Effect of Growth Regulator and Irrigation on Fruit Cracking and Yield of Litchi in the Hilly Area

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Abstract: The experiment was conducted at the Hill Agricultural Research Station, Ramgarh, Khagrachari Hill District during July, 2010 to June, 2011. A factorial complete randomized design was followed with three irrigation levels (at 7, 15 days intervals and control) and four chemical treatments viz. GA_3 100ppm, Ethephone 18 mmole/l, 1% $ZnSO_4$ and control with three replications. Both the factors irrigation and chemical showed significant effect on most of the yield attributes and fruit characters. Irrigation significantly increased litchi yield by increasing number and size of the fruits as well as reduced cracking. Ethephone and GA_3 reduced cracking while$ZnSO_4$increased number of fruit and yield. Edible portion (%) seed size and TSS had minimum variation with irrigation or chemical spray. Any one of the three chemicals (Ethephone, $ZnSO_4$or GA_3) spray with weekly irrigation increased marketable yield of litchi in the hilly areas of Bangladesh.

Introduction

Lychee or litchi (*Litchi chinensis* Sonn.) is a popular tropical and subtropical fruit and the principal member of the genus *Litchi* under Sapindaceae family. It is native to China and now cultivated in many countries of the subtropical and tropical region of world (Morton, 1987). Lychees are commonly sold fresh in Asian markets, and in recent years, also widely in supermarkets worldwide. India is the second highest litchi producer after China (Singh and Babita,2014). It is one of the most popular seasonal fruits in Bangladesh. Almost all peoples like well ripen fresh litchi due to its attractive reddish lookup, fantastic taste,delicate whitish pulps having a floral smell and a fragrant, sweet flavor.Litchi is nutritious fruits contains plenty amount of vitamins minerals and low in saturated fats. The flavor of fruits are usually lost during canning or processing, so lion parts of this fruits are used as fresh or deserts. Fresh and healthy fruits are more priced compared to diseased and cracked fruits.Fruit trees in the Eastern hilly areas of Bangladesh experienced severe water scarcity during Spring and early Summer that causes low fruit retention. A heavy rain after long drought causes severe fruit cracking specially in litchi. Fruit cracking is one of the major disorders that drastically lowered the yield and quality of litchi thus reduced farmer's profit. Initial cracking or pericarp desiccation may be the result of high permeability of the cuticle to water vapour, cuticle damage and the presence of lenticels **(**Jianguo *et. al.*, 1993**)**. Litchi fruit cracking is assumed to be associated with an active uptake of water (Peng *et. al.*, 2004). Uneven water supply, micronutrient deficiency and imbalanced growth regulator are responsible for cracking of litchi fruits (Suryanarayana and Das, 2004). Growth regulators caused a favorable effect on fruit setting, fruit retention and weight of individual fruits (Singh and Lal**,** 1980). The present work was under taken to find out the effect of growth regulator and water supply for reducing fruit cracking and to increase litchi yield in the hilly areas.

Materials and Method

The experiment was conducted at the Hill Agricultural Research Station, Ramgarh, Khagrachari Hill District during July, 2010 to June, 2011. A complete randomized design (factorial) was followed having three levels of irrigation (at 7, 15 days intervals and control) and four chemical treatments viz. $GA_3$100ppm (Sing and Lal, 2003), Ethephone 18 mmole/l and 1% $ZnSO_4$ (Peng *et. al*., 2003) and control (no spray) with three replications. A popular well adopted litchi variety China-2 which have profuse bearing but prone to cracking, were used in the experiment. Out of more than 800 fruiting litchi trees in the experimental station, 36plant having similar age (15 years), canopy and size were selected in November, 2009 for applying the treatments. Each plant was considered as a treatment. The rainfall of the experimental area in January, February, March, April and May, 2010 was 15.24, 0.00, 32.07, 83.02 and 405.0mm, respectively.The canopy areas ofselected plants were cleared removing weeds and stubbles in December, February and April to minimize sharing of water, fertilizers and space with litchi plants with others. All plants were fertilized two

times in June and September, 2009 with each blanket dose of cowdung, urea, TSP and MoP @ 10.0, 1.0, 1.5 and 0.6 kg /plant, respectively.Irrigation and chemical application according to the treatment was started after flowering (Mid February) and at the pea stage of fruits (1st May), respectively. Each irrigation were provided with 100 liter of water for each plants thus ensured moderate soaking by the upper surface of the canopy soil (around 10 m^2) of all plants using watering cane. The soil was lightly spaded and many small barrier was made to minimize surface run-off thus ensured proper water use efficiency. Chemical was sprayed onto the flowering shoots, tender fruits and leaves of the plant for three times at middle of February, March and April according to treatment. Irrigation and spray was stopped after April as due to heavy rainfall.Data on number of inflorescence/plant, number of fruits per inflorescence and fruit characteristics were recorded from each plant. Single fruit weight, fruit size, seed weight, skin weight, TSS (%) and edible portion were recorded randomly selected 10 fruits from every harvest of each plant. Fruit yield and edible portion was calculated from other related parameters. Data were analyzed using MSTAT software and mean separation was done by Duncan's New Multiple Range Test (Zaman *et al.*, 1987).

Result and discussion

Effect of irrigation

Irrigation significantly showed positive effect on increasing litchi yield by increasing number and weight of fruits, effective inflorescence and reduce cracking (Table 1a.). Higher number of effective inflorescence per plant (185.5), number of normal fruits (14.10) and total fruits (13.13) per inflorescence was counted from weekly irrigated plants while non-irrigated control pants gave lower number of inflorescence (159.9/plant),number of normal (11.10) and total fruits (12.24) fruits per inflorescence. Lower number of fruit cracking was observed from irrigation at 14 days interval (0.88/inflorescence, 8.32%) which was closely followed by weekly irrigated plants (0.97/inflorescence, 8.62%) compared to control (1.14/inflorescence, 12.24%). More number of normal fruits (2429) and higher fruit yield (37.50 kg) per tree obtained from weekly irrigated plants and it was lower in control (1776 fruits, 25.70 kg/plant). This result resembled with the report of Singh and Babita (2014) that irrigation increase litchi frit yield and reduces cracking. Steven *et. al.*(2003) reported that pericarp desiccation occurred prior to crack development, with cracking the result of dehydration rather than the initial cause.Control plot gave a reasonable yield and with limited cracking because all plant received a good natural shower in April (83.02 mm) and May (405 mm) of the experimental year (2010) that helped good growth and development of litchi fruits in the later stage.Steven and Simons (1993) observed that micro-cracking extended through the sub-epidermal sclerenchyma layer into the mesocarp. He also found that pericarp desiccation occurred prior to crack development, so cracking is the result of dehydration rather than the initial cause.

Table 1a.Effect of irrigation on yield parameters in litchi

Treatment	Inflorescence /plant	No. of fruits /inflorescence			Cracked (%)	Fruits /tree	Yield (kg/tree)
		Cracked	Normal	Total			
7 days interval (T_1)	185.5a	0.97b	13.13a	14.10a	8.62b	2429a	37.50a
14 days interval (T_2)	179.3a	0.88b	11.90b	12.78b	8.32b	2186a	32.30b
Control (T_3)	159.9b	1.14a	11.10b	12.24b	10.57a	1776b	25.70c
Significance	*	*	*	*	*	*	*
CV %	11.37	11.68	6.72	7.65	12.02	9.85	10.26

Same letter in a column indicated insignificant variation among them * and ** indicated at 1% and 5% level of significance.

The length and width of fruits, seed weight, edible portion and Total soluble solid (TSS) showed insignificant variation with different irrigation level but single fruit weight and skin weight increased with irrigation (Table 1b.). Higher fruit weight (15.5g/fruit) and skin weight was recorded from weekly irrigated plants and it was found lower in non-irrigated control (14.6g and 3.21g, respectively).

Table 1b.Effect of chemical treatment on fruit characters of litchi

Treatment	Fruit size			Seed wt. (g)	Skin wt. (g)	Edible portion	TSS%
	Length (cm)	Dia. (cm)	Wt. (g)				
7 days interval (T_1)	2.99	2.92	15.5a	2.59	3.50a	39.3	18.75
14 days interval (T_2)	2.93	2.88	15.0ab	2.50	3.40a	39.7	18.53
Control (T_3)	2.89	2.83	14.6b	2.65	3.21b	40.8	18.70
Significance	NS	NS	*	NS	*	NS	NS
CV %	1.94	2.14	2.87	5.49	5.69	4.88	8.24

Same letter in a column indicated insignificant variation among them * and ** indicated at 1% and 5% level of significance.

Jianguo *et. al.* **(**2003) observed that water-stress reduced the calcium accumulation in fruit peel especially in the rapid growth of aril, and thus increased the fruit-cracking rate. Frequent irrigation increasing calcium contents in leaves and the fruit peel should lower fruit-cracking in litchi.Frequently irrigated plants having optimum supply of water helps uniform growth of the fruits and its skin resulted less cracking and higher number of normal fruits and weight of fruits. Huang and Jiankai (1958) opined that the pericarp growth is slower that pulp growth in litchi fruitsin later stage. Sudden rainfall or water availability after long drought resulted pericarp burst due to rapid expansion of pulp along with higher turgor pressure.

Effect of chemical treatment

Application of different chemicals effectively increased number of healthy fruits as well as fruit yield by reducing fruit cracking in litchi (Table 2a.). Number of inflorescenceand total number of fruits per inflorescence were not significantly differed due to chemical application. Both GA_3 and Ethephone significantly reduced fruit cracking compared to $ZnSO_4$ and control but fruit yield was statistically similar with all kinds of chemical application. The higher cracked fruit recorded from the control (2.11/inflorescence, 16.50 %) which was statistically similar with ZnSO4 application(1.69/inflorescence, 12.33 %) and the rate of cracking was below 5% in GA_3 and Ethephone application. Ethephone application resulted higher number of fruits per plant (2354) and fruit yield (35.6 kg) and it was lower in control (1822, 26.8 kg). Jianguo *et. al.* **(**2003) found that application of a solution containing calcium compounds significantly lowered fruit cracking rate. Suryanarayana and Das (1984) found the greatest increases in mean fruit weight and edible pulp weight with GA at 40 ppm and this treatment was also the most useful in minimizing fruit cracking. 2,4-D at 10 ppm and GA at 20 ppm were almost as effective.

Table 2a. Effect of chemical application on yield parameters in litchi

Treatment	Inflorescence /plant	No. of fruits/inflorescence			Cracked (%)	Fruits /tree	Yield (kg/tree)
		Cracked	Normal	Total			
GA_3 (C_1)	167.4	0.57b	12.73a	13.30	4.25b	2161ab	31.8b
Ethephone (C_2)	187.2	0.51b	12.50a	13.01	4.02b	2354a	35.6a
$ZnSO_4$ (C_3)	173.4	1.69a	12.01a	13.70	12.33a	2185a	33.1ab
Control (C_4)	171.4	2.11a	10.49b	12.50	16.54a	1822b	26.8c
Significance	NS	**	**	NS	**	**	**
CV %	11.37	11.68	6.72	7.65	12.02	9.85	10.26

Same letter in a column indicated insignificant variation among them * and ** indicated at 1% and 5% level of significance.

Fruit diameter, single fruit weight and seed weight differed significantly over control but fruit length, skin weight, edible portion and TSS% was not affected with chemical application (Table 2b.). Application of

GA_3gave higher fruit weight (15.3 g) closely followed by Ethephone and $ZnSO_4$ (15.1 g) and it was lower in control plants (14.7 g). Skin weight, edible portion and TSS was similar with different chemical application and control. Huang and Jiankai Xu (2003) obtained similar result that the pericarp growth did not differ significantly between the fruits with normal or aborted seeds with chemical application. Singh and Lal **(**1980) reported that all growth regulators caused a favorable effect on fruit setting, fruit retention and weight of individual fruitsGA_3 at 50 mg l^{-1} for increasing retention and GA_3 at 100 mg l^{-1} for improving fruit weight. All the chemicals increased number and weight of fruits that increased fruit yield providing inspiration for uniform growth.

Litchi fruit cracking is assumed to be associated with an active uptake of water, which is motivated by the enhanced respiration of the fruits, the sudden influx of water into the fruits by the drop of osmotic potential in the aril sap (Peng *et. al.*, 2004). When the pericarp or skin growth cannot kept pace with the sudden increased growth of pulp having excessive moisture after a long drought result pericarp cracking. Uniform water supply can reduce such deformation, increase fruit size, retention of fruits and finally increased yield and farmer's profitability.

Table 2b. Effect of chemical application on fruit characters of litchi

Treatment	Fruit size			Seed wt. (g)	Skin wt. (g)	Edible portion (%)	TSS%
	Length (cm)	Diam. (cm)	Wt. (g)				
GA_3 (C_1)	2.94	2.91a	15.3a	2.52b	3.51	39.6	18.90
Ethephone (C_2)	2.92	2.87a	15.1ab	2.57b	3.32	38.9	18.74
$ZnSO_4$ (C_3)	2.94	2.91a	15.1a	2.74a	3.41	40.6	18.60
Control (C_4)	2.93	2.81b	14.7b	2.62ab	3.30	40.5	18.40
Significance	NS	**	*	*	NS	NS	NS
CV %	1.94	2.14	2.87	5.49	5.69	4.88	8.24

Same letter in a column indicated insignificant variation among them * and ** indicated at 1% and 5% level of significance.

Combined effect of irrigation and chemical

All yield attributing parameters and fruit cracking were significantly differed with different combinations of irrigation and chemical application (Table 3a.). The highest number of inflorescence (201.3/plant) was counted from 14 days interval irrigation with ethephone application. The minimum number of inflorescence (135.3/plant) was recorded in control (no irrigation) with GA_3 application.

Table 3a. Interaction effect of irrigation and chemical on yield parameters in litchi

Treatment	Inflorescence /plant	No. of fruits /inflorescence			Cracked (%)	Fruits /tree	Yield (kg/tree)
		Cracked	Normal	Total			
I_1C_1	187.7ab	0.67cd	13.43a	14.10ab	4.75d	2521a	36.83ab
I_1C_2	191.3ab	0.60cd	13.50a	14.10ab	4.26d	2583a	39.94a
I_1C_3	182.3ab	1.73b	13.40a	**15.13a**	11.21b	2498ab	**40.68a**
I_1C_4	180.7ab	1.87b	11.70b	13.10bc	14.27b	2114b	32.49bcd
I_2C_1	189.3ab	0.53d	12.00ab	12.53c	4.24d	2272b	34.91abc
I_2C_2	201.3a	**0.20e**	13.10a	13.30b	1.50e	**2637a**	35.95a
I_2C_3	170.0b	1.60b	12.30ab	13.90b	11.51b	2091bc	29.66cde
I_2C_4	166.3b	2.17a	10.50c	12.67c	16.01ab	1746c	24.73ef
I_3C_1	135.3c	0.50d	12.50ab	13.30bc	3.76d	1691cd	23.79ef
I_3C_2	169.0b	0.73c	10.90c	11.63d	6.29c	1842c	26.87def
I_3C_3	168.0b	1.73**b**	11.70b	13.43b	12.88b	1966bc	29.16c-f
I_3C_4	167.3b	2.30a	9.60d	11.90d	19.33a	1606d	23.18f
Significance	*	*	*	*	**	*	*
CV %	11.37	11.68	6.72	7.65	12.02	9.85	10.26

Same letter in a column indicated insignificant variation among them. * and ** indicated at 1% and 5% level of significance.

Both GA_3 and Ethephone significantly reduced fruit cracking with different irrigation levels and it was the lowest (0.20/inflorescence, 1.5%) in 14 days irrigation interval with ethephone spray. Fruit cracking might be reduced applying GA_3 or ethephone thus kept cracking below 7% with or without irrigation. The maximum

cracking (2.3/inflorescence, 19.33%) was observed in absolute control (no irrigation, no spray).

The highest number of normal fruits (2637/plant) obtained from the plants with 14 days irrigation interval with ethephone spray (I_2C_2) which was closely followed (2583 fruits/plant) by 7 days irrigation intervals with ethephone spray (I_1C_2). The maximum yield (40.68 kg/plant) was obtained from the application of $ZnSO_4$ with weekly irrigation (I_1C_3) closely followed by I_1C_2 (39.94 kg/plant) and I_1C_1 (36.83 kg/plant) treatments. The lowest number of fruits (1606/plant) yield (23.18 kg/plant) was obtained from the absolute control (I_3C_4) where no spray or irrigation was provided. Li Jianguo *et. al.,* (2003) observed that initial pericarp desiccation may be the result of high permeability of the cuticle to water vapour, cuticle damage and the presence of lenticels.The effect of irrigation was not prompt and control treatment gave a reasonable yield because the crop gained a good shower in April (83mm) and May (406 mm).

Though the length and width of fruits, seed weight and TSS% was not affected but single fruit weight, skin weight and edible portion showed significant variations with different combination of irrigation and chemical spray (Table 3b.).

Table 3.b Interaction effect of irrigation and chemical on fruit characters of litchi

Treatment	Fruit size			Seed wt. (g)	Skin wt. (g)	Edible portion	TSS%
	Length (cm)	Dia. (cm)	Wt. (g)				
I_1C_1	3.00	2.97	15.0b-e	2.47	3.51abc	39.7a-d	18.9
I_1C_2	2.97	2.87	15.5ab	2.61	3.42a-d	38.7bcd	18.9
I_1C_3	3.03	2.97	16.2a	2.65	**3.70a**	38.8bcd	18.7
I_1C_4	2.97	2.87	15.3bc	2.63	3.51abc	40.0a-d	18.5
I_2C_1	2.93	2.91	**16.3a**	2.48	3.50arc	36.5d	18.6
I_2C_2	2.93	2.91	15.1bcd	2.40	3.28cde	37.3cd	18.6
I_2C_3	2.90	2.91	14.3e	2.63	3.50abc	**42.9a**	18.6
I_2C_4	2.93	2.80	14.2e	2.48	3.50abc	42.0ab	18.3
I_3C_1	2.90	2.85	14.6cde	2.61	3.60ab	**42.7a**	**19.2**
I_3C_2	2.87	2.83	14.6cde	2.69	3.32b-e	40.6abc	18.7
I_3C_3	2.90	2.85	14.9b-e	2.64	3.14de	40.3a-d	18.5
I_3C_4	2.90	2.77	14.5de	2.65	3.04e	39.6a-d	18.4
Significance	NS	NS	**	NS	*	**	*
CV %	1.94	2.14	2.87	5.49	5.69	4.88	8.24

Same letter in a column indicated insignificant variation among them * and ** indicated at 1% and 5% level of significance.

Bolder fruits obtained from the treatment I_2C_1 (16.3g) closely followed by I_1C_3 (16.3g) while the lowest single fruit weight was found in I_2C_4 (14.2g). The maximum skin weight was found in I_1C_3 (3.70 g/fruit) which were statistically similar with all irrigated treatment combinations except I_2C_2 while it was lower in all un-irrigated treatments except I_3C_1. The maximum edible portion (42.9%) was found in I_2C_3 which was closely followed by I_3C_1 (42.7%) while it was lower (36.5%) in the treatment combination I_2C_1. The total soluble solid was unchanged with different levels of irrigation and chemical sprays.

Conclusion

Irrigation significantly increased litchi yield by increasing number and size of the fruits as well as reduced cracking. All the chemicals reduced cracking except $ZnSO_4$ but showed positive effect of all yield and yield attributes. GA_3, $ZnSO_4$ and Ethephone spray with weekly irrigation can be suggested forhigher marketable yield of litchi in the hilly areas of Bangladesh.

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