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Effect of planting time and spacing on reproductive growth and physiological changes in king chilli (*Capsicum chinense*) under poly-house condition

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Abstract
A study was conducted in Rabi season 2014-15 in the poly-house, Department of Horticulture, CAU, Imphal to observe effect of planting time and spacing days to flowering, fruit maturity, net assimilation rate and plant growth efficiency of king chilli (*Capsicum chinense*) under poly-house condition. 4 planting times viz. November 30th, December 19th, January 7th and January 26th were considered as factor A and 3 spacings viz. 60 x 60 cm, 60 x 45 cm and 45 x 45 cm were considered as factor B. The experiment was laid out in FRBD (Factorial Randomized Block Design) with 3 replications. The result of the experiment showed that days to first flowering, 50% flowering and 80% fruiting significantly varied with variation of planting time, but not with spacing. Minimum days for first flowering (84.93 days), 50% flowering (92.47 days) and 80% fruiting (126.06 days) were exhibited by January 7th planting with a spacing of 45 x 45 cm. Maximum net assimilation rate (NAR) of 0.03858 gm^{-2}/day and 0.09871 gm^{-2}/day during 60-90 DAP AND 90-120 DAP respectively. Highest plant growth efficiency (PGE) (44.61%) was exhibited by November 30th planting with spacing of 60 x 60 cm during 60-90 DAP, followed by planting time December 19th with spacing of 60 x 45 cm (82.42%) during 90-120 DAP.

Keywords: Planting time, spacing, days to flowering, net assimilation rate, plant growth efficiency

Introduction
King chilli (Ghost chilli*)*, *Capsicum chinense* also known as Bhut Jolokia in Assamese, Naga Jolokia in Nagamese and U-morok in Manipuri, is extensively grown in the north- eastern region of India, predominantly in Assam, Manipur and Nagaland. After Professor Paul Bostland of New Mexico State University found that this chilli has 1, 001, 304 Scoville Heat Units beating Red Savina Habanero, it was recognized as the world's hottest pepper in the Guinness Book of World Records, 2007 (Lopez, 2007) [4]. The plant is woody perennial semi-shrub of 45 to 120 cm in height, with multiple stems. The fruit is sub-conical to conical in shape with smooth skin about 6 to 8.5 cm length and 2.5 to 3 cm of breadth. The mature fruit may weigh up to about 9g with 19 to 34 seeds. Cultivation under poly house protect the crop from adverse weather conditions, onslaught of diseases and insect pests and helps to obtain yield 2-3 times more than that under open field situation. Controlled application of water and nutrients under protected structures is an added advantage. Scientific research for production of this remunerative crop under poly house has not been done. Standardization of technology like planting time and spacing for production under poly house condition will help develop scientific package of practices for higher yield of quality fruits.

Materials and Methods
The experiment was carried out in Rabi season2014-15 in the poly-house, Department of Horticulture, CAU, Imphal. 4 planting times viz. November 30th (D_1), December 19th (D_2) , January 7th (D_3) and January 26th (D_4) were considered as factor A and 3 spacings viz. 60 x 60 cm (S_1), 60 x 45 cm (S_2) and 45 x 45 cm (S_3) were considered as factor B. The experiment was laid out in FRBD (Factorial Randomized Block Design) with 3 replications. Thus, there were altogether 36 treatment combinations in the experiment. Locally available seeds were collected and sown in nursery bed inside poly house. As there were four planting dates, seeds were sown accordingly at 20 days interval. Seeds were sown in raised nursery bed of 1 x 2.5 m size. Seeds were sown in lines in ridges. After sowing a layer of ash was spread followed by mulch application. After 12 days of sowing mulches were removed on seed germination. Total thirty six raised beds of 1.8 x 1.8 m were prepared. Stones and gravels were removed and labelled.

The height of the raised beds were kept 15 cm for drainage of excess water. Farm yard manure was first applied uniformly all over beds @ 4kg/bed. Inorganic fertilizers for nitrogen, phosphorus and potassium were applied @120 kg, 40 kg and 30 kg/ha in the form of Urea (46% N), SSP (16% P_2O_5) and murate of potash (60% K_2O). Full dose of phosphorus and potassium were applied at time of planting as basal application. Nitrogen was given in three split doses - first at planting, second and third doses were given at 30 days interval after basal dose application. Two months old seedlings were used for transplanting. After transplanting light irrigation was given. Hoeing and weeding were performed at regular interval as per requirement. Due to high hotness of chilli, hand gloves were used for harvesting of fruits. Regular observation was taken and days to first flower emergence were recorded for different treatments. Days to 50% flowering were recorded when 50% of the plants in different treatments opened flowers fully. Days to 80% fruiting were recorded in different treatments when 80% of the plants in a plot fruited fully. One plant from each plot of the different treatments was uprooted at 60, 90 and 120 days after transplanting. Soil was removed from the root zone and fresh as well as dry weight of plant was recorded. Plant drying was done in oven for 24 hours at 60˚c.

Net assimilation rate was calculated by using the following formula given by Vernon and Allison (1963) [6].

NAR= $(w_2 - w_1)(\log_e L_2 - \log_e L_1)/(t_2 - t_1)(L_2 - L_1)$

Where, L_1 and w_1 are the leaf area and dry weight of plants at time t_1: L_2 and w_2 are leaf area and dry weight of plants at time t_2, respectively.

Plant growth efficiency was calculated by following formula:

PGE= $D_2 - D_1/D_m \times 100$,

Where D_m=maximum dry weight at harvest, D_1=dry weight of plant at time 1 and D_2=dry weight of plant at time 2.

Results and Discussions

Effect of planting time

In the experiment, days to first flowering was found to be significant with planting time at all stages of growth. Minimum days taken to first flowering (84.80 days) was exhibited by planting time D_3 and longest days were taken by D_4 to bear first flowering (92.07days). Minimum days taken to 50% flowering (91.60 days) was exhibited by planting time D_3 and longest days were taken by D_4 to bear 50% flowering (105.20 days). Minimum days taken to 80% fruit maturity (126.25 days) was exhibited by planting time D_3 and longest days were taken by D_4 to bear 80% fruit maturity (138.75 days). As, D_4 took the most days to perform first flowering, 50% flowering and 80% fruiting. So it can be concluded that temperature plays an important role as ambient temperature is minimum at D_1 and maximum at D_4, which is similar to result obtained by Islam *et al*. (2011) [3], Hossain *et al.* (2014) [2] and Alam *et al.* (2011) [1].

Net assimilation rate was found to be significant with planting time. The interaction of planting time and spacing had no significant influence on net assimilation rate. Maximum net assimilation rate (0.09398 gm^{-2}/day) was exhibited by planting time D_4at 90-120 DAP, whereas minimum net assimilation rate was found by planting time D_1 (0.01568 gm^{-2}/day) at 90-120 DAP. . Maximum Net assimilation rate was exhibited by D_4 and minimum by D_1 at 90-120 DAP, which shows that according to temperature net assimilation rate varies, which is similar to result obtained by Misra *et al.* (2014) [5]. Plant growth efficiency was found to be significant with planting time. Maximum Plant growth efficiency (41.00% & 79.76%) was exhibited by planting time D_1 and D_2 at 60-90 DAP and 90-120 DAP respectively, whereas minimum Plant growth efficiency was found by planting time D_2 (14.16%) at 60-90 DAP and planting time D_1 (48.52%) at 90-120 DAP.

Effect of spacing

Days to first flowering, 50% flowering and 80% fruiting didn’t significantly vary with the change in spacing. Maximum net assimilation rate (0.02540 gm^{-2}/day) was exhibited by spacing S_3 at 60-90 DAP while lowest net assimilation rate was exhibited by spacing S_1 (0.964539 gm^{-2}/day). Maximum net assimilation rate (0.05598 gm^{-2}/day) was exhibited by spacing S_2 at 90-120 DAP while lowest net assimilation rate was exhibited by spacing S_1 (0.05310 gm^{-2}/day). This may be due to lack of competition between plants for nutrients, which is similar to result obtained by Misra *et al.* (2014) [5]. Maximum Plant growth efficiency (26.24% & 70.95%) was exhibited by spacing S_3 and S_2 at 60-90 DAP and 90-120 DAP respectively, while lowest plant growth efficiency was exhibited by spacing S_2 (23.51%) at 60-90 DAP and spacing S_3(66.81%) at 90-120 DAP.

Combined effect of planting time and spacing

Minimum days taken to first flowering (84.93 days) was exhibited by planting time D_3S_3 and longest days were taken by D_4S_1 to bear first flowering (92.40 days).Minimum days taken to 50% flowering (92.47 days) was exhibited by planting time D_3S_3 and longest days were taken by D_4S_1 to bear 50% flowering (105.60 days). Minimum days taken to 80% fruit maturity (126.06 days) was exhibited by planting time D_3S_3 and longest days were taken by D_4S_1 to bear 80% fruit maturity (139.90 days). Maximum net assimilation rate (0.09871gm-2/day) was exhibited by interaction D_4S_3 at 90-120 DAP while lowest net assimilation rate was exhibited by spacing D_1S_1 (0.01296 gm-2/day). Maximum Plant growth efficiency (44.61% & 82.42%) was exhibited by interaction D_1S_1 and D_2S_2 at 60-90 DAP and 90-120 DAP respectively, while lowest plant growth efficiency was exhibited by interaction D_2S_2 (23.51%) at 60-90 DAP and spacing D_1S_1 (66.81%) at 90-120 DAP.

Treatments	First flowering	50% flowering	80% fruiting	Net assimilation rate (gm^{-2}/day)		Plant growth efficiency (%)	
				60- 90 DAP	90-120 DAP	60- 90 DAP	90-120 DAP
D_1	87.55	99.78	132.13	0.018174(0.71984)	0.01568(0.71811)	40.99(6.43)	48.51(6.99)
D_2	90.47	100.80	133.35	0.014885(0.71755)	0.04811(0.740320	14.15(3.79)	79.76(8.95)
D_3	84.80	91.60	126.25	0.028665(0.72709)	0.05580(0.74552)	24.00(4.94)	72.75(8.55)
D_4	92.07	105.20	138.75	0.032393(0.72964)	0.09398(0.77068)	20.47(4.57)	74.75(8.67)
C.D.$_{05}$	0.64	1.11	2.33	0.0017	0.003	0.20	0.12
S_1	88.70	99.78	132.94	0.02230(0.72269)	0.05310(0.74345)	24.97(4.91)	69.07(8.28)
S_2	88.65	99.44	132.75	0.02288(0.72309)	0.05598(0.74545)	23.50(4.78)	70.95(8.42)
S_3	88.82	98.85	132.17	0.02540(0.72482)	0.05110(0.74207)	26.24(5.12)	66.81(8.18)
C.D.$_{05}$	NS	NS	NS	0.0015	0.002	0.17	0.10
D_1S_1	86.66	100.40	132.46	0.01872(0.72022)	0.01296(0.71621)	44.61(6.71)	43.59(6.64)
D_1S_2	87.40	100.90	132.53	0.01920(0.72056)	0.01837(0.71990)	39.90(6.35)	52.22(7.25)
D_1S_3	88.60	98.07	131.40	0.01659(0.71874)	0.01578(0.71813)	38.47(6.24)	49.73(7.08)
D_2S_1	90.40	101.50	133.80	0.01293(0.71619)	0.04822(0.74042)	12.35(3.57)	82.42(9.10)
D_2S_2	90.81	101.50	133.20	0.01422(0.71709)	0.05918(0.74778)	11.48(3.44)	82.42(9.10)
D_2S_3	90.20	99.40	133.06	0.01749(0.71937)	0.03693(0.73275)	18.63(4.37)	74.44(8.65)
D_3S_1	85.33	91.60	125.60	0.02962(0.72775)	0.05726(0.74641)	24.40(4.98)	72.89(8.56)
D_3S_2	84.13	90.73	127.10	0.02744(0.72625)	0.05711(0.74640)	22.13(4.75)	74.12(8.63)
D_3S_3	84.93	92.47	126.06	0.02893(0.72727)	0.05304(0.74366)	25.49(5.09)	71.23(8.46)
D_4S_1	92.40	105.60	139.90	0.02793(0.72659)	0.09397(0.77068)	18.52(4.36)	77.38(8.82)
D_4S_2	92.26	104.60	138.20	0.03066(0.72846)	0.08926(0.76763)	20.51(4.58)	75.03(8.69)
D_4S_3	91.56	105.50	138.16	0.03858(0.73388)	0.09871(0.77374)	22.37(4.78)	71.84(8.50)
C.D.$_{05}$	1.11	1.90	4.06	0.003	0.005	0.35	0.21

*value presented in the parenthesis is the square root transformed value of the original data

*the data is based on mean of 3 replications *DAP- Days after planting

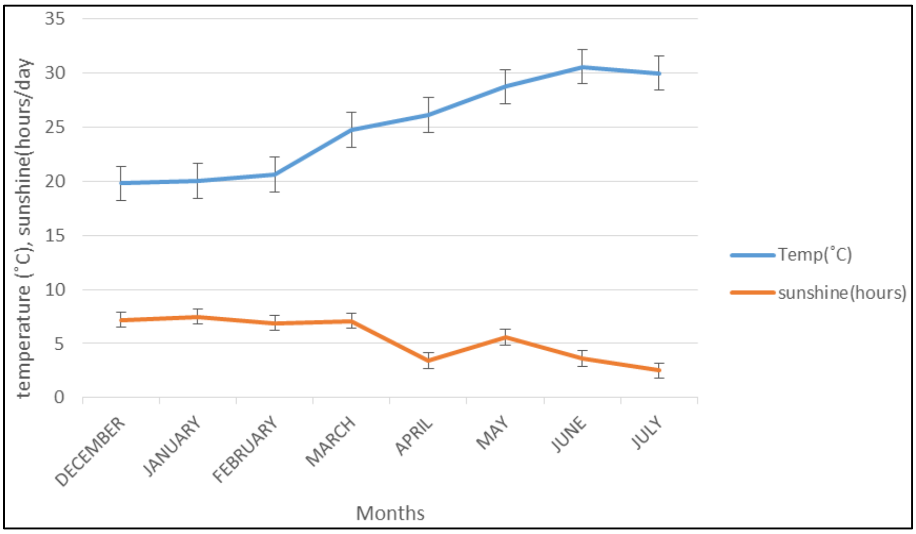

Fig 1: Temperature and sunshine hours in the poly-house during December 2014- July 2015

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