. About 6.00 mm diameter wells were aseptically punched on each agar plate. The volume of 50µl of the plant extract were then introduced into the wells. The plates were incubated at 37°C for 24 hr.

RESULTS AND DISCUSSION

The plant extracts were used in the study to investigate their antimicrobial potential. Both gram negative and gram positive bacteria were used. The results and screening of antimicrobial activity of *E. alba* leaves, *A. mexicana* seeds, coriander seeds, cinnamon bark, clove buds and fenugreek seed extracts are in given Table 1.

The ethanolic extract of *E. alba*, clove and *A. mexicana* showed higher activity in comparison to fenugreek and cinnamon. Ethanolic extract of fenugreek and coriander showed no activity against *S. aureus*, whereas cinnamon and *A. mexicana* showed moderate activity, *E.alba* and clove showed higher activity.Against *B. subtilis*, fenugreek, cinnamon and *A. mexicana* showed moderate activity, *E.alba* and clove showed higher.For *E.coli* all these extracts showed moderate activity in which cinnamon and clove showed lowest.

Methanolic extract of clove showed moderate activity against *B. subtilis* and *S. aureus*. Methanolic extract of *A. mexicana* showed maximum activity for *E.coli* in all plants. Fenugreek and coriander did not show any activity against *S. aureus.* Water extract of all plants showed minimum activity in comparison to methanolic and ethanolic extracts. Fenugreek water extract did not show any activity against *S. aureus*. Coriander did not show any activity against any microorganism.

Plants have provided a source of inspiration for novel drug compounds as plants derived medicines have made significant contribution towards human health. Phytochemicals can be used for the treatment of diseases as is done in case of Unani and Ayurvedic system of medicines or it can be the base for the development of a medicine, a natural blueprint for the development of new drugs (Javed *et al*., 2002). Firdous *et al*. (1990) studied antimicrobial activities of *Adhatoda vasica, Calotropis procera, Nerium odorum* and *Ocimum sanctum* leaf on certain gram positive and gram negative bacteria.

The results are encouraging as the methanolic, ethanolic and aqueous extracts have shown considerable antimicrobial activity. The plant-based antimicrobials have enormous therapeutic potential as they can serve the purpose without any side effect that are often associated with synthetic antimicrobials. Continued further exploration of plant-derived antimicrobials is the need of today.

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Pharmacognostical studies of madar (*Calotropis procera*) for drug preparation in Indian system of medicine

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ABSTRACT

The study was undertaken to find out the pharmacognostical characters of madar or ak [*Calotropis procera* (Ait.) W. T. Aiton], family Asclepiadaceae. In the present study, macroscopical, microscopical (stem and leaf), chemical analysis, TLC, powder analysis, extractive and ash value were studied. The stomatal index, palisade ratio, vein termination number and vein islet number were also studied. The numerical data can be considered as a diagnostic constant in identification and authentication of the raw drug obtained from madar. Since the drug of madar plant is used in Ayurveda, Homoeopathy and Unani, especially for curing ulcers, eye troubles, headache etc., it is of vital importance for human health. The plants of madar contain α – amyrin, α - amyrin, taraxasterol and its isomer, taraxasteryl isovalerate, taraxasteryl acetate, α – sitosterol and a wax, which are very essentially required for human-beings. The latex contains the cardiac glycosides; calotropin, uscharin and calotoxin.

Key Words: Pharmacognostical studies, Madar, *Calotropis procera*, Indian system of medicine, Microscopical, Stomatal index, Macroscopical

Madar[*Calotropis procera* (Ait.) W. T. Aiton] plant is the source of rubber like product; called mudar gummi and strong fibre used for ropes, fishing net, halters; durable under water. Its young parts are clothed with white cottony tomentum; bark soft, corky, spongy (Kirtikar and Basu,1935). It is a good soil-binder so recommended for deserts (Wealth of India,1950). The stems and leaves contain caustic latex in abundance which is vesicant, irritant and rubefacient. The latex contains a protein- based substance which has high nutritional value for use in food supplements or in cosmetics (Anon,1980). The latex is equally rich in hydrocarbons and has bonafide cardiac glycosides. It is said to be an adulterant of Persian opium (Duke, 1987). It also acts as a drastic purgative and emetic so used as an arrow- poison in Africa. The drug has received a good deal of interest from chemical as well as pharmacological point of view. Because of the importance of this plant in ISM System, it is required to ascertain the genuineness of plant species before preparation of medicines. So an attempt was made for detailed pharmacognostic studies of the whole plant. The numerical data can be considered as a diagnostic constant in identification and authentication of the raw drug.

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MATERIALS AND METHODS

The samples of madar were collected from the area of ALTT Centre, Ghaziabad, to study macro-morphological characters. For anatomical studies, samples of twigs of third internode were fixed in F.A.A. The section of about 15-20 ìm thickness was stained with saffranin and fast green, and mounted with DPX for microscopic examination and diagrams of sections were taken by using Camera Lucida. For anatomical studies Metcalf and chalk (1950) and Trease and Evans (1972); for the macroscopical studies, Johansen (1940), Youngken (1951) and Cromwell (1955); for the powder analysis Jackson and Snowdon (1968); for colour reaction test I.P. (1966); Wallis (1950) for pharmacognosy, and Stahl (1969) for the physical evaluation were consulted. The extraction of plant powder was carried out with ethyl alcohol using a rapid extraction method (quality control methods for medicinal plant materials: (WHO, 1998).The sample of 5 g of the plant powder

was extracted with 25 ml of ethyl alcohol on water bath under reflex for 30 minutes. After cooling, mixture was filtrered. This filtrate was concentrated on a water-bath to a final volume of 10 ml. This concentrated solution was used for TLC. The Rf value was calculated by the formula.

$$Rf = \frac{\text{Distnace travelled by the spot from the point of application}}{\text{Distance between the point of application and solvent front}}$$

RESULTS AND DISCUSSION

The plant was an erect shrub, young parts clothed with white cottony tomentum; bark soft, corky and spongy. Stem is erect, branched, glabrous, woody below and herbaceous above, tomentose, solid, cylindrical and 160-210 cm long. Leaves are simple, cauline, ramal, sessile, opposite, decussate, exstipulate, thick, glaucous-green, elliptical or obovate oblong with cordate or often amplexicaul base, acute or shortly acuminate, unicostate reticulate venation, cottony pubescent when young, lamina 5.7 - 15.0 cm long and 4.5 - 8.2 cm broad, Table 1. Flowers in umbellate cymes, white, purple-spotted or pink, with erect petals, scented, in long- pedunculated cottony, which become glabrous; follicles sub-globose, ellipsoid or ovoid, recurved, 7.5-10.0 cm × 5.0-7.5 cm; seeds broadly ovate, acute, flattened, narrowly margined, light brown, comprising a tuft of silky hairs. Odour was observed strong and unpleasant, and taste was bitter.

The transverse section of stem showed single layered epidermis covered with thin cuticle; trichomes non-glandular and glandular; stomata paracytic; epidermis followed by 1-2 layered collenchymatous hypodermis; cortex composed of large, oval to elliptic shaped parenchymatous cells; pericycle fibres in groups, thick walled but unlignified except few of the cells in each strand less lignified; phloem fibres alternate, radial in position, with pericyclic groups of fibres and unlignified; xylem vessels circular to oval radially arranged; cambium prominent rectangular, radially compressed thin-walled cells; inner or intraxylary phloem present near the protoxylem; lactifers present abundantly between the pericyclic fibre and phloem, pith large parenchymatous. Aggregate crystals of calcium-oxalate and latex duct were present in paranchymatous cells of cortex and pith. Phloem elements in group also present in pith (Table 2).

Table 1. Macroscopical characters of *Calotropis procera*

Parameter	Value
Height of plant (cm)	R = 160.000 – 210.000
No. of leaves/ plant	SD = 50.360 ± 10.340; CV = 20.532
Leaf colour	Dark green
Lamina size (cm)	L = 12.333 ± 02.050; CV = 16.622
	W = 07.333 ± 01.160; CV = 15.819
Flowers/plant	SD = 15.940 ± 03.600; CV = 22.585

*Significant at 0.1%

Non-glandular trichomes were unicellular simple non warty and trichomes were sessile with unicellular oval head as well as stalked.Transverse section of leaf showed single layered epidermis, covered by thick and striated cuticle and non-glandular and glandular trichomes; stomata paracytic found on both the surface; collenchymatous cells 4-5 layered, one vascular bundle in centre, ground tissue smaller, parenchymatous 30-35 celled wide contained aggregate crystals of calcium-oxalate (Table 2) in midrib. Lamina showed dorsi-ventral and differentiated into 4-5 layered palisade and 9-10 layered spongy parenchyma with less air spaces. Stomata, paracytic present on both surfaces, more frequent on lower surface. The stomatal index was 19.41 ± 1.02 on upper epidermis and 23.05 ± 1.22 on lower epidermis.The palisade ratio between the palisade and epidermal cells was calculated and found to be 10.75-12.50 (Table 2).

Some salient characteristics were observed under microscope, *viz.* presence of fragments of upper and lower epidermis with paracytic stomata.Non-glandular as well as glandular trichomes were present. Collenchymatous cells with angular thickening were observed, parenchymatous cells of cortex and pith. Fragments of palisade and spongy tissue were analysed. Xylem vessels and tracheids with spiral and helical were observed thickenings. Unlignified phloem fibres parenchyma with sieve elements and companion cells.Cambium cells rectangular and thin-walled. Lacticifers elongated, unbranched pipe-like and associated with vascular tissue. Fragments of unlignified pericyclic fibres. Aggregate crystals of calcium-oxalate single or in groups were observed.

The preliminary colour reaction tests of plant powders and the result showed the presence of alkaloids, lignin, tannin, carbohydrates, proteins, sugars, subernin, glycosides, saponin, steroid and oil, and absence of flavins. Degrees of changes in colour reaction in Table 3.

Thin layer chromatography: After developing, the plate was examined under U V and visible light. Observations showed that number of chemical compounds in plant samples. The spots were 3-5. The Rf values are presented in Table 4.

The fluorescence behaviour of powder as well as their extracts in different solvent was studied under visible and ultraviolet light. The observations were recorded in Table 5.

Extractive values: The alcohol soluble extractive, water soluble extractive values and LOD are tabulated in Table 6.

Table 2. Anatomical characters of stem, leaf with powder analysis of madar plant

Character	Stem	Leaf	Powder analysis
Trichomes	Non-glandular	Non- glandular and glandular	Non- glandular and glandular
Unicellular and non- warty (mm)		F = 7 - 8 / unit area L = 0.350 ± 00.010 cv = 02.857 W = 0.040 ± 0.003 cv = 07.500	F =10 – 15 /unit area L = 00.350 ± 00.010 cv = 02.857 W = 00.042 ± 00.006 cv = 14.286
Multicellular (mm)		F=10 – 12 /unit area L = 00.301 ± 00.016 cv = 05.316 W = 00.030 ± 00.003 cv = 10.000	F = 7 – 8 / unit area L = 00.310 ± 00.020 cv = 06.452 W = 00.043 ± 00.004 cv = 09.302
Glandular sessile (mm)		F = 4 – 5 / unit area L = 00.092 ± 00.005 cv = 05.435 W = 00.080 ± 00.004 cv = 05.000	F = 2 – 3 / unit area L = 00.098 ± 00.006 cv = 06.122 W = 00.090 ± 00.006 cv = 06.667
Glandular (mm) stalked		————	F = 4 – 5 / unit area L = 00.225 ± 00.012 cv = 05.333 W = 00.035 ± 00.003 cv = 08.570
Cuticle (mm)		W = 00.020 ± 00.002 cv = 10.000	
Epidermis (mm)	L = 00.035 ± 00.005 cv = 14.286 W = 00.028 ± 00.007 cv = 25.000	L = 00.049 ± 00.004 cv = 08.163 W = 00.042 ± 00.003 cv = 07.143	
Collenchyma (mm)	L = 00.036 ± 00.005 cv = 13.889 W = 00.030 ± 00.004 cv = 13.333	L = 00.047 ± 00.005 cv = 10.638 W = 00.043 ± 00.004 cv = 09.302	————
Pericycle	L = 00.041 ± 00.006 cv = 14.634 W = 00.026 ± 00.005 cv = 19.231	————	
Palisade cell (mm)		4 – 5 layered	
Spongy parenchyma (mm)	————	L = 00.048 ± 00.005 cv = 10.417 W = 00.040 ± 00.004 cv = 10.000	————
Stomata			
Guard cell (mm)	————	L = 00.160 ± 00.012 cv = 08.000 W = 00.045 ± 00.006 cv = 13.333	L = 00.160 ± 00.014 cv = 08.750 W = 00.045 ± 00.006 cv = 13.333
Stomatal pore (mm)	————	L = 00.100 ± 00.008 cv = 08.000 W = 00.044 ± 00.003 cv = 06.818	L = 00.100 ± 00.012 cv = 12.000 W = 00.044 ± 00.003 cv = 06.818

Character	Stem	Leaf	Powder analysis
Trichomes	Non-glandular	Non- glandular and glandular	Non- glandular and glandular
Parenchyma (mm)	L = 00.064 ± 00.005 cv = 07.813 W = 00.037 ± 00.004 cv = 10.811	L = 00.045 ± 00.003 cv = 06.667 W = 00.038 ± 00.005 cv = 13.158	
Pericycle (mm)	L = 00.041 ± 00.006 cv = 14.634 W = 00.026 ± 00.005 cv = 19.231		
Xylem vessel (mm)	L = 00.068 ± 00.005 cv = 07.353 W = 00.044 ± 00.003 cv = 06.818		L = 01.050 ± 00.127 cv = 12.095 W = 00.055 ± 00.008 cv = 14.545
Diameter of xylem pore (mm)			D = 00.095 ± 00.025 cv = 26.315
Xylem tracheid (mm)			L = 00.830 ± 00.078 cv = 09.398 W = 00.150 ± 00.009 cv = 06.000
Xylem fibre (mm)			L = 00.575 ± 00.093 cv = 16.714 W = 00.055 ± 00.005 cv = 09.091
Pith cell (mm)	L = 00.045 ± 00.002 cv = 04.444 W = 00.030 ± 00.001 cv = 03.333		
Stone cell (mm)			L = 00.096 ± 00.008 cv = 08.333 W = 00.036 ± 00.004 cv = 11.111
Aggregate crystals	L = 00.032 ± 00.003 cv = 09.375 W = 00.026 ± 00.002 cv = 07.692	F = 7 – 8 / unit area L = 00.036 ± 00.004 cv = 11.111 W = 00.028 ± 00.003 cv = 10.714	F = 7 – 8 / unit area L = 00.038 ± 00.004 cv = 10.526 W = 00.028 ± 00.003 cv = 10.714
Palisade ratio		R = 10.75 - 12.50 SD = 11.50 ± 00.616 cv = 05.357	
Latex duct	F = 2 - 3 / unit area		L = 00.105 ± 00.009 cv = 08.571 W = 00.042 ± 00.002 cv = 11.905
Stomatal index			
Upper Surface	————	SD=19.410 ± 01.290 cv = 06.646	
Lower surface	————	SD= 23.050 ± 00.320 cv = 10.065	
Vein islets number	————	SD =24.000 ± 03.265 cv = 13.604	
Vein termination number	————	SD = 28.00 ± 01.633 cv = 05.832	

Significant at 0.1%; * 1.0%; **5.0%

Table 3. Preliminary colour reaction tests of *Calotropis procera*

Reagent	Test for	Nature of colour	Degree of changes
Dragenorff's Reagent {Cromwell (1955)}	Alkaloid	Orange ppt	++++
Mayer's Reagent	Alkaloid	Brown	+++
Wagner's Reagent (Trease and Evans (1983))	Alkaloid	Brown	++
Tannic Acid	Alkaloid	Turbidity	++
Hager's Reagent	Alkaloid	Yellow	+++
Phloroglucinol + HCl	Lignin	Dark red	+++
$FeCl_3$	Tannin	Black	++++
Molisch's Test	Carbohydrates	Red	++++
Fehling Solution	Carbohydrates	Red	+++
Millon's Reagent	Protein	Red	++++
Xanthoproteic Test	Protein	Yellow	++++
Bendict's Reagent after Heating	Sugars	Yellow red	++
Sample + Heating with Strong KOH + H_2SO_4	Subernin	Red black	++++
Molisch's Test after Hydrolysis	Glycoside	Red	++++
Plant Powder + H_2O + Shake	Saponin	Froth (W)	++++
Plant Powder + Conc. HCl	Flavin	Negative	———-

Table 4. Rf values of *Calotropis procera*

Wavelength →	Sunlight	UV Light (254 nm)	UV Light (365 nm)
Rf values →	0.33, 0.53, 0.93	0.33, 0.53, 0.86	0.13,0.33,0.47,0.53, 0.93

Total ash values: The Ash values are tabulated in Table 6.

Pharmacognostical study plays a very important role in the determination of purity, quality and identification of crude plant drugs. In order to determine the quality of medicinal plants along with its authenticity, pharmacognostical characters, viz. macroscopical, anatomical, powder analysis, chemical analysis, TLC, fluorescence behaviour, extractive values and ash values are very important. Anatomy often proves very useful for individual identification of plants, so microscopical methods are of great value for their precise identification and any differentiation in the authenticity of plant drugs. They provide evidences concerning to relationship of groups such as families or help to establish the affinities of genera of uncertain taxonomic status. So far as the anatomical studies of stems and leaves of plants are concerned, microscopy is an important tool (instrument) in determining different species in a particular genus or in checking adulteration of a particular plant species in a given genuine sample. The number of stomata and epidermal cells, vein-islets and vein termination number per unit

Table 5. Colour change under UV fluorescence of *Calotropis procera*

Extract	Sunlight	UV light (264nm)	UV light (365nm)
Powder as such	Green brown	Blue green	Green blue
Water	Brown	Green	Green
Benzene	Lemon	Light green	Gray blue
Petroleum ether	Colour less	Green	Blue violet
Methanol	Green	Green	Gray
Chloroform	White	Light green	Green
Acetone	Green	Green	Pale green
Ethyl acetate	Green	Green	Pale gray
Ethyl alcohol	Green	Blue green	Green black

Table 6. Extractive values (%) and ash values (%) of *Calotropis procera*

	Extractive values (%)			Ash values (%)		
Parameter →	Water-soluble	Alcohol soluble	LOD	Total ash value	Acid insoluble	Sulphated ash
Percentage →	12.71 ± 1.03 CV = 08.118	16.18 ±0.81 CV = 5.024	18.68 ±0.63 CV = 3.371	18.68 ±2.03 CV = 10.89	13.13 ± 0.42 CV = 3.224	3.689 ± 0.33 CV = 8.95

area, palisade ratio, stomatal index etc. provide constant data for different species of plants. Moreover, different types of stomata, crystals, fibers, trichomes etc. present in powdered drug help in authenticating of certain plants species in a given sample. Our findings are in conformity with the repot of Prasad and Bhattacharya, 1959; Mehra Karnik, 1969; Rashmi *et al*., 2007 and Rashmi and Tyagi, 2009.

These characters give easy clue to detect out the drug from other common species of *Calotropis* and help in checking the adulteration and achieving desired therapeutic values of plant. The numerical data can also be considered as a diagnostic constant in the identification of genuine raw drug.

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Effect of corm size on growth and flowering behaviour of gladiolus (*Gladiolus hybrida*) hybrids under different plant spacings in midhill areas of Himachal Pradesh

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ABSTRACT

An experiment was conducted to find out the effect of corm size and plant spacings on growth, flowering and corm production of newly- developed gladiolus (*Gladiolus hybrida* L.) hybrid ,Hb 1-8, during 2009-10 at the Department of Floriculture and Landscaping, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh.Three corm sizes (3.0-3.5 cm, 3.6-4.0 cm and 4.1-4.5 cm) and three spacings (30cm × 6cm, 30cm × 10cm and 30cm × 14 cm) were tested in a randomized block design replicated thrice. The hybrid, Hb1-8, with S_3 and P_3 showed better performance for number of days taken for sprouting (13.11 days), plant height (88.23 cm), number of days taken for bud break (100.29 days), number of days taken for first floret opening (104.45 days), spike length (73.44 cm), number of corms/ plant (1.69) and number of cormels (33.76).

Key Words: Corm, Flowering, Gladiolus, Hybrid, Plant height, Midhill areas

Gladious *(Gladiolus hybrida* L.) is an ornamental bulbous plant that stands for its beauty of flowers and perfection. The highly decorative and attractive spikes are predominantly used for cut flowers. The availability of different species and varieties enabled the use of gladiolus for different purposes.*Gladiolus primulinus* being very attractive, is most suitable for mixed borders, *G. grandiflorus* is quite ideal for exhibition purposes, whereas *pixiola* type like *nanus*, *colvillei*, *byzantinus* etc. are accredited to be very useful for forcing under glasshouses besides for pot culture (Misra *et al.,* 2006). The spikes of gladiolus are very popular in various flower arrangements as they are used for preparing high class bouquets (Mukhopadhyay, 1995). It ranks next to tulip among bulbous cut flowers in the flower markets of Holland (Misra *et al.,* 2006). In India, it is grown commercially in over 6,000 ha (Nair and Singh, 2004).

The quality as well as quantity of flower spikes and daughter corms depend on several factors such as growing environmental conditions, size of corm and cormel, depth of planting, time of planting and fertilizer management including cultural operations (Arora and Khanna 1990). Gladiolus is mainly propagated by corms and size of mother corms and planting density play very important role in production of quality spikes and propagation index. The size of corm influences growth, development, yield and quality of flowers and propagules. Similarly, spacing affects photosynthetic activities as well as availability of nutrients to plants, affecting quality of spikes and corms considerably. Therefore, an experiment was conducted to find out the optimum spacing between plants and the effect of different corm sizes on growth, flowering and multiplication.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm of Department of Floriculture and Landscaping, College of Horticulture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh), during March-October 2009. The experimental farm is located at 1 276 m above mean sea- level at a latitude of 30°52′N and longitude of 77°11′33″E.The climate of this area is typically semi-temperate. Maximum temperature during the investigation ranged from 24.9°C to 33.3°C and minimum temperature from 8.47^0 C to 19.5°C. Maximum and minimum relative humidity was 85 and 18% respectively. Maximum rainfall was 408 mm. The newly- developed hybrid of gladiolus, Hb1-8, was selected for the present studies.

The field was ploughed to a depth of 30-40 cm to get a fine tilth. The clods were broken and weeds as well as stones were removed. A basal dose of fertilizers

and manure comprising 5 kg FYM, 30 g N, 20 g P_2O_5 and 20 g K_2O/m^2 were incorporated in soil. The nitrogen was supplied in the form of calcium ammonium nitrate, P_2O_5 in the form of single super- phosphate and K_2O as muriate of potash at the time of field preparation, respectively. The nitrogen was applied in two split doses. Second dose of nitrogen was applied at the time of six-leaf stage. The hybrid with corms of varied sizes, i.e. 3.0-3.5 cm, 3.6-4.0 cm, 4.1-4.5 cm were treated with Dithane M-45(0.2%) and Bavistin (0.1%) before planting. Corms were planted at a spacing of 30 cm × 6 cm, 30cm × 10 cm and 30cm × 14 cm, thereby adjusting 16, 10 and 7 corms/m^2 respectively. The depth of planting was twice the size of the corms.

The experiment was laid out in an open field on 26 March 2009 in a randomized block design (factorial) using 9 treatment combinations, and replicating thrice. There were 7 plants per replication. After 40 days of planting earthing- up was carried out and half dose of nitrogen was given in the form of CAN. After planting pre-emergence spray of paraquat (6 ml/litre) was applied to control the weeds. The weeds namely, *Cyprus rotundus* and *Oxalis latifolia* were most prominent. Hoeing was done manually. This helped in controlling the weed population as well as for better aeration and moisture conservation. The field was irrigated depending upon requirement of plants. Generally, plants were watered daily during the first week of transplanting and later on alternate days.

Crop was sprayed with Rogor (1.5 mg/ltre) to control the thrips. Drenching of Dithane M-45 (0.2%) and Bavistin (0.1%) was carried out at regular intervals of 15-20 days to check fungal diseases. The data were recorded on days taken to sprouting (days), plant height (cm), days taken to bud break (days), days taken to first floret opening (days), duration of flowering (days), spike length, total number of florets/ spike, weight of spike (g), days taken for harvesting stage (days), size of florets (cm), number and size of corms/ plant, number and weight of cormels/ plant. Disease and insect pest incidence was checked at regular intervals. The statistical analysis of data was carried out as per method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The interaction effect of corm size (S) and plant spacing (P) was significant (Table1).Earlier sprouting was observed with S_3P_3 taking 13.11 days. However, maximum number of days for sprouting was observed with S_1P_2 which took 20.90 days. This might be due to that with wider spacing, large- sized corms received more space and nutrients at initial stage and resulted in early sprouting (Shalini *et al.*, 2004) also reported similar results with gladiolus cv. Debonair.

The interaction effect of corm size and spacing (S × P) also revealed significant differences in plant height. Plants with maximum height (88.23cm) were as recorded in S_3P_3 interaction. Smallest plants were recorded for S_1P_1 (60.81). This might be due to more food reserves in large corms and more photosynthetic activities when raised with wider spacing. The beneficial effect of large corms and greater planting distance confirms earlier findings of Mukhopadhyay and Yadav (1984) and El-Gamassy and El-Gendy (1962).

There were significant differences in interactions between corm size and plant spacing (S × P) as early bud break in S_3P_3 took minimum number of days (100.29) and S_1P_1 showed delayed bud break taking 112.07 days (Table 1). This might be due to more food reserves in large corms and more photosynthetic activities when raised with wider spacing.

The data elucidated that S_3P_3 took lesser days for commencement of flowering which occurred in 104.45 days. In contrast, S_1P_1 showed delayed flowering taking 115.87 days. It is evident that S_3P_3 interaction resulted in maximum duration of flowering, bearing flowers for 12.27 days, whereas S_1P_1 showed minimum flowering duration of 7.07 days (Table 2). Beneficial effects of larger corm size and wider plant spacing on duration of flowering have been reported by Kumar and Yadav (2006), Sharma and Gupta (2003).

The corm size and plant spacing (S × P) revealed that maximum spike length was recorded in S_3P_3 producing 73.44 cm spike length. In contrast, S_1P_1 produced smaller spikes of 46.02 cm length. Beneficial effect of larger corm size and wider spacing have been documented by Shiraz Shalini *et al.* (2004), Sharma and Gupta (2003), Patil *et al.*(1995), Mukhopadhyay and Yadav (1984).

There was maximum weight of spike (51.51 g) in S_3P_3 interaction. However, minimum spike weight (23.12 g) was recorded in S_1P_1 interaction. This might be due to more photosynthetic activities in wider spaced plants as they received more sunlight and bigger corm size owing to more reserve foods also contributed for better spike weight.

There was minimum number of days (102.7) for harvesting stage, recorded in S_3P_3 interaction. However, maximum days were registered by S_1P_1 (114.02) interaction. Larger- sized corms may have provided sufficient food material to plants due to which they might have reached harvesting stage earlier than plants raised from smaller corms. Wider spacing provided sufficient space to plants which helped the plants to utilize more water, nutrition, air and light to put better growth.There was maximum floret size (9.48 cm) in S_3P_3 interaction. However, minimum floret size was noticed in S_1P_1 (5.88 cm) interaction. Beneficial effects

Table 1. Effect of spacing and corm size on vegetative characters of gladiolus

	Days taken for sprouting			Plant height (cm)			Days taken to bud break			Days taken for first floret opening		
	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)
S_1 (3.0-3.5 cm)	20.80	20.90	19.62	60.81	63.13	65.98	112.07	109.29	109.75	115.87	112.72	114.27
S_2 (3.6-4.0 cm)	17.85	17.78	17.50	73.25	74.82	77.45	110.20	102.94	104.15	113.44	106.42	107.94
S_3 (4.1-4.5 cm)	14.57	13.98	13.11	81.99	83.99	88.23	102.06	102.45	100.29	105.86	106.37	104.45
CD (5%)	Hybrid × Corm size × Plant spacing (H×S×P) = 0.87			Hybrid × Corm size × Plant spacing (H×S×P) = 0.58			Hybrid × Corm size × Plant spacing (H×S×P) = 0.87			Hybrid × Corm size × Plant spacing (H×S×P) = 1.19		

Table 2. Effect of spacing and corm size on floral characters of gladiolus

	Duration of flowering			Spike length			Weight of spike			Days taken for harvesting stage		
	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)
S_1 (3.0-3.5 cm)	7.07	7.29	7.30	46.02	48.34	51.19	23.12	26.06	30.74	114.02	110.99	112.71
S_2 (3.6-4.0 cm)	7.86	8.50	9.20	58.46	60.03	62.66	34.60	35.69	38.12	111.65	104.89	106.12
S_3 (4.1-4.5 cm)	9.70	10.93	12.27	67.20	69.20	73.44	42.58	45.93	51.51	104.12	104.42	102.71
CD (5%)	Hybrid × Corm size × Plant spacing (H×S×P) = 0.35			Hybrid × Corm size × Plant spacing (H×S×P) = 0.58			Hybrid × Corm size × Plant spacing (H×S×P) = 1.44			Hybrid × Corm size × Plant spacing (H×S×P) = 1.61		

Table 3. Effect of spacing and corm size on corm characters of gladiolus

	Duration of flowering			Spike length			Weight of spike			Days taken for harvesting stage		
	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)	P_1 (30×6 cm)	P_2 (30×10 cm)	P_3 (30×14 cm)
S_1 (3.0-3.5 cm)	5.88	6.38	7.12	1.07	1.17	1.30	2.82	3.22	3.56	2.87	11.20	17.47
S_2 (3.6-4.0 cm)	7.28	7.65	8.70	1.35	1.39	1.44	3.33	3.76	3.98	18.29	19.60	20.83
S_3 (4.1-4.5 cm)	8.85	9.07	9.48	1.56	1.60	1.69	4.25	4.26	4.49	24.54	28.87	33.76
CD (5%)	Hybrid × Corm size × Plant spacing (H×S×P) = 0.38			Hybrid × Corm size × Plant spacing (H×S×P) = 0.05			Hybrid × Corm size × Plant spacing (H×S×P) = 0.16			Hybrid × Corm size × Plant spacing (H×S×P) = 1.61		

of larger corm size and wider plant spacing has been documented by Shiraz Shalini *et al.* (2004), Patil *et al.* (1995), Mukhopadhyay and Yadav (1984).

Interaction was found to be significant as S_3P_3 produced maximum corms/plant, i.e. 1.69, whereas minimum number of corms /plant were recorded in S_1P_1 (1.07) interaction. The positive response of wider spacing on corm production might be due to availability of more nutrients and light which ultimately increased the rate of net photosynthesis and translocation of assimilates to storage organs. Sharma and Gupta (2003) observed maximum number of corms/ plant (1.51) with wider plant spacing (40cm×40 cm), whereas minimum number of corms/ plant (1.00) were produced when plants were raised under closer spacing (10cm × 40 cm). The results were in the accordance to those of Kumar and Yadav (2006), Anwar and Maurya (2005), Nair and Singh (2004), Singh and Singh (2000), Singh and Bijimol, (1999), Mukhopadhyay and Yadav (1984).

Spacing and size (S × P) interaction revealed that significantly bigger size of corms were noticed with S_3P_3 (4.49 cm), whereas smallest corm size was noticed in S_1P_1 (2.82 cm) interaction. Beneficial effect of large corm size and wider plant spacing have been reported by Kumar and Yadav (2006), Anwar and Maurya (2005), Dilta *et al.* (2004), Nair and Singh (2004), Sharma and Gupta (2003), Sharma and Talukdar (2003), Singh and Singh (2000).

There was maximum number of cormels (33.76) registered by S_3P_3 interaction (Table 1, 2 and 3). S_1P_1 produced minimum number of cormels/ plant, i.e. 2.87. This observation can further be explained in the light of beneficial effects of large corm size and wider plant spacing as reported by Kumar and Yadav (2006), Nair and Singh (2004), Shalini *et al.* (2004), Sharma and Gupta (2003), Sharma and Talukdar (2003), Singh and Singh (2000), Laskar and Jana (1994), Arora and Khanna (1990), Mukhopadhyay and Yadav (1984).

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Evaluating pharmacognostical properties of latjira (*Achyranthes aspera*) for medicinal value

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ABSTRACT

The *Achyranthes aspera* Linn; a wild medicinal plant, pharmacognostically it is important and has 0.3-0.9m height. It has 16.62 cm^2 leaf area and fruits are very minute and utriculate type. The stem has wavy margins and anatomically two meduallary vascular bundles. There are gylandular and non-glandular trichomes. Non-glandular trichomes are unicellular, bicellular and multicellular. Leaves and stomatal index on upper surface (11.82-1304) and lower (10.00 - 10.98) are found. Vein islet number and vein termination are 16-24 and 24-14 respectively. The Rf values were 0.24, 0.29, 0.37, 0.90 in sunlight , 0.20, 0.24, 0.29, 0.37 and 0.90 in UV light (254 mm). Fluorescence of powdery form has green colour in sunlight and UV light (264 mm) and orange in 365 mm UV light, veined in water.

Key Words: Pharmacognosy, *Achyranthes aspera*, ISM, Macroscopical, Microscopical, Chemical analysis, TLC, Powder analysis, Extractive, Ash value

Latjira *(Achyranthes aspera* Linn.) of the family Amaranthaceae is an erect, annual or perennial herb. The plant drug is used in Ayurveda, Homoeopathy and Unani, especially for curing hydrophobia, leprosy, cough, rheumatism etc. It is much valued in indigenous medicine. The plant ash is rich in potash and it is suggested that the plant might be of value as a cheap green manure (CSIR, New Delhi 1950). The plant is used as one of the ingredients in the "Siddha" preparation of "NaagaParpam" and "Naaga Chendooram". Fruits contain a large amount of alkaline ash with potash. Plant grows in drier situations but does not tolerate waterlogging. The plant contains amyrin, campesterol, b-sitosterol, palmatate acid, chrysin, flavanoid, glucosides, hentriacontane, saponin, oleanolic acid, achyranthine (betaine), ecdysterone, ecdtstone, inokosterone and amino acids. Seeds contain mainly saponina and hentriacontane, alkaloid, oleanolic acid, saponin and achyranthine (Joshi, 2000). It is a pungent and laxative and used in piles, *boils eruption* of the skin etc. The seeds are useful in piles and leprosy. The pharmaceutical industries are facing a problem for the shortage of good raw material. It is essential to ascertain the quality of a plant material before it is employed for the preparation of drugs. It is required to ascertain the genuineness of plant species before preparation of medicines. So an attempt was made for detailed pharmacognostical studies of its whole plant. These data can be considered as a diagnostic constant in identification and authentication of the raw drug.

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MATERIALS AND METHODS

The plant samples of latjira were collected from the area of ALTT Centre, Ghaziabad. For anatomical studies, twig samples of third internode were used. The samples were fixed in FAA and were sectioned on a sliding microtome to obtain section of about 15-20 µm thickness. Diagrams of sections were taken using Camera Lucida. For anatomical studies Metacalf (1980) and Trease and Evans (1972); for the macroscopical studies, Johansen (1940), Youngken (1951) and Cromwell (1955) ; for the powder analysis Jackson and Snowdon (1968); for colour reaction test I.P. (1966); Wallis (1950) for pharmacognosy, and Stahl (1969) for the physical evaluation were consulted. TLC was investigated as per the WHO, 1998.

RESULTS AND DISCUSSION

Plant is an erect and 0.3-0.9m in height. Stem is stiff simple or branched, pubescent, quadrangular, ribbed, green often tinged with reddish purple colour. Leaves

are thick ,variable, ovate, elliptic or obovate, sometimes nearly orbicular, usually rounded at apex and soft on both sides, pubescent, tomentose; margin entire and slightly wavy, upper surface glabrous and below surface rough with reticulate venation. Petiole is 4.5–7.0 cm long and 2.5–4.0 cm broad. Flowers are greenish white in colour, numerous, stiffly deflexed against the woolly-pubescent rachis; in elongate terminal spikes which are at first short but soon lengthen, reaching as much as 50 cm. Fruits are utricles, oblong or ovoid, indehiscent, top areolate or rounded. Seeds are brown, oblong, testa coriaceous and are black in colour (Fig. 1). The results are given in Table 1.

Stem: Transection shows circular in outline with 6-10 ridges and furrows. Epidermis is single layered covered with thin cuticle and both types of trichomes, non-glandular as well as glandular. Hypodermis 1-4 layers of collenchymatous cells in ridges and 1–2 layers of collenchymatous cells in furrows. Cortex 2-5 layers of parenchymatous cells; endodermis well distinguished, as a single layered barrel shaped cells,

Table 1. Macromorphological characters of *Achyranthes aspera*

Parameter	Results
Leaf colour	Dark green
Stem colour	Green
Height of plant (cm)	63.333 ± 28.674; CV = 45.275
No. of leaves/ plant	320.60 ± 14.100; CV = 4.390
Leaf area (cm^2)	16.616±8.359 ; CV = 5.171
Petiole size (cm)	L=5.083±0.705 ; CV = 13.869
	W=3.200 ± 0.505 ; CV = 15.780
Spikes/plant	48.600 ± 8.800; CV = 18.100
Lamina size (cm)	L =5.750±0.559; CV = 9.722
	W = 3.750±0.559; CV = 14.907

and pericycle with 3-4 layers. Stem shows prominent anomalous secondary growth. The vascular system consists of primary phloem, secondary phloem, cambium, secondary xylem, prosenchyma (conjuctive tissue) and primary xylem. Primary phloem is crushed and obligated, whereas secondary phloem are multilayered and formed a complete ring.

About 2 – 3 layers of sclerenchymatous pericycle also noted. Phloem is made up of small zone consisting of sieve tubes, companion cells and phloem parenchyma. Cambium is well distinct. Secondary xylem and prosenchyma are undistinguishable with large xylem vessels and thick walled prosenchyma. Primary xylem is present near the pith. The central part of the stem is occupied by thin walled parenchymatous pith containing two medullary vascular bundles. Pith cells contain micro crystals of calcium oxalate and some irregularly shaped stone cells with narrow lumen (Fig. 1).

Leaf: The leaf shows single layer of epidermis with two types of trichomes. Stomata are of paracytic and anomocytic and more frequent on lower surface.The length and breadth of pore are 0.09 – 0.10 mm and 0.03 –0.04 mm. The stomatal index of upper and lower surface of leaves are 11.82 – 13.04 and 10.00 – 10.98 respectively. Midrib contains 5-6 layers of collenchyma below the upper epidermis and 1-2 layers below the lower epidermis; meristele having 4 collateral conjoint vascular bundles. Mesophyll is differentiated into 7- 8 layers of palisade and 4-5 layers of spongy parenchyma. Micro crystals of calcium oxalate are present in parenchymatous cells. The vascular bundles are covered by bundle sheath (Plate 1, Fig C). The result are given in Table 2.

Trichomes: There are two types of trichomes, non-glandular as well as glandular found on both the surfaces of leaf. Non-glandular trichomes are of three types, viz. unicellular, bicellular and multicellular. Unicellular trichomes with wavy margins and warts and bifurcated on apex; bicellular trichomes contain small basal cell and large apex cell and are more frequent. Multicellular trachomas contain 2-7 cells with small basal cell. Glandular trichomes are of two types, multicellular as well as sessile. These contain 2- 6 celled stalk and 1-8 celled head.

Vein islet number and vein termination number: The values of vein islet number and vein termination number are 16 - 24 and 12 - 14 respectively in leaves.

Powder analysis: Powder is green in colour. The microscopical features of plants powder are studied under microscope (Fig. 1).

Fragments of numerous unicellular trichomes are noted.

Fragments of helical to spiral xylem vessels are identified.

Fragments of parenchyma cells present, which are polygonal to rectangular in shapes.

Fragments of palisade and spongyparenchymatous cells are identified.

Crystals of calcium oxalate are in the form of rosette, tetragonal, cubic and prism shaped found in parenchymatous cells.

Vessels with annular thickening with simple perforation rims, their length and width are measured.

Tracheids are few. These are pitted, simple and elongated with narrow end.

Xylem fibres are present in both the cases.

Stone cells with irregular shapes are found in plant powder (Table 2).

Chemical analysis

Preliminary colour reaction tests: Various chemical

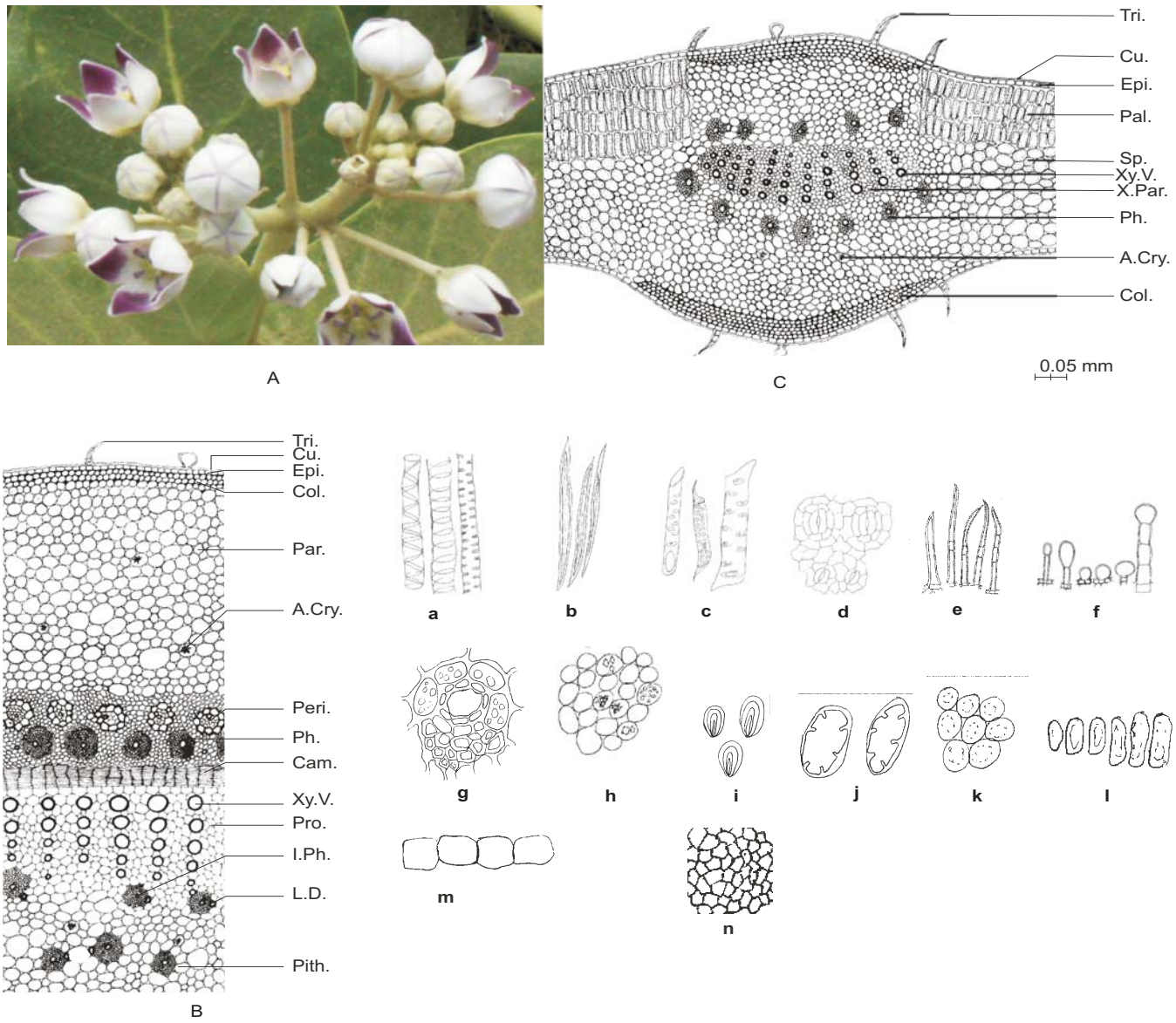

Fig. 1. Microscopical characters of latjira plant

Abbreviations of plates

M. Cry.- Micro Crystal; Par. –Parenchyma; P.Cell - Parenchymatous Cell; P.L.-Palisade Layer; Peri – Pericycle; Ph.-Phloem; Pro.- Prosenchyma; R. Cry.- Rosette Crystal; S. – Stomata; St .C.- Stone Cell; S. Par. – Spongy Parenchyma; Tri. – Trichome; V.B. - Vascular Bundle; X.V - Xylem Vessels; Xy – Xylem.

A. Morphology
B. Transverse section of stem
C. Transverse section of leaf through midrib
D. Powder analysis-
a Different types of xylem vessels
b Different types of tracheids
c Different types of fibres
d Some cells containing yellow content
e Different types of non-glandulartrichomes
f Different types of glandular trichomes
g Stone cells
h Palisade cells
i Epidermal cell
j Some parenchymatous cells containing rosette crystals
k Phloem parenchyma
l Cells of parenchyma
m Spongy parenchyma
n Stomata

Table 2. Anatomical characters of stem, leaf with powder analysis of *Achyranthes aspera*

Character	Stem	Leaf	Powder Analysis
Trichomes	Non-glandular	Non- glandular and glandular	Non- glandular and glandular
Unicellular and warty (mm)		F =10–19 / unit area L = 0.185 ± 0.030 CV=16.216 W = 0.037 ± 0.006 CV=16.216	L = 0.295 ± 0.035 CV = 11.864 W = 0.045 ± 0.006 CV=13.333
Multicellular (mm)	——	F = 8 – 10/ unit area L= 0.610 ± 0.003 CV=0.490 W =0.022 ± 0.008 CV=36.363	L= 0.690 ± 0.003 CV=0.434 W = 0.022 ± 0.008 CV=36.363
Glandular (mm)	——	4-5/unit area L= 0.012± 0.001 CV=8.333 W = 0.008 ± 0.002 CV=25.000	L= 0.014 ± 0.006 CV=42.857 W = 0.008 ± 0.002 CV=25.000
Cuticle (mm)	W= 0.035 ± 0.001 CV= 2.857	W = 0.028± 0.004 CV=14.286	——
Epidermis (mm)	L= 0.036 ± 0.004 CV= 10.246 W = 0.037 ± 0.007 CV = 18.667	L = 0.061± 0.012 CV=19.672 W = 0.050 ± 0.003 CV=6.000	——
Collenchyma (mm)	L = 0.056 ± 0.012 CV = 21.428 W = 0.041 ± 0.006 CV = 14.634	L = 0.048 ± 0.004 CV=8.333 W = 0.047 ± 0.003 CV=6.382	——
Chlorenchyma (mm)	L = 0.065 ± 0.003 CV = 4.615 W = 0.040 ± 0.004 CV = 10.000	——	——
Palisade cell (mm)	——	L = 0.067 ± 0.002 CV=2.985 W = 0.040 ± 0.009 CV=22.500	L = 0.067 ± 0.002 CV=2.985 W = 0.040 ± 0.009 CV=22.500
Spongy parenchyma (mm)	——	L = 0.057 ± 0.003 CV=5.217 W = 0.035± 0.003 CV=8.571	L = 0.057 ± 0.003 CV=5.217 W = 0.035± 0.003 CV=8.571
Stomata guard cell (mm)	——	L = 0.105 ± 0.012 CV=11.428 W = 0.042 ± 0.003 CV=8.571	L = 0.105 ± 0.012 CV = 11.428 W = 0.042 ± 0.003 CV = 7.142
Stomatal pore (mm)	——	L = 0.072 ± 0.006 CV=8.333 W = 0.035 ± 0.003 CV=8.571	L = 0.092 ± 0.009 CV=9.783 W = 0.035 ± 0.003 CV=8.571
Parenchyma (mm)	L = 0.069± 0.008 CV = 11.594 W = 0.033 ± 0.006 CV = 18.181	L = 0.095 ± 0.008 CV=8.421 W = 0.062 ± 0.003 CV=4.838	——

Character	Stem	Leaf	Powder Analysis
Endodermis (mm)	L= 0.028 ± 0.006 CV = 21.428 W= 0.018 ± 0.009 CV = 50.000	——	——
Pericycle (mm)	L = 0.039 ± 0.006 CV = 15.385 W = 0.018 ± 0.006 CV = 33.333	——	——
Phloem	Compressed	——	——
Cambium	Continuous	——	——
Prosenchyma (mm)	L= 0.070 ± 0.002 CV = 2.857 W = 0.038 ± 0.003 CV = 7.894	——	——
Xylem vessel (mm)	L= 0.048 ± 0.006 CV = 12.500 W = 0.045 ± 0.008 CV = 17.778	L = 0.062 ± 0.009 CV=14.516 W = 0.057 ± 0.009 CV=15.789	L = 0.825 ± 0.026 CV=3.151 W = 0.067 ± 0.018 CV=26.865
Diameter of xylem pore (mm)	——	——	D = 0.150 ± 0.024 CV=16.000
Xylem tracheid (mm)	——	——	L = 0.637 ± 0.011 CV=1.726 W = 0.060 ± 0.006 CV=10.000
Xylem fibre (mm)	——	——	L = 0.750± 0.028 CV=3.733 W = 0.395 ± 0.023 CV=5.822
Pith cell (mm)	L = 0.097 ± 0.022 CV = 22.680 W = 0.078 ± 0.028 CV = 35.897	——	——
Stone cell (mm)	L = 0.074 ± 0.002 CV = 2.702 W= 0.035 ± 0.008 CV = 22.857	L = 0.085± 0.002 CV = 2.353 W = 0.050±0.005 CV = 10.00	L = 0.094 ± 0.006 CV = 6.383 W = 0.030 ± 0.004 CV = 13.333
Micro crystals	2-4/unit area	3-4 / unit area.	——
Palisade ratio	——	——	R = 7.500 – 10.750 SD = 8.680 ± 0.240 CV=2.765
Stomatal index			
Upper surface	——	——	R= 11.827 – 13.043 SD = 12.397 ± 0.517 CV=4.170
Lower surface	——	——	R= 9.090 – 12.280 SD = 10.970 ± 0.192 CV=1.750
Vein islets number	——	——	R= 16.000 – 24.000 SD = 19.333 ± 0.099 CV=2.064
Vein termination number	——	——	R= 12.000– 14.000 SD=12.666 ± 0.942*** CV=7.437CV=6.320

tests are carried out with plant powder The result shows the presence of alkaloids, lignin, carbohydrates, protein, suberin, glucoside, saponin, flavoanoid, steroid, oils (traces). Tannin and sugars are absent. Degree of changes in colour reaction test is given in Table 3.

TLC : Number of spots was observed from the TLC plate. Their Rf values are given in Table 4.

Fluorescence behaviour of powder: The Fluorescence behaviour of the plant powder as well as its extracts in different solvents is studied. Some coloursare observed with extract which are given in Table 5.

Extractive and ash values: The percentage of water soluble, alcohol soluble, LOD, total ash, acid insoluble ash and sulphated ash were studied (Table 6).

Table 3. Colour reaction tests of *Achyranthes aspera*

Reagent	Test for	Nature of colour	Degree of changes
Dragenorff's Reagent	Alkaloid	Orange ppt	++++
Mayer's Reagent	Alkaloid	Brown	++
Wagner's Reagent	Alkaloid	Brown	+++
Tannic acid	Alkaloid	Turbidity	++
Hager's Reagent	Alkaloid	Yellow	++
Phloroglucinol + Hcl	Lignin	Dark Red	+++
$FeCl_3$	Tannin	Negative	-
Molisch test after hydrolysis	Glycoside	Yellow	+++
Millon's Reagent	Protein	Red Ppt	+++
Xanthoproteic test	Protein	Yellow	++++
Bendict's Reagent after heating	Sugars	Negative	-
Sample + heating with strong KOH + H_2SO_4	Suberin	Red Black	+++
Molisch test	Carbohy-drates	Red	+++
Plant powder + H_2O + shake	Saponin	Froth (W)	+++
Mg powder + Conc. HCL	Flavin	Green Black	+++
Libermann's Buchard Reagent	Steroids	Violet	+++
Sudan IV	Oils	Red	++

Table 4. Rf values of *Achyranthes aspera*

Wavelength →	Sunlight	UV Light (254 nm)	UV Light (365nm)
Rf values →	0.24, 0.29, 0.37, 0.90	0.20, 0.24. 0.29, 0.37, 0.90	0.24, 0.37, 0.90

Table 5. Fluorescence nature of *Achyranthes aspera*

Extract↓	Visible (sunlight)	UV Light (264nm)	UV Light (365nm)
Powder as Such	Green	Green	Orange
Water	Yellowish brown	Leafy green	Green
Benzene	Yellow	Green	Orange
Chloroform	Yellowish green	Green	Orange
Acetone	Yellowish green	Dark green	Red
Phenyl ether	Colourless	Light green	Pink orange
Ether acetate	Green	Green	Orange
Methanol	Green	Green	Redish orange
Ether alcohol	Dark green	Black green	Black orange

Pharmacognostical study plays a very important role in the determination of purity, quality and identification of crude plant drugs. In order to determine the quality of medicinal plants along with its authenticity, pharmacognostical characters, viz. macroscopical, anatomical, powder analysis, chemical analysis, TLC, fluorescence behaviour, extractive values and ash values are very important. Anatomy often proves very useful for individual identification of plants, so microscopical methods are of great value for their precise identification and any differentiation in the authenticity of plant drugs. They provide evidences concerning to relationship of groups such as families or help to establish the affinities of genera of uncertain taxonomic status.

So far, as the anatomical studies of stems and leaves of plants are concerned, microscopy is an important tool (instrument) in determining different species in a particular genus or in checking adulteration of a particular plant species in a given genuine sample. The number of stomata and epidermal cells, vein-islets and vein termination number per unit area, palisade ratio,

Table 6. Extractive values and ash values (%) of *Achyranthes aspera*

Parameter	Extractive Values (%)			Ash Values (%)		
→	Water soluble	Alcohol soluble	LOD	Total ash value	Acid insoluble	Sulphated ash
Percentage ®	15.627± 0.391 CV = 2.502	24.607 ± 0.750 CV = 3.047	15.670 ± 0.290 CV = 1.851	11.169 ± 0.146 CV = 1.307	1.786 ± 0.132 CV=0 .391	16.625 ± 0.241 CV=1.449

stomatal index *etc.* provide constant data for different species of plants. Moreover, different types of stomata, crystals, fibres, trichomes *etc*. present in powdered drug help in *authenticating* of certain plants species in a given sample.Our findings go inconformity with those of Prasad and Bhattacharya (1959); Mehra and Karnik (1969); Rashmi *et al*. (2007) and Rashmi and Tyagi (2009).

Thus, distinguished characters give easy clue to detect out the drug from other common species of *Achyranthes* and help in checking the adulteration, achieving desired therapeutic values of plants. The numerical data can also be considered as a diagnostic constant in the identification of genuine raw drug.

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Variability analysis for agro-morphological and phyto-chemical characters in Indian Aloe (*Aloe vera*) germplasm

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ABSTRACT

The study was undertaken to explore the variability for agro-morphological and phyto-chemical traits in the Indian Aloe [*Aloe vera* (L.) Burm. f.] germplasm at National Bureau of Plant Genetic Resources, New Delhi, during 2009-10. Several explorations were made in diversity- rich areas to collect the germplasm. Fifty diverse genotypes were collected from the 13 states in the country. These accessions were planted and studied for variability analysis for agro-morphological and phyto-chemical parameters. Significant differences were observed for both the traits, indicating a tremendous variability in Aloe germplasm. The highest estimate of genetic combining variability (GCV) was observed for fresh weight per plant (28.07%), followed by gel content (25.82%) and aloin content (18.81%), while highest heritability was recorded for fresh weight per plant (98.20%). High broad sense heritability along with high genetic advance and high genetic advance as per cent of mean was estimated for fresh weight per plant. The genotypes, IC11251, IC471883, IC112531, IC422483 and IC265889, were found superior with respect to yield and quality characters.

Key Words: Aloe, Aloin, Genetic variability, Phenotypic combining variability, Genetic combining variability, Heritability, Genetic advance

Aloe or *ghritkumari* [*Aloe vera* (L.) Burm. f.], commonly known as Indian Aloe is one of the important medicinal plants used in pharmaceutical and cosmetic industries. In India, its natural populations are vegetatively propagated. It is known to occur in dry and semi- dry areas and wildly distributed from dry northern plains to southern peninsular region. Fifty accessions were augmented from different indigenous sources and studied for variability analysis. The statistical parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), genetic divergence, heritability (broad sense) and genetic advance for different agro-morphological and quality traits were studied for assessment of variability in the germplasm. Heritability estimates along with genetic advance are useful in predicting the expected progress to be achieved through selection (Johnson *et al*., 1955). Burton and De Vane (1953) explained that the expected genetic advance under a particular system supplies true practical information, which is required by a plant breeder, since the success of any breeding programme depends upon quantum of variability present in the available germplasm.

MATERIALS AND METHODS

Fifty diverse genotypes of *Aloe vera* were collected from the naturally-occurring diversity rich areas of 13 states, viz. Uttarakhand (01), Uttar Pradesh (03), Delhi (05), Haryana (01), Rajasthan (30), Madhya Pradesh (01), Gujarat (01), Maharashtra (02), Andhra Pradesh (01), Karnataka (01), Tamil Nadu (02), West Bengal (01) and Odisha (01). These accessions were multiplied by vegetatively propagules and maintained at NBPGR Experimental Farm, Issapur, New Delhi. These genotypes of *Aloe vera* were evaluated in a randomized block design with three replications at two locations namely, NBPGR Experimental Farm Issapur, New Delhi and J.V. College Research Farm, Baraut, Uttar Pradesh, during *kharif* 2009 and 2010. Each entry was planted in two rows 4.5 m length with a spacing of 45 cm. The liquid crude gel was treated with activated charcoal and centrifuged at 15000 rpm for 30 minutes at 25°C. Prepared aloin sample by soaking in methanol, evaporated on water bath up to 5 ml and filtered through waters make. Absorbance recorded on spectrophotometer at wavelength 512 nm. Besides, other agro-morphological and descriptors were also recorded as

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Table 1. Analysis of variance (ANOVA) for 11 characters found in Aloe

Character	Replications	Locations	Locations × replications	Treatments	Locations × Treatments	Error
D F	2	3	6	49	147	392
Plant height (cm)	3.31	698.08**	4.17	514.51**	52.49**	3.75
Leaf length (cm)	1.31	365.50**	3.69	442.58**	24.55**	2.45
Leaf width (cm)	0.01	152.99**	0.05	9.14**	0.77	0.04
Leaf thickness (mm)	0.87	232.79**	0.22	27.24**	3.86**	0.24
Leaf rind thickness (mm)	0.02	195.77**	0.29	32.51**	3.85**	0.26
Leaf skin thickness (mm)	0.01	1.52	0	0.1	0.03	0
Number of leaves/plant	0.02	382.48**	0.21	18.80**	1.53**	0.19
Fresh weight/ plant	3840	3445333.30**	4778.7	6381695.30**	1063273.60**	8288
Sap content (%)	0.88	25.25**	1.79	81.37**	1	7.92
Gel content (%)	0.08	18.19**	0.32	561.83**	0.89	1.01
Aloin content (%)	0.03	0.43	0.01	5.32**	0.05	0.02

*,** Significant at 5% and 1 % level, respectively

per the Minimal Descriptors and Descriptor States for Characterization and Evaluation of Medicinal Plants (Singh *et al.,* 2003). The 11 quantitative characters, viz. plant height, leaf length, leaf width, leaf thickness, leaf rind thickness, leaf skin thickness, number of leaves/ plant, fresh weight/ plant, sap content, gel content and aloin content were recorded (Table 1). The analysis of variance for these genotypes was estimated as per procedure for RBD and F- test was applied to all treatments (Snedecor and Cochran, 1967). The genotypic coefficient of variation (GCV) and phenotypic coefficients of variation (PCV) were calculated as per Burton and De vane (1953). Heritability (broad sense) and genetic advance as per cent of mean were computed by using formula suggested by Allard, 1960 and Johnson *et al*., 1955, respectively.

RESULTS AND DISCUSSION

Analysis of variance for all the 11 morphological characters revealed significant differences among the genotypes. The relative magnitude of components of variability, viz. phenotypic and genotypic coefficient of variation (PCV and GCV) along with heritability in broad sense (h^2) and genetic advance (GA) as per cent of mean was reflected in broad range observed for each trait (Table 2). The study showed high range for fresh weight (590.83 - 4208.33g/ plant), plant height (39.50 - 73.82 cm) and leaf length (30.18 - 62.86 cm). The highest estimates of PCV and GCV were observed for fresh weight/plant (28.33 and 28.07%), followed by gel content (26.10 and 25.82 %), aloin content (19.18 and 18.81 %) and leaf width (15.44 and 15.03%). Narrow differences between PCV and GCV gave evidence to genotypes that variability existing in them was mainly due to their genetic make-up.

High estimates of heritability were observed for fresh weight/plant (98.20%), followed by gel content (97.90%), aloin content (96.10%), leaf width 94.70%),

Table 2. Variability parameters for 11 characters of Aloe at both the locations

Character	Range	Mean	PCV (%)	GCV (%)	Heritability (broad sense)	Genetic advance	GA (%) of mean
Plant height (cm)	39.50-73.82	53.53	12.14	11.59	91.10	12.20	22.79
Leaf length (cm)	30.18-62.86	45.16	13.52	13.07	93.40	11.75	26.02
Leaf width (cm)	2.95-6.89	5.56	15.44	15.03	94.70	1.67	30.06
Leaf thickness (mm)	10.79-16.55	14.35	10.30	9.73	89.20	2.72	18.96
Leaf rind thickness (mm)	11.08-17.15	14.80	11.00	10.44	90.10	3.02	20.40
Leaf skin thickness (mm)	1.11-1.50	1.28	7.07	6.14	75.30	0.14	10.90
Number of leaves/plant	9.24-16.10	12.21	10.44	9.82	88.60	2.33	19.08
Fresh weight/plant	590.83-4208.33	2371.43	28.33	28.07	98.20	13.58.77	57.30
Sap content (%)	70.42-83.52	75.86	5.04	3.41	45.80	3.61	4.76
Gel content (%)	13.64-47.71	26.48	26.10	25.82	97.90	13.94	52.65
Aloin content (%)	2.41-5.31	3.52	19.18	18.81	96.10	1.34	38.03

leaf length (93.40 %), plant height (91.10%) and leaf rind thickness (90.10%). Leaf thickness (89.20%), number of leaves/ plant (88.60%) and leaf skin thickness (75.30%) showed moderate heritability estimates. Sap content (45.80%) showed low heritability estimates. High heritability in broad sense indicated that large proportion of phenotypic variance was attributable to genotypic variance and were less influenced by environment. High percentage of genetic advance as (%) of mean was observed for fresh weight/ plant (57.30%), whereas it was low for sap content (4.76%) and leaf skin thickness (10.90%). Hence, selection can bring for improvement in these traits.

Higher values of heritability showed lesser environmental and more genetic effects. Highest values of genotypic and phenotypic variance indicated a wide range of variability and high heritability associated with higher values of relative genetic advance. It would employ that additive gene effects were more important and also estimated heritability for important morphological traits. These findings were in accordance with the results in basil (*Ocimum basilicum*) by Kritikar and Basu (1984) and Ahmad and Khaliq (2002) in which whole plant is also being used for medicinal purposes.

The characters with high heritability coupled with high genetic advance would respond to selection better than those with high heritability and low genetic advance was suggested by Johnson *et al.* (1955). In present investigation the characters like fresh weight per plant and gel content had high heritability coupled with high genetic advance

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Correlation studies on integrated plant nutrient management in guava (*Psidium guajava*) cv. Allahabad Safeda

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ABSTRACT

The studies were undertaken on integrated plant nutrient management on guava (*Psidium guajava* L.) cv. Allahabad Safeda, during 2011-12 at JNKVV, College of Agriculture, Rewa, Madhya Pradesh. The results showed that plant height had highly significant positive association with canopy height. There was positive but non-significant association with girth of scion, plant spread N-S and volume of trees. Negative association was found with the circumference of rootstock and spread E-W. The number of fruits/tree had highly significant positive association with fruit yield. Negative association was found with average weight/fruit. Fruit yield/tree showed significant association with fruit yield/ha but non-significant association with average weight/fruit. Average weight/fruit was associated non-significantly with fruit yield/ha. The nitrogen content in leaf was positively associated with phosphorus content in leaf, potassium content in leaf, leaf chlorophyll content index and leaf area index. Total phosphorus content in leaf showed significant positive association with total potassium content in leaf. However, it was positive but non-significant with leaf chlorophyll content index and leaf area index. The potassium content in leaf was positively associated with leaf area index and leaf chlorophyll content index. Leaf chlorophyll content index was positively but non-significantly associated with leaf area index.

Key Words: Nutrient value, Yield, Guava, Correlation, Integrated plant nutrient management, Leaf chlorophyll, Leaf area index

Guava (*Psidium guajava* L.) is one of the most important fruit crops of India, occupying fourth and fifth place, respectively in terms of area and production (Yadav and Shanker, 2007). Guava is native to the tropical America stretching from Mexico to Peru. Guava is considered as one of the exquisite, nutritionally valuable and remunerative fruit crop. It excels most other fruit crops in productivity, hardiness, adoptability and nutritive value. Guava bears on current season's growth and flowers appear in the axils of new leaves, therefore, it responds well to pruning. Fruit yield depends on individual fruit weight. The fruit weight in turn depends on other fruit characters which contribute to the final yield. Therefore, selection of mother trees for further propagation and crop improvement programme, knowledge of various fruit characters which contribute to yield and fruit quality is important (Sheikh and Hulamani, 1993). The knowledge on association of characters among themselves with fruit yield is important for selection and genetic improvement in guava. It is influenced by diverse environment, seasonal characteristics and spatial heterogeneity over that in turn, interact with cultivars chosen and cultural practices adopted. Improvement in yield is the foremost goal of varietal improvement programme. In order to incorporate desirable characters to maximize qualitative and economic yield, the information on nature and extent of genetic variability attained in guava varieties for desirable characters, their association and relative contribution to yield constitute the basic requirements. The correlation study was taken up in guava (Agarwal, 2010). Hence studies were undertaken on correlation on integrated plant nutrient management in guava.

MATERIALS AND METHODS

The studies were undertaken at the Fruit Research Station, Kuthulia, College of Agriculture, Rewa, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, during 2011-12. Eleven treatments comprising T_1, 500 g : 200 g: 500 g NPK /tree (as the control); T_2, T_1 + Zn (0.5 %)+ B (0.2 %) + Mn (1%)as foliar spray twice (August and October); T_3, T_1 + organic mulching @10 cm thick; T_4, T_2 + organic mulching @10 cm thick; T_5, 50% dose of recommended fertilizers + 25 kg FYM + 250 g *Trichoderma;* T_6, 50% dose of recommended fertilizers + 50 kg FYM + 250 g *Azospirillum;* T_7, 50% dose of recommended fertilizers + 50 kg FYM + 250 g *Azotobactor;* T_8, 50% dose of recommended fertilizers +

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25 kg FYM + 5kg vermicompost; T_9, 50% dose of recommended fertilizer + 25 kg FYM + 250 g *Pseudomonas florescence;* T_{10}, 50% dose of recommended fertilizer + 25 kg FYM + 250 g *Trichoderma*+ 250 g *Pseudomonas*; and T_{11}, 50% dose of recommended fertilizer + 25 kg FYM + 250 g *Aspergillus niger.*

The treatments were replicated thrice in a randomized block design having two trees/treatment/replication. The vegetative growth parameters, viz. plant height (m), canopy height (m), circumference of root stock (m), circumference of scion (m), plant spread N-S (m), plant spread E-W (m) and tree volume (m^3) were recorded by the standard methods. The yield parameters, viz. for number of fruits/tree, average fruit weight (g) and fruit yield (kg/tree) were considered. The yield was recorded by weighing the fruits at the time of each picking. Fifty uniform mature fruits from each tree were used for recording of various observations of fruits.

The fruit quality parameters were recorded for TSS(°Brix), acidity (%), pulp: seed ratio, number of seeds/fruit and 100- seed weight (g). The determination of chemical constitution of fruits, homogeneous sample of fruit juice was prepared after crushing the pulp of randomly selected fruits from each treatment which used for the estimation of fruit quality parameters as per the methods of AOAC (1990). The leaf analysis was recorded for total nitrogen (%), total phosphorus (%), total potassium (%), leaf chlorophyll content index and leaf area index. Treatment-wise leaf samples were collected and were analyzed for their NPK content. The leaf samples were also collected from each plant. Then leaf samples were dried in an oven at 60-70°C temperature for 25 hours. These leaf samples were prepared for chemical analysis. The coefficients of correlation among different characters were calculated as per the method of Panse and Sukhatme (1976).

RESULTS AND DISCUSSION

Different possible correlation coefficients between plant height, canopy height, circumference of rootstock and scion spread (N-S and E-W) and volume of tree were worked out (Table 1). The data revealed that plant height had highly significant positive association (0.696) with canopy height. Positive but non-significant association were observed with girth of scion (0.130), plant spread N-S (0.337) and volume of tree (0.412). Negative association was found with the circumference of rootstock (-0.006) and spread E-W (-0.157). Canopy height showed significant positive association with spread N-S (0.611) and tree volume (0.844) and positive but non-significant association with circumference of scion (0.227) and spread E-W (0.306). Negative association was found with circumference of rootstock (-0.132). Circumference of rootstock showed highly significant positive association with circumference of scion (0.853) and positive but non-significant association with the spread E-W (0.306), spread N-S (0.585) and plant volume (0.149).

Table 1. Simple correlation coefficient between vegetative growth parameters

Character	Canopy height (m)	Circum-ference		Plant spread (m)		Tree volume M^3
		Root-stock (m)	Scion (m)	E-W	N-S	
Plant height (m)	0.654*	-0.005	0.127	-0.151	0.334	0.403
Canopy height (m)		-0.134	0.230	0.302	0.607*	0.833**
Circumference of rootstock (m)			0.837**	0.300	0.569	0.137
Circumference of scion (m)				0.631*	0.687*	0.532
Plant spread (E-W) (m)					0.549	0.723*
Plant spread (N-S) (m)						0.778**

*,**Significant at 5% and 1 % probability

Circumference of scion had significant positive association (0.631) with spread E-W and (0.687) spread N-S. Positive but non-significant association was observed with plant volume (0.0532). Spread of plant E-W showed significant positive association with plant volume (0.723) and positive correlation with spread N-S (0.549). Spread of plant (N-S) showed significant positive association with plant volume (0.778). These finding are in agreement with Sheikh and Hulamani (1993), Pandey *et al.* (1997), Pandey *et al.* (2002), Raghava and Tiwari (2008), Kumar *et al.* (2009), Man Bihari and Suryanarayan (2009; 2011), Agarwal (2010) and Lakpathi *et al.* (2013).

Different possible correlation-coefficient between number of fruits/tree, fruit yield (kg/tree) average fruit weight and fruit yield/ha were worked (Table 2). The data revealed that number of fruits/tree had highly significant positive association (0.979) with fruit yield (kg/tree) and fruit yield/ha. Negative association was found with average weight/fruit (-0.519). Fruit yield/tree showed significant association with fruit yield/ha (0.984) but non-significant association with average weight/fruit. Average weight/fruit was associated non-significantly with fruit yield/ha (–0.463). Similar associations between above traits have been reported by Sheikh and Hulamani (1993), Pandey *et al.* (1997), Kumar *et al.* (2009), Man Bihari and Suryanarayan (2009), Agarwal (2010) and Lakpathi *et al.* (2013).

Correlation coefficients between TSS, acidity, pulp: seed ratio, number of seeds/fruit and 100-seed weight were calculated (Table 3). It is obvious from the data that total soluble solids had highly significant association with acidity (0.939). Negative association was found with pulp: seed ratio (–0.501), number of seeds/fruit (-0.158) and 100-seed weight (–0.157). Acidity showed negative correlation with pulp: seed

Table 2. Correlation coefficient among yield attributes

Character	Fruit yield (kg/tree)	Average fruit weight (g)	Fruit yield (q/ha)
Number of fruits/tree	0.978* *	-0.519	0.978**
Fruit yield (kg/tree)		-0.458	0.984**
Average fruit weight (g)			-0.463

*,**Significant at 5% and 1% probability

ratio (–0.537), number of seeds/fruit (–0.281) and 100-seed weight (–0.326). Pulp: seed ratio showed positive correlation with number of seeds/fruit (0.854) and 100-seed weight (0.512). Number of seeds/fruit showed positive correlation with 100-seed weight (0.530). These results were in conformity of the findings of Sheikh and Hulamani (1993), Pandey *et al.* (1997), Pandey *et al.* (2002), Raghava and Tiwari, (2008), Man Bihari and Suryanarayan (2009; 2011), Agarwal (2010) and Lakpathi *et al.* (2013).

Correlation coefficient between nitrogen content in leaf, phosphorus content in leaf, potassium content in leaf, leaf chlorophyll content index and leaf area index were calculated (Table 4). The data revealed that nitrogen content in leaf was positively associated with phosphorus content in leaf (0.047), potassium content in leaf (0.056), leaf chlorophyll content index (0.249) and leaf area index (0.051). Total phosphorus content in leaf showed significant positive association with total potassium content in leaf (0.728). However, it was positive but non- significant with leaf chlorophyll content index (0.057) and leaf area index (0.392). The potassium content in leaf was positively associated with leaf area index (0.422) and leaf chlorophyll content index (0.402). Leaf chlorophyll content index was positively but non-significantly associated with leaf area index (0.065). Similar associations between above traits have been reported by Sheikh and Hulamani (1993), Pandey *et al.* (1997), Agarwal (2010) and Lakpathi *et al.* (2013).

Table 3. Correlation coefficient among fruit quality parameters

Character	Acidity (%)	Pulp:seed ratio	Number of seeds/ fruit	100 seed weight (g)
TSS (°Brix)	0.939**	(–) 0.501	(–) 0.158	(–) 0.157
Acidity (%)		(–)0.537	(–) 0.281	(–) 0.326
Pulp:seed ratio			0.854 **	0.512
Number of seeds/fruit				0.525

*,**Significant at 5% and 1% probability

Table 4. Correlation coefficient in leaf analysis

Character	Total phosphorus in leaves (%)	Total potassium in leaves (%)	Leaf chlorophyll content index	Leaf area index
Total nitrogen in leaves (%)	0.047	0.056	0.249	0.051
Total phosphorus in leaves (%)		0.728*	0.057	0.392
Total potassium in leaves (%)			0.402	0.4222
Leaf chlorophyll content index				0.065

*,**Significant at 5% and 1% probability

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- The prime objective of the *Current Horticulture* is for the advancement of the basic and fundamental research in horticultural science among horticulturists—researchers, scientists, students, educators and other stakeholders—to promote scientific exchange and interaction among them in a mission-mode approach.

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