Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP4: 72-75

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(Special Issue- 4)
International Conference on Food Security and Sustainable Agriculture
(Thailand on 21-24 December, 2018)

Effect of plastic low tunnel on flowering and fruiting behaviour during off season of summer squash (*Cucurbita pepo* L)

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Abstract
An experiment was conducted during 2009-10 and 2010-11 to study the effect of low tunnel on flowering and fruiting behaviour during off season of summer squash var. Australian Green at farm of Bihar Agricultural College Sabour Bhagalpur. The experiment was laid in randomized block design with seven treatments in three replications. The treatments comprised the seven date of sowing i.e., 30th November under open field, 15th December under open field, 30tyh December under tunnel, 15thy January under tunnel;, 30th January under tunnel, 15th February under open field and 28th February under open field. Result was found to be significant in flowering and fruiting behaviour during off season of bottle gourd**.** Number of days taken to first female flower appearance (48.50 days), and first harvest of fruit (55.50 days) was minimum while, fruit length (36.20 cm) fruit girth (7.81cm), fruits/plant (8.0) fruits weight (0.970) and yield per hectare 4.25 (quintal) were maximum when the date of sowing was 30th December under low tunnel condition (T3).Plastic low tunnel force early flowering in off season.

Keywords: low tunnel flower, fruits, date of sowing

Introduction
Cucurbits are mainly warm season crops, which are grown in tropical and subtropical regions. But summer squash is one vegetable crop among the cucurbits which can be grown under low temperature otherwise summer squash is being grown successfully under the temperature range of 15-25 ºC. Vegetable markets are flooded with several vegetables but mainly with cucurbits, when they are grown during their main season and sometimes the growers are even not getting back their cost of production. But the prices of same vegetables are usually very high during their off-season available. Presently the farmer are growing some the cucurbits for their off season cultivation in the rivers bed (diara land) in northern India after depletion of the water by digging deep trenches, but the area is imitated which can be extended further. But protected cultivation of cucurbits provides the best way for their off season cultivation in several parts of our country especially in northern parts of India. But for protected cultivation, the initial cost of protected structures should be minimum and within the reach of the farmers. Plastic low tunnel are such low cost structures under which summer sash and several other cucurbits can be grown successfully and commercially for their off season cultivation during winter months(Well and Loy1985) [22]. India has also entered in the era of greenhouse vegetable cultivation more recently and the total areas under protected vegetable production is not more than 10000 hectares. India being a vast country with diverse and extreme agro-climatic conditions, the protected vegetable cultivation technology can be utilized for year round and off season production of high value low volume vegetable crops (parthenocarpic cucumber muskmelon capsicum etc.), production of virus free high quality seedlings, quality hybrid seed production and as a tool for disease resistance breeding programmes. Among the protected structure Plastic low tunnel is a cheap and better way for off-season cultivation of cucurbits production. Plastic house cater to winter production of vegetable. The vast majority of the houses are covered with plastic polyvinyl chloride or polyethylene sheet usually called polytunnel. Plastics tunnel has spread in recent years because it prevents frost damage during

flowering and fruiting stage. In fact this technique could be increasingly necessary to mitigate adverse effects of climate change on fruit growing (Carlen and kruger, 2009) [2] Production under high or low tunnels can improve fruit precocity, allowing growing to get the premium prices usually occurring early in the harvest season (Demchak, 2009) [3] protecting crops under plastic (polyethylene), either with high tunnels or greenhouses, generates changes in the environmental condition of light, temperature and reletave humidity that may have effect on the productive and physiological responses of the plant (Li *et al*., 2012) [10]. Studies have shown that air temperature inside the tunnel is 3 to 20 ^{0}C higher and soil temperature is 2-5 ^{0}C higher than soil temperature recorded in open fields (Ogden and Van Iersel, 2009; Zhao *et al*. 2014) [12]. Studies conducted in tomatoes and strawberries indicate that the increases in temperature in high tunnels directly influences fruit precocity, with a harvest starting between 7 to 21 days earlier than in the open field (Wien, 2009; Singh *et al*.,2012; Crown *et al*., 2014 Zhao *et al*., 2014) [21, 16, 4]. Temperature and relative humidity play an important role in leaf stomatal conductance (g_s) and therefore in the transpiration rate and photosynthesis of the plant (Righi *et al*., 2012 [14]. Polyethylene film that are commonly used to cover greenhouse or tunnel can reduce transmission of photosynthetically active radiation (PAR) between 20% and 30% compared to radiation under unprotected conditions (Cowan *et al*., 2014) [4] It has been found that a decreases in PAR availability may have negative effects on crop production under plastic because it decreases photosynthetic rate, which in turn affects yield and quality (Sandri *et al*., 2003) [15]. Low Tunnel can warm the soil and protect the plants from hails, cold wind, and injury and advance the crops than normal season because temperature goes below 8 ^{0}C for 30-40 days during winter season in plain of north India. The fruits remain available from April to November thus causing glut in market, which lead to price crash in the main season (Kumar *et al*. 2015) [9]. But the price of the produces have high premium value during their off-season availability by adopting the season forcing techniques like green house, poly house net house and low tunnel (Enoch and Enoch, 1999) [5] but installation of these structures are costlier so unaffordable by the small and marginal farmers. Out of these techniques, low tunnel is found one of the best for non woody species, such as ornamental and vegetable (Zhao *et al*. 2014). Which can warm the soil and protect the plants from hails, cold wind, injury and advance the crops than normal season because temperature goes below 8 ^{0}C for30-40 days during winter season in plain of north India? Technology for cucurbits production has been extended to the farming community successfully. Farmers are gradually adopting different protected structure to combat the climatic vagaries and emerging challenges in vegetable production. The low tunnel techniques can use for raising seedlings by modifying the microclimate (Ken-Bar 2004) [8]. Generally, the tunnels are made in north to south direction to receive maximum sunlight. Transparent plastic of 30-50 micron is commonly used for making low tunnels, which reflects infra-red radiation to keep the temperature of the low tunnels higher than outside. These tunnel increases the inside temperature and entrapment of carbon dioxide, resulted more photosynthetic activity of crops hence early produce. They create a favourable microclimate around the crops by proving, frost and pest protection and reducing moisture loss. (Butler and Ross, 1999) [1].

In several part of country, especially in northern plains, temperature is hovering 4 to 15 ºC during winter season. So warm season crops like bottle gourd, bitter gourd okra do not allow successful production in open field in open field during winter season Keeping all the above facts in view, the proposed study was planned with the objective to find out best date of sowing and growing condition to get earliest flowering and fruiting in bottle gourd for fetching higher price in market.

Material and Methods

The field experiment was conducted in winter season during 2009-10 & 2010-11 at vegetable research farm of the Bihar Agricultural College, Sabour, Bhagalpur, Bihar. Bhagalpur was situated in the plane of Ganga basin at height of 141feet above sea level with 25º 15' 12.20''N latitude and 86º 59' 20.61'' E longitude. The experimental site was characterized by subtropical climate in which temperature ranges from 4 ºC to 28 ºC during winter. The soil was sandy loam, well drained having pH 7.22, organic carbon 0.41%, available N 228.15 kg/ha, P_2O_5 49.25 kg/ha and available K_2O 363.78 kg/ha. The experiment was conducted in randomized block design in three replications with seven treatments. The treatments comprised the seven dates of sowings i.e., 30th November under open field, 15th December under open field, 30th December under tunnel, 15th January under tunnel, 30th January under tunnel, 15th February under open field and 28th February under open field. Seedling of bottle gourd var. Narendra Reshmi was transplanted with spacing of 3 m x 0.5 m. For making plastic low tunnel, 60 cm width, 50 cm high and 50 micron transparent plastic were used, immature bamboo stick were pegged on the both sides of water channel. The tunnels were made in north-south direction and vents were made in tunnel on east side. All the necessary cultural practices were carried as per package of practices during the growth period of the crop. Plastic of the tunnel was removed from the bed in the 2nd week of February in each year. The five plants were randomly selected in each treatment for recording various plant growth parameters and yield parameters. Mean values of different characters were used for statistical analysis. The data were recorded on vine length (cm), primary branches, first female flower appearance, first picking, fruit length (cm), fruit girth (cm) and fruits per plant. Mostly artificial soil media was used for raising healthy and vigorous seedlings of vegetable in plastic pro- trays. There were three ingredients viz., cocopeat, vermiculite and perlite which are being used as a rooting medium for raising the nursery. Benefit of this nursery was better root development of transplants and reduction in the mortality in transplanting of seedling as compared to the traditional system of nursery raising. Seedlings were raised by sowing seeds in plastic pro-trays which were filled with growing media prepared by mixing coco peat: vermiculite: perlite in the ratio of 3:1:1 (V/V). Seedlings were ready in about 20-25days. Vine length was measured from the base of each plant to the growing point of a main vine. Primary branches per plant are the total number of fruiting branches emerging from the main stem was counted at the time of last picking. The fruits selected for recording fruit length were used for measuring fruit diameter in centimetres at middle periphery of fruits with the help of Verneer Callipers. The data generated for both growing seasons were pooled together and then analysed statistically (Panse and Sukhatme 1978) [13].

Results and Discussion

The impact of climate change is likely to have a great influence on the agriculture and eventually on the food

security. Protected structures i.e., low tunnel can play important role to minimize the impact of temperature fluctuation over precipitation, fluctuating sun shine hour and infestation of disease and pest (Singh and Satpathy, 2005) [19]. Such analyses are being made to support the regional policies for making agriculture sector resilient to climate change. The major results and discussion related to present research with different parameters are discussed below:

Flower attributing parameters

Days taken to first female flower appearance and first harvest were significantly influenced by the sowing date and growing conditions. Minimum number of days taken to first female flower and first harvest was observed when the sowing was done on 30th December under low tunnel (T_3) over other date of sowing under low tunnel. Early flowering force to early fruiting. Data related to first flowering and first harvest of fruits was due to air temperature inside the tunnels was always recorded higher as compared to outside. The maximum temperature different of about 10 ^oC between inside and outside. The favourable effect of low tunnel on flowering and harvesting might be due to the conducive microclimate condition through which crop had reached to early flowering and fruiting by increasing the temperature at that time. Ogden and van Iersel (2009) [12] have also indicated that low tunnels modify climatic conditions, promoting earlier flowering and fruit ripening as well as fruit precocity production. Obshato and Shabalina (1984) [11] opined that the time of fruiting was related to early temperature condition which favour to low tunnel structure. In similar study conducted by Ibarra *et al.* 2001 [7] observed that muskmelon crop grown under plastic cover flowered 24 days earlier than uncovered plants.

Fruiting parameters

Perusal of data presented in Table 1 revealed that fruit length, fruit girth, fruit weight, yield per plant and yield per hectare, were significantly influenced by the sowing date and growing conditions. Maximum fruit length, fruit girth, fruit weight, yield per plant, fruit per plant and yield per hectare were found when the sowing was done on 30th December under low tunnel (T_3) over other date of sowing under low tunnel. It might be due to better growth and development of all yield contributing parameters under low tunnel which increases the net photosynthesis and production of more assimilates available for individual to grow. Singh and Kumar (2009) [18] found that out of the five varieties of summer squash evaluated for their off season cultivation under plastic low tunnel during winter period, variety Australian Green took minimum days (58) to fist harvest after transplanting along with maximum fruit yield per plastic (5.90kg/plant) and highest total fruit yield (696.0q/ha), Similar results were also given by Singh *el al* (1989) [17]. Vegetative growth was greatest in plants in the tunnel where the the thermal condition were best early and total marketable yield were highest under the poly tunnel (Siwek and Capecka1999) [20]. It is important to note that no significant differences were observed in fruit weight in both condition i.e., grown in tunnels and in open field.

Table 1: Meteorological data recorded during crop season (October-April).

Months	Minimum air temperature ^0C		Relative humidity	Rainfall(mm)
	Outside	Inside tunnel		
October	22.00	32	50-70	0
November	19.00	33	30-60	0
December	12.00	30	55-90	0
January	11.00	29	60-90	0
February	13.00	30	30-70	0
March	16.00	32	30-60	0
April	23.00	33	30-70	0

Table 2: Effect of sowing time and growing conditions on growth and yield attributing parameters of summer squash

Treatments	Female flower	First picking	Fruit length(cm)	Fruit girth(cm)	Fruits/plant	Fruit weight (kg)	Yield/ plant	Yield/ha
T1=30th Nov. Open field	62.50	74.50	26.80	6.87	3.00	0.749	2.24	138.88
T2=15th Dec. Open field	54.00	65.50	19.60	5.11	2.65	0.335	0.88	54.86
T3=30th Dec. under tunnel	48.50	55.50	36.20	7.81	8.00	0.970	4.25	258.09
T4=15th Jan. Under tunnel	56.50	69.50	32.60	6.61	3.45	0.815	2.081	173.72
T5=30th Jan. tunnel	62.00	76.00	30.75	5.69	3.50	0.625	2.020	136.09
T6=15th Feb. Open field	56.00	66.00	11.18	3.41	3.60	0.152	0.55	33.79
T7=28th Feb. Open field	56.00	64.00	9.25	3.08	2.60	0.137	0.35	21.70
SD	1.64	1.99	1.13	0.33	0.29	19.70	0.11	7.76
CD at 5%	3.33	4.05	2.47	0.73	0.55	40.14	0.25	16.91

Economics

Net income and cost benefit ratio is significantly influenced by off season flowering and fruiting induced by low tunnel technology. Net income and cost benefit ratio was maximum when sowing the crop on 30th December under tunnel. This might be due to high market value in off-season. Growers typically reported satisfaction with adopting this technology.

Acknowledgments

The authors are thankful to the Department of Horticulture (Vegetable and Floriculture), Bihar Agricultural College, Sabour, Bhagalpur for supporting and funding to develop the present research.

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