

## Effect of growing conditions, time of pollination and fruit retention in hybrid seed production of summer squash (*Cucurbita pepo*)

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**ABSTRACT** An investigation was carried out under insect proof net house (IPN) and open field at Centre for Protected Cultivation Technology (CPCT), IARI, New Delhi in hybrid seed production of summer squash (*Cucurbita pepo* L.) cv. Pusa Alankar showed that number of leaves, leaf area and female flower were more in insect proof net house. Significantly higher number of fruits set and matured fruits/plant was registered in insect proof net house. Among the fruit development and seed yield characters viz. fruit weight (1179.90 g), fruit length (34.19 cm), number of seeds/fruit (343.70), number of filled seeds/fruit (333.60), seed yield/fruit (38.47 g), seed yield/plant (73.09 g) and seed yield/ha (1096.42 kg) were significantly higher under insect proof net house. Among the physical parameters of seed viz. seed width, seed coat weight showed significant differences. The seed quality attributes were also significantly superior under insect proof net house except germination%. Pollination at 6 am established better fruit development, seed quality and seed yield under insect proof house. Retention of two fruits/plant gave higher seed yield/plant (60.51 g) and seed yield/hectare (908.55 kg) than those of one fruit/plant (40.21 g & 603.15 kg, respectively). Seed quality attributes were higher, if one fruit/plant was retained. The incidence of virus was zero under IPN, whereas 60% plants were affected with virus at maturity under open field conditions.

**Key words:** Summer squash, growing conditions, seed production, pollination time, fruit retention, seed yield and vigour index

Summer squash (*Cucurbita pepo* L.),  $2n=40$ , belongs to family cucurbitaceae is said to be originated from America probably in north-eastern Mexico. It has now been widely distributed and some of its cultivars even withstand under cooler climate. The average productivity of pumpkin, squashes and gourds is 9.7 t/ha in India, which is lower than the world average productivity 14.0 t/ha [1]. The major reason for lower productivity in India can be attributed to the limited application and availability of high quality seeds of released hybrids. Seed production of summer squash is limited to hills of Himachal Pradesh and Uttarakhand. Since high incidence of virus, diseases and short growing period limits the seed production under northern plains conditions of

India. In open field the seed yield is very low due to unfavourable environmental conditions. But with changing climatic conditions, like unseasonal rains during summer (April-June), sudden increase in temperature, the seed yield and quality were drastically reduced. The seed crop under insect proof net house can easily overcome these problems by protecting it from various insect vectors and unfavourable climatic conditions. It can also provide an option for advancing the fruit crop during early summer season [2]. Therefore, the present investigation was planned to study the effect of growing conditions, time of pollination and fruit retention on growth behaviour, flowering, fruit setting, fruit development and seed quality attributes under insect proof net house and open

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field conditions in summer squash during summer season of Delhi conditions.

## MATERIALS AND METHODS

The field experiment was carried out during summer 2012 at Centre for Protected Cultivation Technology (CPCT), IARI, New Delhi, under both experiments *viz.* insect proof net house and open field conditions. The insect proof net house is made with UV stabilized white insect proof nylon net, with double door facility and having dimensions 60 m x 6 m x 2 m equipped with drip fertigation facilities [3]. The seeds of parental lines of Pusa Alankar were obtained from the IARI Regional Station Katrain, Kullu (HP). The seedlings were raised in plug tray with soilless medium at CPCT. The 28 days-old-seedling (two leaves stage) were transplanted @ one seedling per hill at the spacing of 1.0 m x 0.6 m under both conditions following planting ratio of 3:1. The male flowers were pinched from the seed parent before the anthesis regularly, with utmost care to avoid selfing. The female flower likely to be opened next day was tied with coarse thread during evening (5-7 pm). On the next day the protected male flower were collected and pollination was carried out manually at 6 am, 8 am and 10 am by rubbing the anthers gently over the stigmatic lobes under both conditions regularly for entire month. One fruit/plant and two fruits/plant were retained under both the conditions. The pollinated flowers were labeled over the peduncle.

Recommended cultural practices and plant protection measures were followed during the experimentation. The mature fruits (bright yellow) were harvested; the fruits were cut longitudinally. The seeds, along with placenta, were extracted manually, washed and dried under shed in one day and subsequently in sun [4]. The observation on number of leaves, leaf area, number of female flowers/plant in seed parent, number of male flowers/plant in pollen parent, number of flowers pollinated/plant, number of fruits set/plant [5], number of mature fruits/plant, fruit weight, fruit length, fruit width, flesh thickness, number of seeds/fruit, number of filled seeds/fruit, seed yield/fruit, seed yield/plant, seed yield/ha, 100-

seed weight, seed length, seed width, seed coat weight, EC, germination percentage, seedling length, seedling fresh weight, seedling dry weight, vigour index I and II were recorded. The laboratory observations *viz.* germination percentage [6], seed vigour indices [7] and electrical conductivity [8] were carried out at Seed Testing Laboratory, Division of Seed Science and Technology, IARI, New Delhi. The data obtained was subjected to *t*'-test at Indian Agricultural Statistical Research Institute New Delhi.

## RESULTS AND DISCUSSION

Plant growth, fruit development, seed yield and seed quality attributing characters were significantly influenced by growing conditions, time of pollination and fruit retention in summer squash and their interaction are presented in Tables 1 to 6.

### *Growth behaviour and fruit setting*

The significantly higher number of leaves, leaf area and number of flowers/plant were recorded under IPN as compared to those of open field conditions in parental lines of Pusa Alankar (Tables 1&2). This may be due to better assimilative power of crop under IPN [9], better photosynthetic efficiency of plants and increased quantity of chlorophyll [10, 11]. In IPN, 46.80 days were recorded for the opening of the first female flower in the seed parent, whereas under open field conditions, it took 52.60 days. The total number of female flowers/plant was significantly higher in IPN (2.80) as compared to those of open field condition (1.80). The male flower opening was 4-5 days earlier than the female flower opening under both the experimental conditions. This was in close agreement with the results obtained by Hossain *et al.* [12] in pumpkin and Singh *et al.* [2] in parental lines of pumpkin (Pusa Hybrid-1). The number of fruits set (2.4) and matured fruit (1.9) per plant were significantly higher in insect proof net house, which could be due to better availability of favourable environmental conditions especially the higher relative humidity (Table 6) which might have helped in maintaining the pollen viability and avoided desiccation of pollen on stigmatic surface. The more

Table 1. Effect of growing conditions on plant growth behaviour of parental line of summer squash cv. Pusa Alankar

Character	Seed parent			Pollen parent		
	IPN	Open field	(P=0.05)	IPN	Open field	(P=0.05)
Number of leaves on 20 days from transplanting	7.00	6.50	NS	7.03	6.63	NS
Leaf area on 20 days from transplanting (cm <sup>2</sup> )	131.77	113.74	**	116.49	115.42	NS
Number of leaves on 40 days from transplanting	14.03	11.00	NS	12.23	10.33	**
Leaf area on 40 days from transplanting (cm <sup>2</sup> )	792.58	314.76	**	771.69	310.38	**
Number of leaves on 60 days from transplanting	29.89	21.16	**	26.86	20.76	**
Leaf area on 60 days from transplanting (cm <sup>2</sup> )	1518.40	698.60	**	1482.31	664.78	**

NS-Non-significant, \*Significant at P= 0.05, \*\* Significant at P=0 .01, IPN-Insect proof-net house

number of matured fruits/plant could be due to congenial environment and less incidence of virus under insect proof net house, whereas higher irradiation could have affected the maturation of fruit under open field [9].

#### Fruit attributes and seed yield attributes

The fruit weight (1179.90 g), fruit length (34.19 cm) and fruit width (9.08 cm) were highly significant in IPN as compared to those of open field environment (Table 2). However, flesh thickness has shown non-significant difference under both growing conditions.

The seed yield contributing characters *viz.*, number of seeds/fruit (343.70), filled seeds/fruit (333.60) were significantly higher in IPN which may be due to higher viable pollen, better post fertilization growth and development of fruit; similar result was reported by earlier worker [2] in pumpkin. The higher seed yield/fruit (38.47 g), seed yield/plant (73.09 g) and seed yield/ha (1096.42 kg) in IPN were due to higher number of filled seeds/fruit and more matured fruits/plant. There was significant difference in 100-seed weight under both conditions (Table 2). Similar results were obtained by Flemine [4] and Singh *et al.* [2] in pumpkin.

#### Physical properties and seed quality attributes

Among the physical parameters of seed *viz.* seed width (0.79 cm) and seed coat weight (0.30 g) had registered the significant differences, whereas the

seed length (1.45 cm) and cotyledon weight (1.41 g) could not register any significant variation between the two growing conditions (Table 2). Significantly higher seed coat weight under IPN may be due to better development and maturation of fruits and absence of virus incidence than those where higher incidence of viruses and higher light intensity might be responsible for poor fruit development under open field conditions.

Seed quality attributes *viz.* seedling length (35.35 cm), seedling fresh weight (12.10 g), seedling dry weight (1.17 mg), seed vigour index I (3464.30) and II (2363.76) were significantly higher in IPN than those of open field conditions (Table 2). The superiority of these attributes under insect proof net house in comparison to open field may be due to the higher photosynthetic efficiency and better assimilation of food reserve in seed [2]. The seed germination of 98% and the lower electrical conductivity in IPN indicated the sound development of seeds (Table 2).

#### Effect of pollination time on fruit and seed yield attributes

The data presented in table 3 showed maximum percentages of fruits set (100%) at 6 and 8 am pollination under IPN. This might be due to higher pollen viability and stigma receptivity at 6 am, whereas later decline in fruit set could be attributed to lower pollen viability and stigma receptivity [13].

Table 2. Effect of growing conditions on flowering behaviour, fruit set, seed yield, seed quality and seed vigour in hybrid seed production of summer squash cv. Pusa Alankar

Character	IPN	Open field	(P=0.05)
<b>Flowering behaviour</b>			
Days to opening of first female flower in seed parent	46.80	52.60	**
Average number of female flowers up to 30 days of first flowering (per plant) in seed parent	2.80	1.80	**
Days to opening of first male flower in pollen parent	44.10	48.50	**
Average number of male flowers up to 30 days of first flowering (per plant) in pollen parent	23.80	18.00	**
Average number of flowers pollinated/plant	2.60	1.60	**
<b>Fruit set</b>			
Average number of fruits set/plant (7days from the pollination)	2.40	1.40	**
Average number of matured fruits/plant	1.90	1.10	**
Fruit weight (g)	1179.90	442.80	**
Fruit length (cm)	34.19	27.21	**
Fruit width (cm)	9.08	6.73	**
Flesh thickness (cm)	2.12	1.98	NS
<b>Seed yield attributes</b>			
Number of seeds/fruit	343.70	186.10	**
Number of filled seeds/fruit	333.60	173.70	**
Number of unfilled seeds/fruit	10.10	23.40	**
Seed yield/fruit (g)	38.47	21.66	**
Seed yield/plant (g)	73.09	23.82	**
Seed yield/ha (kg)	1096.42	316.88	**
<b>Seed quality</b>			
100-seed weight (g)	12.17	11.19	**
Seed length (cm)	1.45	1.41	NS
Seed width (cm)	0.79	0.74	**
Seed coat weight (g)	0.30	0.26	*
Cotyledon weight (g)	1.41	1.43	NS
<b>Seed vigour</b>			
Electrical conductivity (ds/m)	0.16	0.19	**
Germination (%)	98.00	98.00	NS
Seedling length (cm)	35.35	24.12	**
Seedling fresh weight (g)	12.10	10.47	**
Seedling dry weight (mg)	1.17	0.88	**
Seed vigour index I	3464.30	2363.76	**
Seed vigour index II	114.66	86.82	**

NS-Non-significant, \*Significant at P= 0.05, \*\*Significant at P=0.01, IPN-Insect proof-net house

Most of the fruit development and seed quality attributes are significantly superior under IPN, irrespective of time of pollination and growing conditions, which might be due to more pollen viability and stigma receptivity at 6 am pollination and congenial environmental conditions as compared to later pollination time and open field environment which probably favoured better fruit setting and fruit development in summer squash. The results were in agreement with earlier studies [5]. The number of seeds/fruit (325.10), filled seeds/fruit (314.20), seed yield/fruit (37.39 g), seed yield/plant (71.04 g), and seed yield/ha (1065.61 kg) were higher at 6 am under both the growing conditions. The higher number of seeds and filled seeds/fruit at 6 am may be due to the fertilization of higher number of ovules which further declined might be due to higher temperature and the desiccation of stigma. The superiority of seed quality attribute under 6 am pollination in IPN could also be due to better accumulation of food reserve as indicated by higher 100-seed weight (Table 3).

#### *Physical and seed quality contributing characters*

The perusal of data (Table 3) showed non-significant differences in seed length and cotyledon weight except the seed width and seed coat weight at 6, 8 and 10 am pollination under both the growing conditions. The seed width and seed coat weight were 0.80 cm & 0.30 g and 0.77 cm & 0.28 g under insect proof net house & open field conditions, respectively at 6 am pollination, whereas subsequent pollination time showed decreasing trend under both the conditions. Electrical conductivity was significantly lower in insect proof net house (0.14 ds/m) than those of open field conditions (0.18 ds/m), indicated the sound development of seed and which is considered to be best at 6 am pollination under both the growing conditions. The germination percentage in seeds harvested from the 6, 8 and 10 am pollination was at par under both the growing conditions. Seedling length (36.74 cm), seedling fresh weight (12.09 g) seedling dry weight (1.19 mg), seed vigour index-I (3600.52), seed vigour index-II (116.62) were also significantly higher at 6 am pollination, whereas subsequent pollination time showed decreasing trend under both the growing conditions.

#### *Effect of fruit retention on fruit and seed yield attributes*

Highly significant differences were recorded in the fruit development attributes under two sets of fruit retention. Significantly higher fruit weight (1222.70 g/fruit), fruit length (36.07 cm), fruit width (9.19 cm) and flesh thickness (2.14 cm) were recorded in one fruit/plant compared to the first fruit of those plants retaining two fruits/plant. This might be due to partitioning of the food assimilates among the two fruits. The number of seeds/fruit and seed yield/fruit were significantly higher under one fruit/plant than those of two fruits/plant may be due to more availability and translocation of photosynthates from source to the developing fruit and thus resulted in increased fruit weight, seed number and seed weight. All these yield parameters were lower in two fruits/plant under both the growing condition. 100-seed weight also showed significant difference in both the growing conditions (Table 4).

#### *Physical and seed quality contributing characters*

The data presented in table 4 showed significant differences in seed width and seed coat weight with one fruit/plant as compared to first and second fruit of two fruits/plants under both the conditions.

Electrical conductivity was significantly lower in one fruit/plant (0.15 ds/m) than two fruits/plant (0.17 ds/m) under both the conditions, which indicate the sound development of seeds. A non-significant difference was recorded in germination percentage in fruit retention under both the conditions. Seedling length (37.17 cm), seedling fresh weight (12.22 g), seedling dry weight (1.2 mg), seed vigour index-I (3642.00), seed vigour index-II (90.16) were also significantly higher with one fruit/plant as compared to those of first and second fruit of two fruits/plants.

The data presented in table 5 showed zero percent incidence of summer squash mosaic virus under IPN as compared to open field conditions (60 %). It may be due to absence of virus transmitting agent under IPN. Similar results were reported by Flemine [4] and Singh *et al.* [13] in pumpkin. The occurrence of powdery mildew was higher under IPN (40 %) than open field conditions

Table 3. Effect of pollination time and growing conditions on fruit set, seed development, seed yield and seed quality parameters in hybrid seed production of summer squash cv. Pusa Alankar

Character	Pollination at 6 am			Pollination at 8 am			Pollination at 10 am		
	IPN	Open field	(P=0.05)	IPN	Open field	(P=0.05)	IPN	Open field	(P=0.05)
Number of flower pollinated	30	30	**	30	30	**	30	30	**
% fruit set	30(100)	22(74)	**	30(100)	20(67)	**	28(94)	12(40)	**
Fruit weight (g)	1173.30	470.90	**	1168.30	466.90	**	1078.50	346.50	**
Fruit length (cm)	34.11	28.15	**	34.09	28.04	**	32.77	24.15	**
Fruit width (cm)	8.99	6.86	**	8.93	6.72	**	8.02	5.56	**
Flesh thickness (cm)	2.09	2.02	NS	2.08	2.01	NS	1.98	1.30	**
Number of seeds/fruit	325.10	192.30	**	321.10	184.20	**	278.30	125.20	**
Number of filled seeds/fruit	314.20	170.30	**	310.20	163.60	**	264.30	92.00	**
Number of unfilled seeds/fruit	10.90	22.00	**	10.90	23.60	**	14.00	33.20	**
Seed yield/fruit (g)	37.39	22.91	**	36.94	22.62	**	32.29	18.40	**
Seed yield/plant (g)	71.04	25.20	**	70.18	24.88	**	61.35	20.24	**
Seed yield/ha (kg)	1065.61	335.18	**	1052.79	330.93	**	920.26	269.19	**
100-seed weight (g)	12.25	11.36	**	12.12	11.14	**	11.39	9.88	**
Seed length (cm)	1.44	1.43	NS	1.43	1.39	NS	1.30	1.28	NS
Seed width (cm)	0.80	0.77	*	0.80	0.77	*	0.73	0.63	**
Seed coat weight (g)	0.30	0.28	**	0.29	0.24	**	0.26	0.19	**
Cotyledon weight (g)	1.41	1.44	NS	1.39	1.41	NS	1.42	1.43	NS
Electrical conductivity (ds/m)	0.14	0.18	**	0.15	0.19	**	0.19	0.21	*
Germination (%)	98	98.00	NS	98.00	98.00	NS	97.30	96.40	NS
Seedling length (cm)	36.74	25.08	**	36.3	24.35	**	30.04	21.26	**
Seedling fresh weight (g)	12.09	11.46	**	12.07	11.30	**	11.11	10.33	**
Seedling dry weight (mg)	1.19	0.89	**	1.17	0.84	**	1.06	0.62	*
Seed vigour index I	3600.52	2457.84	**	3557.40	2386.30	**	2922.89	2049.46	**
Seed vigour index II	116.62	88.00	**	114.66	82.51	**	103.13	72.01	*

NS-Non-significant, \*Significant at P= 0.05, \*\*Significant at P=0.01, IPN-Insect proof-net house

**Table 4.** Effect of growing conditions and fruit retention on fruit development, seed yield and seed quality in hybrid seed production of summer squash cv. Pusa Alankar

Character	Pollination at 6 am		Pollination at 8 am		Pollination at 10 am	
	IPN	Open field (P=0.05)	IPN	Open field (P=0.05)	IPN	Open field (P=0.05)
Fruit weight (g)	1222.70	590.80	1051.30	435.30	738.60	340.10
Fruit length (cm)	36.07	29.97	30.46	25.57	27.55	23.66
Fruit width (cm)	9.19	7.08	8.76	5.78	7.44	5.49
Flesh thickness (cm)	2.14	2.01	1.73	1.56	1.63	1.28
Number of seeds/fruit	395.60	203.20	236.80	148.30	178.40	125.20
Number of filled seeds/fruit	382.50	183	224.30	118.90	163.70	92.40
Number of unfilled seeds/fruit	13.10	20.20	12.50	29.40	14.70	32.80
Seed yield/fruit (g)	40.21	27.41	33.84	19.73	26.73	17.70
Seed yield/plant (g)	40.21	27.41	33.84	19.73	26.73	17.70
Seed yield/ha (kg)	603.15	365.41	507.60	262.40	400.95	235.41
100-seed weight (g)	12.19	11.33	11.37	10.44	10.60	9.50
Seed length (cm)	1.47	1.45	1.40	1.38	1.30	1.27
Seed width (cm)	0.80	0.74	0.76	0.72	0.73	0.68
Seed coat weight (g)	0.31	0.30	0.28	0.25	0.27	0.22
Cotyledon weight (g)	1.44	1.45	1.42	1.37	1.42	1.40
Electrical conductivity (ds/m)	0.15	0.17	0.17	0.19	0.19	0.19
Germination (%)	98.00	98.00	98.00	98.00	97.30	96.35
Seedling length (cm)	37.17	26.83	31.89	23.94	24.41	20.92
Seedling fresh weight (g)	12.22	11.17	11.17	9.54	10.37	9.29
Seedling dry weight (mg)	1.20	0.92	0.96	0.78	0.83	0.64
Seed vigour index I	3642.00	2629.14	3125.22	2346.12	2367.77	2014.59
Seed vigour index II	118.40	90.16	94.08	77.02	80.54	62.11

NS-Non-significant, \*Significant at P = 0.05, \*\*Significant at P=0.01, IPN-Insect proof-net house

Table 5. Percent incidence of major diseases in hybrid seed production of summer squash cv. Pusa Alankar

% Incidence of disease	Insect proof net house	Open field condition
Squash mosaic virus	0%	60%
Powdery mildew	40%	30%

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Table 6. Weather conditions during flowering period of the crop (Average on weekly basis) from 15/03/2012 to 15/04/2012

Growing condition	Temperature (°C)			Relative humidity (%)			Light intensity(lux)
	Max.	Min.	Mean	Max.	Min.	Mean	
<i>Open field</i>							
First week	31.5	15.2	23.4	72.4	21.6	47.0	490 x100
Second week	30.9	15.5	23.2	61.0	29.3	42.45	780 x100
Third week	35.0	19.4	27.2	60.2	22.1	41.15	790 x100
Fourth week	37.2	20.2	28.5	62.1	20.8	41.45	795 x100
<i>Insect proof net house</i>							
First week	30.2	14.8	22.5	78.8	22.6	50.7	432 x 100
Second week	29.4	14.6	22.0	66.2	30.9	48.5	620 x100
Third week	33.9	18.8	26.35	64.1	24.5	44.3	615 x100
Fourth week	36.0	19.7	27.85	63.6	21.1	42.3	650 x 100

(30%), might be due to higher relative humidity under IPN compared to open field (Table 6).

It can be concluded that for growing virus free seed crop and attaining better flowering, fruit setting, fruit growth and matured fruits/plant during hybrid seed production of summer squash cv. Pusa Alankar, insect proof net house be used. The pollination should be done at 6 am. The two fruits/plant should be retained for higher seed yield under north Indian plain conditions.

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MATERIALS AND METHODS

The study was conducted in the open field at the vegetable research station, IARI, New Delhi. The experimental area was divided into two main blocks, one for the control and one for the treatment. The control block was further divided into two sub-blocks, one for the control and one for the treatment. The treatment block was further divided into two sub-blocks, one for the control and one for the treatment. The experimental area was divided into two main blocks, one for the control and one for the treatment. The control block was further divided into two sub-blocks, one for the control and one for the treatment. The treatment block was further divided into two sub-blocks, one for the control and one for the treatment.

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