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Stresses of Cucurbits: Current Status and Management

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Foreword

Agricultural land is shrinking day by day due to the modernization of our society. This has resulted in a drastic reduction of per capita cultivable land holding capacity in the world. Though vegetables still now have not come under staple food for the vast population of the world, it potentially plays a major role in global food security. Cucurbits are a vast group of vegetables grown almost throughout the world. Part of the daily diet of the majority of people around the world is comprised of cucurbitaceous vegetables. The vegetables are a very good source of nutrients and can be a remedy for those people who are suffering from undernourishment. It gives me a full satisfaction that the book entitled "STRESSES OF CUCURBITS: CURRENT STATUS AND MANAGEMENT" is an excellent combined effort by the authors to enlighten every aspect for successful production of these vegetables. It also gives me an immense pleasure that in the book special attention has been paid by the authors for the students so that they can use it as a textbook for their academic syllabus. There are numerous books and articles available on cucurbits but comprehensive and up-to-date information regarding cucurbit cultivation is lacking in them. However, the aspects of cucurbits cultivation and management of different abiotic and biotic stresses have efficiently and effectively been addressed in this unique book. Definitely, Dr. Bholanath Mondal, Dr. Chandan Kumar Mondal and Dr. Palash Mondal deserve credit for such joint contribution. I am sure that this book will provide to be a useful guide for the researchers, scientists, teachers, students, extension workers, vegetable growers and policymakers as well.

I wish all success of this publication.

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Preface

Available land for cultivation is shrinking day by day due to rapid urbanization and industrialization. Conversely, the human population in the world is increasing at a sharp rate which urgently needs the demand for higher production of food. Vegetables are the miraculous example that can meet up the growing demand of this planet. The vegetables are not only rich in different kinds of nutrients but also fetch good remuneration globally. With the advent of improved cultivation techniques and more efforts on crop production research, vegetables are now cultivated all the year round and thus meeting the demand for the daily dietary requirement of ever-increasing population of the world. However, this intensification of vegetable production makes the crops more prone to abiotic and biotic stresses which severely reduce the yield and quality of vegetables. Like other vegetables, cucurbits are also highly prone to attack by different pests due to its tenderness and softness of the crops. To mitigate these biotic stresses, a concomitant expansion in the use of synthetic pesticides has already been witnessed by us. So, concerns over potential health and environmental dangers, increased pest resistance to pesticides and continued prevalence of pest-induced crop losses have stimulated the search for better understanding of this diverse group of vegetables. This book is meant to give the reader a holistic appreciation of the importance of cucurbitaceous vegetables and also deals comprehensively on these issues for better cultivation of cucurbits in a sustainable way. We hope that the book will be useful to all the users including farmers, farm advisors, students, scientists, agriculture researchers, agriculture practitioners as well as plant protection specialists. Many photographs have been incorporated in this book for better and easy understanding of different topics. We sincerely acknowledge the contribution of those resource persons who have uploaded the photos, figures, documents in the public domain as many of their helpful information have been incorporated during the writing of this book. Suggestions to improve the contents of the book are most welcome.

About the Book

In global vegetable production, India ranks second only after China. Vegetables are important in the daily diet not only for the diversity in the menu but it is also the only natural means of boosting the human immune system. It ensures health and nutritional security by supplying vitamins and minerals, which, in other ways, are not so easily available, as well as acceptable to the human body system. Conversely, vegetable cultivation nowadays has become an entrepreneurial activity for small farmers, providing employment opportunity to a vast number of rural youths. Among different vegetables, cucurbit is the big group of almost indigenous vegetables, grown all over the country (or subcontinent) since time immemorial. The members of this big family are tropical in nature and fetch several biotic and abiotic stresses. These stresses cause severe losses in both yield and quality. Intensive farming practices, climatic vulnerability and rapid shift in vegetable ecosystem ultimately increase these stresses day by day. Stresses like insects, mites, nematodes, bacteria, fungi, weeds, rodents, etc. are the most significant biotic stresses, which are responsible in limiting potential productivity as well as quality deterioration of produces. Application of hazardous toxic chemicals to combat these pests of cucurbits not only results in a continuous increase in residual toxicity in the produce as well as in nature but also paralyzing agro-ecosystem. Again, changes in climatic condition and increased use of modern agro-technology towards intensive farming make these problems more and more complex. Besides, abiotic stresses such as drought (water stress), excessive watering (waterlogging), extreme temperatures (cold, frost and heat), salinity and mineral toxicity, nutrient deficiency, etc. play negatively on the growth and development of the crops. In this backdrop, updated and alternative information with regard to holistic management of crops as well as its problems is of urgent need for successful and profitable production of cucurbit vegetables. The book contains complete information on all the issues regarding the problems and panacea for the successful production of these particular vegetables. The book will cover all the issues related with these aspects, i.e. about cucurbits, holistic crop management including abiotic stresses, management of insect pests, diseases, mites, nematodes, weeds, rodents and other vertebrates with latest information, findings and approaches.

It will be helpful for agricultural students (both UG and PG level including PhD), amateur gardeners, corporate farming personnel, horti-enthusiasts extension

workers, policymakers, etc. in India and abroad. The book is divided into 13 sections. Each of these sections is further divided into one or more subsections for better understanding. Numerous figures and tables are included to facilitate the comprehension of the presented material. Related colour photographs have also been incorporated. It will be a treasure of knowledge with regard to the management of cucurbitaceous vegetables for better productivity and remunerative cultivation. The authors are from Visva-Bharati, Santiniketan, West Bengal and Ramkrishna Ashram Krishi Vigyan Kendra (ICAR), Nimpith, West Bengal having vast knowledge and experience in teaching, research and extension in this sector.

Contents

About the Authors

Bholanath Mondal, Assistant Professor, Department of Plant Pathology, Palli-Siksha Bhavana, Visva-Bharati, has over 12 years of teaching, research and extension experience. He has honoured with Fellow of SAS Society and received Outstanding Paper Award from Department of Science and Technology, GoWB. He is an editorial board member of different journals, acted as Chief Editor of the Journal Green Technology, organized numbers of national and international conferences and published over 55 research articles, 15 book chapters, three booklets, many popular articles, five practical manuals and eight books. He is associated with many research projects and has guided six PhD scholars and ten Master's students for their dissertation works. He has conferred with Young Scientist Award, Best Young Scientist Award, Rashtriya Gaurav Award and Mahatma Gandhi Lifetime Achievement Award for his contribution in Agriculture.

Chandan Kumar Mondal, Eminent Horticulture Scientist, gained vast experience during his 15 years of service at Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith. He is associated with several research projects and has standardized different new technologies on vegetable, fruit and plantation crops cultivation. He is also attached as Guest Faculty at Department of Horticulture, Institute of Agricultural Science, University of Calcutta and has guided seven Master's students for their dissertation works. He has published 27 research papers, developed several extension literature, four books, five booklets and three book chapters. He was conferred with the Best Young Scientist Award (Horticulture) and Best Krishi Vigyan Kendra Scientist Award (Horticulture) at National level during 2016 and 2020 respectively.

Palash Mondal, Assistant Professor, Department of Agricultural Entomology, Palli-Siksha Bhavana, Visva-Bharati, has over 18 years of experience in teaching, research and extension. He was the recipient of Merit Scholarship of ICAR and Senior Research Fellowship of CSIR. He is a member of various scientific societies and associated with the editorial board of some peer-reviewed journals. He was associated with an international project sponsored by DFID, London. Presently, a

number of research projects are under his supervision. He has published 65 research papers, number of extension articles, ten book chapters, two books and a handful of laboratory manuals. He has guided nine PhD scholars and 16 Master's students in the field of agricultural entomology.

An Introduction to Cucurbits

1 Introduction

Among the vegetables, cucurbits form one of the largest groups with their wide adaptation from arid climates to the humid tropics. The term 'Cucurbits' was coined by Liberty Hyde Bailey for cultivated species of the family Cucurbitaceae (Robinson and Decker-Walters 1997). The family Cucurbitaceae consists of about 825 species in around 118 genera (Jeffrey 1990). In Asia, nearly 23 edible major and minor cucurbits are grown and consumed. They are grown mainly in summer and rainy seasons in India and even in winter in some parts of southern and western India as both annual and perennial crops. Cucurbits are frost sensitive, mostly tendril-bearing vines and the members of this broad family are mostly of tropical and subtropical origin. A few numbers of species that are native to or cultivated in temperate climate are prolific seed producing annuals or perennials that live for one season until killed by frost. The Cucurbitaceae family is divided into two sub-families: Zanonioideae and Cucurbitoideae. Cucurbitoideae contains the plants of economic importance, which would be discussed here. Most important genera of this sub-family are as follows:

Genera	Type
Lagenaria	Gourds
Momordica	Gourds (with spiny/warted, edible skinned fruit)
Luffa	Gourds (fibrous fruit)
Cucurbita	Pumpkin, Squashes
Cucumis	Cucumber and some melons
Citrullus	Watermelon and others

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2 Importance of Cucurbits

- Gourds and pumpkins are consumed as vegetables after cooking; Melons (watermelon, muskmelon, etc.) are consumed mainly as desert fruits and cucumber is usually taken as salad.
- Ash gourd and pointed gourd fruits are used in making ketchups, sweets and candies.
- Leaves and shoots of many species are boiled and eaten as a vegetable in both Africa and Asia.
- Some of the crops are well known for their unique medicinal properties. Fruits (including seeds) usually contain several bioactive compounds such as cucurbitacins, triterpenes, sterols and alkaloids. Cucurbitacins are a group of bitter triterpenes, confined mainly to the seeds of Cucurbitaceae (Bisognin 2002).
- Cucurbits are actively used as traditional herbal remedies for various diseases such as anti-inflammatory, antitumor, hepatoprotective, cardiovascular and immunoregulatory activities (Rajasree et al. 2016). It is purported that pointed gourd possesses the medicinal property of lowering total cholesterol and blood sugar.
- Cucurbitaceous vegetables are in general a good source of vitamin A and C and various other vital minerals (Table 1). These vegetables, as rich in vitamin A, help to promote healthy wound healing by activating collagen synthesis through stimulating the body's natural inflammatory response (Priya 2017).
- Due to their low carbohydrate content and the ability to supply of certain amount of minerals and vitamins (Table 1), it is highly recommended for diabetics.
- *Luffa*s are used as natural sponges, an indispensable part of bathing in most of the Asian and African countries.
- *Lagenaria siceraria*, the bottle gourd, has been in use as vessels in African and Asian cultures by many societies in varied and attractive ways. It was, perhaps, first used as a water carrier, but quickly found diverse uses in making pipes, snuff boxes, musical instruments, salt keeping cages, cricket cages, interior decoration of light and even life jackets. Containers crafted from the fruit rind of the gourd were in constant use as bottles for carrying wine and water, making the name "bottle gourd" especially appropriate for the crop. A host of musical instruments were also fashioned from bottle gourds, which are in use in Eastern India including Bangladesh, even today.

3 Commonly Grown Cucurbits in India

The cucurbits are mostly of tropical and subtropical origin. The cultivated types as well as their wild relatives are distributed in Asia (specifically South-East Asia), Topical America and Africa. Details of different cucurbits commonly grown in India are given in Table 2.

Table 1 Nutritive value of cultivated cucurbits (Per 100 g edible portion on fresh weight basis)

Vegetables	Moisture (g)	Carbohydrates (g)	Protien (g)	Fat (g)	Vit A (IU)	Vit B-1 (thiamine) (mg)	Vit B-2 (riboflavin) (mg)	Vit C (ascorbic acid) (mg)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
Bottle gourd	69.1	2.5	0.2	0.1	0	0.03	0.01	6	20	0.7	10
Bitter gourd (small)	83.2	10.6	2.1	1	210	0.07	0.06	96	23	2	38
Bitter gourd (large)	92.4	4.2	1.6	0.2	210	0.07	0.09	88	20	1.8	70
Spine gourd	84.1	7.7	3.1	1	2596	0.05	0.18	0	33	4.6	42
Ridge gourd	95.2	3.4	0.5	0.1	56	0.01	0.01	5	18	5	26
Sponge gourd	93.2	2.9	0.5	0.1	120	0.02	0.06	0	36	1.1	19
Pumpkin (ripe)	86	4.6	1.4	0.1	2180	0.06	0.04	2	10	0.7	30
Winter squash	86	6.6	1.1	0.2	3300	0.03	0.05	6	14.2	0.4	20.9
Summer squash	94.8	3.5	1	0.1	260	0.05	0.03	18	10	0.6	30
Wax gourd	96.5	1.9	0.4	0.1	0	0.06	0.1	1	30	0.8	20
Snake gourd	94.6	3.3	0.5	0.3	160	0.04	0.06	0	26	0.3	20
Pointed gourd	92	2.2	2	0.3	255	0.05	0.06	29	30	1.7	40
Cucumber	96.1	2.5	0.4	0.1	0	0.03	0.01	7	10	1.5	25
Muskmelon	95.2	3.5	0.3	0.2	3420	0.11	0.08	26	32	1.4	14
Snapmelon	95.7	3	0.3	0.1	265	–	–	10	–	–	–
Watermelon	95.8	3.3	0.2	0.2	590	0.02	0.04	1	11	7.9	12
Round melon/Indian squash	93.5	3.4	1.4	0.2	23	0.04	0.08	18	25	0.9	24

(continued)

Table 1 (continued)

Vegetables	Moisture (g)	Carbohydrates (g)	Protien (g)	Fat (g)	Vit A (IU)	Vit B-1 (thiamine) (mg)	Vit B-2 (riboflavin) (mg)	Vit C (ascorbic acid) (mg)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
Ivy gourd	93.5	3.1	1.2	0.1	249	0.07	0.08	15	40	1.4	30
Mirliton squash/ chayote	92.5	5.7	0.7	0.1	50	0.06	0.02	15	50	0.4	22

Table 2 Important information of some cultivated cucurbits

Sl. no.	Common name	Indian name	Botanical name	2n number	Centre of origin	Sex expression
1	Bottle gourd	Louki	*Lagenaria siceraria* (Mol.) Standl.	22	Central Africa, India	Monoecious
2	Bitter gourd	Karela	*Momordica charantia* L.	22	China, Malaysia, India	Monoecious
3	Spine gourd	Kakrol	*Momordica dioica* Roxb.	28	Asia (extensive distribution in India and Bangladesh)	Dioecious
4	Sweet gourd	Kheksa	*Momordica cochinchinensis* (Lour.) Spreng	28	Southeast Asia	Dioecious
5	Ribbed or ridge gourd	Kali tori	*Luffa acutangula* (L.) Roxb.	26	Tropical Asia, India	Monoecious
6	Sponge gourd	Ghia tori	*Luffa cylindrica* (L.) Roem (syn. *L. aegyptiaca*)	26	Tropical Asia, India	Monoecious
7	Pumpkin	Sitaphal/ Kashiphal	*Cucurbita moschata* (Duch. Ex. Lam.) Duch & Poir	40	Central America	Monoecious
8	Winter squash	Kaddu	*Cucurbita maxima* Duch	40	South America	Monoecious
9	Summer squash	Chappan kaddu	*Cucurbita pepo* L.	40	North and Central America	Monoecious
10	Wax or ash gourd	Petha	*Benincasa hispida* (Thunb.) Cogn.	24	South East Asia, India, China, Malaysia	Monoecious
11	Snake gourd	Chinchinda	*Trichosanthes cucumerina* (syn. *T. anguina* L.)	22	India	Monoecious
12	Pointed gourd	Parwal	*Trichosanthes dioica* Roxb.	22	South East Asia, India, Burma	Dioecious
13	Cucumber	Khira	*Cucumis sativus* L.	14	Africa, Asia (India)	Monoecious
14	Muskmelon	Kharbuza	*Cucumis melo* L.	24	Africa, Iran	Monoecious
15	Snapmelon	Phoot	*Cucumis melo* var. *momordica*	24	Iran, India	Monoecious
16	Long or serpent melon	Kakri	*Cucumis melo* var. *utilissimus*	24	India	Monoecious

(continued)

Table 2 (continued)

Sl. no.	Common name	Indian name	Botanical name	2n number	Centre of origin	Sex expression
17	Watermelon	Tarbuz	*Citrullus lanatus* (Thunb.) (syn. *C. vulgaris* Schrad)	22	Kalahari Dessert, Africa	Monoecious
18	Round melon/Indian squash	Tinda	*Praecitrullus fistulosus* Pang.	24	India	Monoecious
19	Ivy gourd[a]	Kundru or Tondli	*Coccinia grandis* (L.) Voigt (syn. *C. cordifolia*)	24	India	Dioecious
20	Sparrow gourd	Meetha Karela	*Cyclanthera pedata* Schrad.	32	Andean South America	Monoecious
21	Mirliton squash/ chayote	Chow chow	*Sechium edule* (Jacq) Sw.	24	Central America	Monoecious

[a]*Coccinia indica* Wight & Arn (syn. *Cephalandra indica*), a wild monoecious relative of *Coccinia* is used as edible vegetable in parts of Eastern and North-Eastern India and Bangladesh. It is believed to have good medicinal properties like lowering blood sugar and blood cholesterol level

In addition to above, there are some underutilized cucurbitaceous vegetables viz. *Cucumis hystrix*, *Cucumis trigonus*, *Luffa graveolens*, *Momordica macrophylla*, *Momordica subangulata, Trichosanthes khasiana*, *Trichosanthes ovata* and *Trichosanthes truncata*, which are grown and consumed mostly by the local peoples of North-Eastern region of India.

4 Botany

1. Cucurbits are herbaceous annuals or perennials with a long tap root and lateral roots, usually confined to a depth of 60 cm; however, in *Cucurbita* sp., the root can go deep to 170 cm to 180 cm. For this reason, these crops are suitable for growing in river bed system to utilize the subterranean moisture. Some of the cucurbits also have xerophytic nature.
2. The plants grow either prostrate along the ground or climb using tendrils. The stems are branched; root may appear in nodes when it comes in contact with moist soil. Some cucurbits (like summer squash, some genotypes of musk-melon, watermelon) show erect or bush like growth habit due to its shorter internodes.
3. The tendrils are borne at the axils of leaves and can grow either simple (in *Cucumis*, *Momordica* and *Benincasa*) or branched. Bush types do not possess tendrils.
4. Leaves can range from simple (3–5 lobed), cordate, reniform to palmately compound. Deeply lobed or nearly pinnatifid leaves are found in *Citrullus*. Those leaves that develop later are more deeply lobed and extra-floral nectaries are often found.
5. Inflorescence is axillary and solitary or clustered or racemose. The flowers are usually large, attractive, mostly unisexual and monoecious. Other sex forms like andromonoecious (in muskmelon), gynomonoecious, gynoecious (in cucumber) and hermaphrodite (in ridge gourd) are also available. Gynoecious sex form is used for producing hybrids in cucumber.
6. Dioecy is present in some of the cucurbits like Spine gourd, Sweet gourd, Pointed gourd and Ivy gourd.
7. All female flowers of cucurbitaceae show prominent large inferior ovary. Exceptionally, in pumpkin, the staminate flowers converting into hermaphrodite have superior ovary—an unusual phenomenon in cucurbits (Singh 2013).
8. As the cucurbit species are mostly unisexual and male and female flowers are borne separately, the pollination and fruit setting are governed by insect pollinators. The typical pollinators are bees and moths. However, sometimes, rich supply of nectar and pollen within the flowers draw hummingbirds and bats.
9. Majority of cucurbits starts flowering in 30–45 days after sowing (Gopalakrishnan 2007). The first 4 to 6 flowering nodes bear male flower, and then female flowers appear in few nodes. Usually the ratio of male to female flower in monoecious cucurbits varies from 25–30:1 to 15:1 (Pessarakli 2016). The lower the male flower population, the higher would be the economic gain.

High Nitrogen content, long days and high temperature accelerate male flower appearance.

10. For different cucurbit crops, the flowering/anthesis time are different, which are discussed hereunder (as per Singh 2013; Pessarakli 2016):
    a. The pumpkin group (*Cucurbita* sp.) usually flowers at early morning. Anthesis occurs between 04:30 h and 04:50 h.
    b. In *Momordica*, anthesis starts by 04:00 h and gets completed by 09:00 h, with anther dehiscence between 05:00 h to 07:30 h. Stigma is receptive 24 h before and after anthesis.
    c. In Spine gourd (*M. dioica*) both staminate and pistillate flowers are solitary, axillary and light yellow in colour. Anthesis of both flowers takes place in the evening/night in between 19:30 h. and 21:00 h. Closing of petals continues till 6:00 a.m. and beyond. Pollination is done by visit of colourful insect pollinators during night.
    d. In Sweet gourd (*M. cochinchinensis)*, both staminate and pistillate flowers are solitary, axillary and creamy white in colour. The anthesis of both flowers takes place in the morning. In sweet gourd natural fruit set is very nominal. The interior of the opened flowers is marked by three big and black spots, posing scaring view of the flower, which may be a distracting factor for insect visit.
    e. Anthesis in *Benincasa* takes place between 04:30 h to 07:30 h with anther dehiscence at 03:00 to 05:00 h. Stigma is receptive from 8 h before to 18 h after anthesis.
    f. In Melons (*Cucumis* sp.), the time of anthesis and anther dehiscence are 05:30 hrs to 06:30 h and 05:00–06:00 h, respectively.
    g. In Cucumber, anthesis and anther dehiscence occurs by 05:30–07:00 h and 04:30–05:00 h, respectively. Here, stigma remains receptive 2 h before and after anthesis.
    h. Anthesis in Watermelon occurs between 06:30–08:00 h in autumn and by 05:30–07:00 h in spring.
    i. In Ivy gourd anthesis takes place in the morning in between 07:00 and 08:00 h. Parthenocarpic fruit set is common in ivy gourd.
    j. In *Luffa*, the male inflorescence is a raceme, whereas the female flowers are borne solitary in the axils.
    k. In sponge gourd (*L. cylindrica*) the anthesis and dehiscence occur early in the morning at around 4:45 a.m. and flower remains open the whole day.
    l. In *Luffa acutangula* anther dehiscence occurs at around 16:30 h and anthesis in both staminate and pistillate flowers takes place an hour later i.e. at around 17:30 h.
    m. In *Lagenaria*, anthesis and anther dehiscence take place by 16:30 h to 19:00 h, where stigma remains receptive 36 h before anthesis to 60 h after anthesis.
    n. Anthesis in Snake gourd (*T. anguina*) occurs between 17:15–21:30 h and anther dehiscence happens before anthesis (Bharathi et al. 2013; Hasanuzzaman et al. 2004).
    o. In pointed gourd (*T. dioica*) anthesis of both staminate and pistillate flowers takes place in the evening in between 19:30 h and 20:00 h. Staminate flowers open a few minutes earlier than pistillate flowers.

11. Fruits are essentially 'berry' (inferior), although called 'pepo' because of tough rind at maturity.
12. Fruits are of different colours and sizes, either consumed as immature (cucumber, *Lagenaria*, *Luffa*), mature (*Trichosanthes*, *Momordica*, *Benincasa*, *Cucurbita*) or in ripe form (Watermelon, pumpkin). The seeds are borne with parietal placentation. The edible portion is placenta in cucumber and watermelon. In *Cucurbita*, *Trichosanthes* and melons, the edible portion is pericarp with a little part of mesocarp. In *Luffa* and *Benincasa* the edible portion is endocarp.

5 Crop-Wise Important Varieties

A number of varieties are cultivated widely by the farmers in India. Some important varieties of commercially grown cucurbitaceous vegetables are described hereunder in Table 3.

6 Soil and Climate

1. Cucurbit vegetables are in general warm season crop. For commercial production, climate must be tropical or subtropical. A slight frost kills the young cucurbits very rapidly.
2. Seed does not germinate if the temperature is less than 11 °C. At any point, the soil temperature should not be less than 15.5 °C. For most effective seed germination, soil temperature should be from 18 to 24 °C. Speed of germination increases with increase in temperature till 30 °C (Wien 1997; Maynard and Hochmuth 2007).
3. The ideal soil temperature for maximum plant growth and yield is 18 to 29 °C. Cucurbits grow well in the day temperature range of 25–35 °C. It can thrive up to minimum temperature 20–25 °C and maximum 40 °C.
4. Melons prefer tropical climate with high temperature during fruit development. Day temperature of 35–40 °C, cool nights and warm days give better quality fruits in melons.
5. Occurrence of prolonged period of cool and cloudy weather during the flowering period adversely affects production due to reduced bee activity, which results in poor pollination and fruit setting.
6. Long days with profuse sunlight generally increase number of male flowers. Whereas, shorter days with less light or less intense light tend to increase growth of female flowers. Short days and high night temperatures augment the production of fruit (Deyo and O'Malley 2008).
7. Presence of high level of humidity during the later part of crop growth increases chances of occurring fungal diseases.
8. Most of the cucurbits are deep rooted crop and the roots of some of the cucurbits can penetrate up to a depth of 200 cm (Weaver and Bruner 1927). So, a deep and

Table 3 Important varieties of some commonly grown cucurbits

Variety	Release detail			Varietal characters	Yield
	Centre of release	Year	Suitable for the area		
1. Bottle gourd					
Pusa summer Prolific long	IARI, New Delhi	1975	All over India	Its vines are vigorous in growth and bears long cylindrical fruits. It has very good yield potential	25–30 t/ha
Pusa summer Prolific round	IARI, New Delhi	1975	–	This was developed through selection from local. It has vigorous growth round fruits of 15–18 cm girth. It is prolific bearer and heavy yielder	20–22 t/ha
Pusa Meghdoot (F1)	IARI, New Delhi	1971	–	This is an F1 hybrid between Pusa Summer Prolific Long and Sel. 2. Fruits are long, light green and attractive. It is relatively early and suitable for cultivation in spring-summer season. Considerably high yielder than Pusa Summer Prolific Long	20–22 t/ha
Pusa Manjari (F1)	IARI, New Delhi	1971	–	This is a round fruited F1 hybrid between Pusa Summer Prolific Round and Sel. 11. It has given 48% higher early yield and 106% total yield over Pusa Summer Prolific Round	20–22 t/ha
Pusa Naveen	IARI, New Delhi	1992	MP and Maharashtra	Fruits round, 15–18 cm in girth, green; prolific bearer; suitable for both summer and kharif seasons; first picking in 60–65 days	30–32 t/ha
Pusa Sandesh	IARI, New Delhi	1994	Northern plains of India	Fruits attractive green, round, deep oblate, medium sized, weighing 600 g; first picking in 55–60 days in kharif and 60–65 days in summer. Suitable for commercial cultivation in spring-summer and kharif seasons	32 t/ha

Pusa Samridhi	IARI, New Delhi	2005	–	Fruits are long without neck. In spring-summer (308 q/ha) in kharif, an increase of 19% and 14%, respectively, over the check Pusa Naveen. Superior in nutritional qualities. Maturity in 50–55 days	27–28 t/ha
Pusa Santushti	IARI, New Delhi	2008	Delhi and Haryana	Fruits attractive green, smooth, pear shaped, fruit length 18.50 cm, fruit diameter 12.40 cm, sets fruit under low temperature (10–12 °C) as well as high temperature (35–40 °C), fruit weight 0.8–1.0 kg. Maturity in 55–60 days	Kharif: 28–29 t/ha summer: 26.1 t/ha
Arka Bahar	IIHR, Hesaraghatta, Bengaluru	2006	–	Pure line selection from IIHR-20A. Fruits medium long, straight without crookneck. Light green shining fruit skin when tender (1 kg). Tolerant to blossom end rot	40–45 t/ha
Kashi Ganga	IIVR, Varanasi	2006	UP, Punjab and Jharkhand	This is an early variety derived from the cross IC-92465 × DVBG-151. Fruits are light green, length 30 cm, diameter 7 cm, fruit weight 800–900 g. It is tolerant to anthracnose. Suitable for rainy and summer season	48–55 t/ha
Swarna Sneha	ICAR-RCER, Patna	2013	Jharkhand, Bihar and adjoining areas	Swarna sneha was developed through pureline selection from IC284939 collected from NBPGR, New Delhi. Plant is vigorous with 4–5 m vine length early flowering and fruiting and suitable for summer and rainy season crop. It is tolerant to powdery mildew and downy mildew. • Fruits are long (30–35 cm length), light green and fruit weight 900–1000 g. Average yield is 40% higher over local check (Arka Bahar)	50–55 t/ha

(continued)

Table 3 (continued)

Variety	Release detail			Varietal characters	Yield
	Centre of release	Year	Suitable for the area		
Punjab Komal	PAU, Ludhiana	2006	–	It is an early maturing, medium sized, oblong fruited variety. Marketable fruits are available in about 70 days after sowing. The fruits are light green with pubescence. There are 10–12 fruits/vine. The fruits are tender and borne on medium long, thin pedicels on 4–5th mode onwards. It is tolerant to cucumber mosaic virus	40 t/ha
Anand bottle Gourd-1	AAU, Anand, Gujarat	2012	–	The fruits are long, tender, attractive, light green colour, slightly rounded at stem end as well as blossom end with fine cluster. The fruit skin is smooth, non-hairy and has long shelf life	24 t/ha
Samarat	MPKV, Rahuri	2006	Maharashtra	Fruits are 30–40 cm long, green in colour, cylindrical in shape Good for box packing, suitable for kharif and summer seasons	
Azad Nutan	CSAUAT, Kanpur	2006	Punjab, Tarai region of UP, Uttarakhand, Bihar and Jharkhand	Long, green. High yielding cultivar	35–40 t/ha
Kalyanpur long green	CSAUAT, Kanpur	1999		The vines are vigorous and long, fruits are long with tapering and somewhat pointed blossom end. The crop duration is 120 days	30 t/ha
Pusa hybrid 3	IARI, New Delhi	1998	Delhi, Haryana, UP and Punjab	Fruits green, slightly club shaped without neck; suitable for easy packing and long distance transportation; first picking in 50–55 days	Kharif: 47 t/ha summer: 42–43 t/ha

Kashi Bahar (hybrid)	IIVR, Varanasi	2006	UP, Punjab, Bihar and Jharkhand	This is a long fruited hybrid with green vine and vigorous growth, fruit straight, light green, length 30–32 cm and average weight 780–850 g. It is suitable for rainy and summer season. It is tolerant to anthracnose, downy mildew and Cercospora leaf spot under field conditions	50–55 t/ha
Pant Sankar Lauki-1	GBPUA&T, Pantnagar	1999	UP and Uttarakhand	The fruits are intermediate sized long and somewhat cylindrical (about 35 cm long). The fruits are green. Vine length is about 5.5 m. The first picking is possible in about 60 days. It is suitable for planting in the plains as well as in the hills	40 t/ha
Pant Sankar Lauki-2	GBPUA&T, Pantnagar	2006	UP and Uttarakhand	The fruits are about 40 cm long, clubs shaped with smooth green colour. The first green fruit is harvested in 65 days. This is suitable for plains and hills. It can be sown from March to July in plains and April to May in the hills	40 t/ha
Pant Lauki-3	GBPUA&T, Pantnagar	2005	The plains and hills areas of North India	This is the medium duration and high yielding variety of bottle gourd. It has long fruits (40 cm) of light green colour with light strips having hairs	30 t/ha
2. Bitter gourd					
Pusa Do Mausami	IARI, New Delhi	1975	Delhi, Punjab, Haryana, UP and Bihar	The fruits reach edible stage in about 55 days from sowing, fruits are dark green, long, medium thick, club shaped with 7–8 continuous ridges, 18 cm long at edible stage, 8–10 fruits weigh 1 kg	12–15 t/ha

(continued)

Table 3 (continued)

Variety	Release detail		Suitable for the area	Varietal characters	Yield
	Centre of release	Year			
Pusa Vishesh	IARI, New Delhi	1987	Delhi and Haryana	Fruits thick, medium long, glossy green; suitable for spring-summer season; vines short, hence more number of plants can be accommodated per unit area; first picking in 55–60 days	15 t/ha
Kashi Urvasi	IIVR, Varanasi		UP, Punjab and Jharkhand	This variety has been derived from the cross IC-85650B × IC-44435A, having dark green and long fruits, mild projection, length 16–18 cm, fruit weight 90–110 g. This is suitable for cultivation under both rainy and summer seasons	20–22 t/ha
Arka Harit	IIHR, Hesaraghatta, Bengaluru	1996	–	Pure line selection from IIHR-4, a local collection from Rajasthan. Fruits spindle shaped, glossy green skin colour without tubercles. Medium-sized fruits, thick flesh, moderate bitterness, with less seeds	9–12 t/ha
Swarna Yamini	ICAR-RCER, Patna	2013	Jharkhand and Bihar and adjoining areas	Swarna Yamini was developed through hybridization followed by pedigree selection. Plant is vigorous with 2.5–3.0 m vine length. Early flowering and fruiting. Suitable for summer and rainy season. Tolerant to powdery mildew and downy mildew. Fruits (65–70 g) are dark green with deep tubercles. Shows 49% increase in yield over local check (Arka Harit)	20 t/ha

Pant Karela-1	GBPUA&T, Pantnagar	1991	UP and Uttarakhand	The vine length is about 2 m. Fruits are thick, about 15 cm long with tapering ends. It takes about 55 days to first harvest. It is suitable for planting in the hills	15 t/ha
Phule Green Gold	MPKV, Rahuri	1998	Maharashtra	Fruits are dark green, 25–30 cm long with prickles, tolerant to downy mildew, suitable for kharif and summer seasons	23 t/ha
Hirkani	MPKV, Rahuri	1987	–	Developed by selection from local type. Fruits are dark green, 15–20 cm long with pickles. Crop duration is 160 days	14 t/ha
Konkan Tara	KKV, Dapoli	1987	–	Fruits are green, prickly, medium long (15–16 cm) and spindle shaped. Fruits have good keeping quality, shelf-life is 7–8 days under ambient temperature	24 t/ha
Preethi	KAU, Vellanikkara	1976	–	Selection from local type. Fruits are white, medium, spiny, 30 cm long and average fruit weight is 310 g	15–34 t/ha
Priya	KAU, Vellanikkara	2001	–	A selection from local type. Fruits are 39 cm long, green-spiny-fruits with white tinge at stylar end	30 t/ha
Pusa hybrid 1	IARI, New Delhi	1990	–	Fruits medium long, medium thick, glossy green; suitable for pickling and dehydration; yield higher than Pusa Vishesh and Pusa Do Mausami; first picking in 55–60 days; suitable for growing in spring-summer	20 t/ha
Pusa Hybrid 2	IARI, New Delhi	2002	Punjab, Haryana, Gujarat, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Orissa, AP, Chhattisgarh and Delhi	Fruits dark green, medium long and medium thick (fruit length 12.5 cm and breadth 4.5 cm) with irregular smooth ridges. The average fruit weight is 85–90 g. Maturity in 52 days	18 t/ha

(continued)

Table 3 (continued)

Variety	Release detail			Varietal characters	Yield
	Centre of release	Year	Suitable for the area		
3. Spine gourd					
Arka Neelachal Shree	IIHR-CHES, Bhubaneswar	2012	–	Developed through clonal selection. This variety has good appearance, high yield (4–5 kg/plant) and high market preference. The vine of this variety is thin and spreading which grows very well on three line wire trellis system	10–12 t/ha
Arka Neelachal Shanti (hybrid)	IIHR-CHES, Bhubaneswar	2012	–	It is developed through hybridization between spine gourd (*M. suboica*) and teasel gourd (*M. dioica*), naturally pollinated, high yielding (15–16 kg/vine) with medium-sized fruit (20 g), moderately tolerant to fruit borer, anthracnose and downy mildew. The variety exhibits plant and flower morphology more similar to teasel gourd while its fruit morphology is more close to spine gourd	25–30 t/ha
Arka Neelachal Gaurav	IIHR-CHES, Bhubaneswar	2012	–	An improved variety of teasel gourd (*M. dioica*) developed through selection. It has excellent culinary properties. Good yield (10–12 kg/plant; fruit weight 30–35 g), round, soft seeded fruits, moderately tolerant to anthracnose and downy mildew	18–20 t/ha
4. Ridge gourd					
Pusa Nasdar	IARI, New Delhi	1964	–	Mid-season, flowering in 50 days, 15–20 fruits per vine, fruits ridged, light green. More suited for rainy season	

Pusa Nutan	IARI, New Delhi	–	–	Fruits are long (25–30 cm), straight, attractive green, average fruit weight 105 g, flesh tender, suitable for spring-summer and kharif seasons. Maturity in 45–50 days	16 t/ha
Arka Prasan	IIHR, Hesaraghatta, Bengaluru	–	–	Open pollinated variety developed by inbred selection from the segregating germplasm, IIHR-53. Early variety (42–45 days for first picking), green, long, tender fruits, excellent cooking quality, nutritionally rich in antioxidant activity and minerals like phosphorus, calcium and zinc. Crop duration is 120–135 days	26.0 t/ha
Arka Sujat	IIHR, Hesaraghatta, Bengaluru	1985	–	Developed by pedigree method of breeding between IIHR-54 X IIHR-18 followed by selection. Lush green and tender, medium long (35–45 cm) fruits with prominent ridges and delicate aroma. Good transport and cooking qualities	53 t/ha
Arka Sumeet	IIHR, Hesaraghatta, Bengaluru	1984	–	Developed by pedigree method of breeding between IIHR-54 X IIHR-18 followed by selection. Lush green, tender, long fruits (50–65 cm) with prominent ridges and delicate aroma. Good transport and cooking qualities	50 t/ha
Hisar Kalitori	HAU, Hisar	–	–	Early long thin and straight fruited variety, tolerant to powdery mildew, suitable for rain fed areas	8–10 t/ha

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