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Effect of pre- and post-harvest treatments on yield, quality and post-harvest shelf life of king chilli (*Capsicum chinense* Jacquin) under foothill conditions of Nagaland (India)

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Abstract

Field and laboratory experiments were carried out at Medziphema (Nagaland) to evaluate the effect of pre- and post-harvest treatments on yield, quality and post-harvest life of King chilli (*Capsicum chinense* Jacquin) under foothill conditions of Nagaland. Highest fresh yield (13.65 t ha^{-1}) and capsaicin content (819421.13 SHU) of fruits were recorded with application of Naphthalene Acetic Acid (40 ppm). Maximum vitamin C content (115.67 mg $100g^{-1}$ of fruit) was recorded with application of Ethrel 250 ppm. Lowest physiological loss in weight (2.55%) and change in fruit colour (10%), highest value of ascorbic acid content (120.5 mg 100 g^{-1} of fruit) and longest shelf-life (9 days) were recorded at 9th day after storage in calcium chloride (0.5%) treated fruits, packed in non-perforated bags and stored under refrigeration at 5^{o}C.

Keywords: *Capsicum chinense* Jacquin, post-harvest storage, plant growth regulators, quality, yield

Introduction

King chilli (*Capsicum chinense* Jacquin) is cultivated mainly in Assam, Nagaland and Manipur in India. The shelf-life of this crop is limited to 3–5 days as a result of which considerable post-harvest losses are incurred. Pre-harvest sprays of plant growth regulators and other chemicals are known to be effective in enhancing the growth, yield, quality and shelf-life of King chilli (Katwale & Saraf 1990). Foliar application of calcium chloride before harvest on red sweet pepper is effective in improving the storage quality of fruits (Sungmin *et al*. 2001a). The keeping quality of King chilli can also be effectively increased by use of different packaging materials (Kader *et al*. 1989). Lower storage temperature results in longer storage life of King chilli (Rona *et al*. 2003). But no information is available on post-harvest management of King chilli in Nagaland. Hence, experiments were conducted to study the effect of pre- and post-harvest treatments on yield, quality and post-harvest life of King chilli under foothill conditions of Nagaland.

Materials and methods

The field experiments were carried out at the

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experimental farm of School of Agricultural Sciences and Rural Development, Medziphema Campus and laboratory experiments at Department of Horticulture, Nagaland University (25°45′43″N latitude and 93°53′04″E longitude) during February–September 2008. The experimental site is characterized by subtropical climate with high humidity (52%–86%), moderate temperature (7–35°C) and high rainfall (200–250 cm year^{-1}). Pre-harvest experiment was laid out in randomized block design with three replications. The treatments comprised of: T_1–Control, T_2–NAA 20 ppm, T_3–NAA 40 ppm, T_4–GA_3 10 ppm, T_5–GA_3 20 ppm, T_6–IAA 25 ppm, T_7–IAA 50 ppm, T_8–Ethrel 100 ppm, T_9–Ethrel 250 ppm, T_{10}–$CaCl_2$ 0.3% and T_{11}–$CaCl_2$ 0.5% (NAA–Naphthalene acetic acid; GA_3–Gibberellic acid; IAA–Indole acetic acid; $CaCl_2$–Calcium chloride). Growth regulators and calcium chloride were sprayed at 30 and 45 days after transplanting as per treatments. Healthy disease-free seeds of local variety were used for raising the seedlings and 60 day old seedlings were transplanted at a spacing of 90 cm × 60 cm in a plot measuring 2.7 m × 1.8 m; 90: 60: 60 kg NPK ha^{-1} was given uniformally to all the treatments. Observations were recorded on fruit length, fruit diameter, fresh weight of fruit, number of fruits plant^{-1}, number of seeds fruit^{-1}, fresh and cured yield ha^{-1}, capsaicin content and vitamin C content. Vitamin C content was determined by 2, 6 dichlorophenol indophenyl dye method (Rangana 1977). Capsaicin content was determined by HPLC (High Performance Liquid Chromatography) (AOAC 1995).

Based on yield and quality attributes from pre-harvest experiments, the treatments T_3 (NAA 40 ppm) and T_{11} ($CaCl_2$ 0.5%) were selected for post-harvest studies. The harvested fruits from both treatments were bulked together. Mechanical sorting of diseased and injured fruits was done and 20 mature green fruits were selected and packed in non-perforated low density polythene bags (W_1) and 6% perforated low density polythene bags (W_2) of 150 µm thickness and stored under room temperature (S_1) and refrigerated condition at 5°C temperature (S_2). All treatments were replicated four times under completely randomized design. Observations were recorded on physiological loss in weight (PLW), colour changes from green to red, fruit rotting, vitamin C content and shelf-life of fruit during storage at 3rd, 6th and 9th day after storage. Colour changes (from green to red) were calculated by visual rating method. A rating scale of 1, 2, 3, 4, and 5 was given for 0–20%, 21–40%, 41–60%, 91–80%, 81–100% red colour development, respectively. The data were analyzed statistically (Panse & Sukhatme 1989).

Results and discussion

Various pre-harvest treatments of plant growth regulators and chemicals significantly increased yield attributing characters and yield of King chilli as compared to control (Table 1). NAA @ 40 ppm (T_3) significantly recorded the highest fruit length (6.81 cm), fruit diameter (3.46 cm), fresh fruit weight (7.08 g), number of fruits plant^{-1} (104.10) and number of seeds fruit^{-1} (77.01). The increase in fruit size could be due to accelerated rate of cell enlargement and formation of larger intercellular spaces during later part of fruit growth as a result of NAA application. Increase in fruit weight might be due to increase in seed content, fruit size as well as rapid multiplication and enlargement of cells. Higher fruit size and fruit weight with NAA application in the present investigation corroborate with the findings of other workers (Doddamani & Panchal 1989; Katwale & Saraf 1990). Highest fresh yield (13.65 t ha^{-1}) and cured fruit yield (5.08 t ha^{-1}) were also obtained from NAA @ 40 ppm (T_3) which was significantly higher than other treatments. The influence of NAA application on fruit and seed yields might have been primarily mediated through the beneficial effects of NAA on the yield determining characters such as higher flower production and fruit set and reduced flower and fruit drop (Yamgar *et al*. 1987; Kumar *et al*. 2006; Singh *et al*. 2007). Quality of King chilli is usually evaluated by two major components namely, capsaicin and vitamin C content. These two quality characters were significantly influenced by application of various pre-harvest treatments. Highest value of capsaicin content (819421.13 SHU) was

Table 1. Effect of pre-harvest treatments on yield and quality attributes of King chilli fruits

Treatment	Fruit length (cm)	Fruit diameter (cm)	Fresh weight of fruit (g)	No. of fruits $plant^{-1}$	No of seeds $fruit^{-1}$	Fresh yield ha^{-1} (t)	Cured yield ha^{-1} (t)	Capsaicin content (SHU)	Vitamin C (mg 100 g^{-1} of fruit)
T_1 (Control)	4.94	2.24	4.43	56.13	39.39	4.62	1.30	461570.43	82.98
T_2 (NAA 20 ppm)	6.70	3.31	6.68	96.37	71.03	11.94	4.31	710067.58	60.07
T_3 (NAA 40 ppm)	6.81	3.46	7.08	104.10	77.01	13.65	5.08	819421.13	40.57
T_4 (GA_3 10 ppm)	5.94	2.82	6.01	76.7	60.15	8.47	2.75	656010.34	84.33
T_5 (GA_3 20 ppm)	6.54	3.17	6.67	92.81	68.63	11.46	4.05	689715.96	102.87
T_6 (IAA 25 ppm)	6.03	2.81	6.07	80.87	64.60	9.12	2.98	495209.94	81.16
T_7 (IAA 50 ppm)	5.79	2.61	5.58	70.98	44.45	7.33	2.20	578127.12	81.68
T_8 (Ethrel 100 ppm)	5.13	2.41	5.49	48.57	51.48	4.93	1.42	339226.30	111.71
T_9 (Ethrel 250 ppm)	4.98	2.41	5.41	43.10	48.48	4.33	1.23	335342.67	115.67
T_{10} ($CaCl_2$ 0.3%)	5.36	2.81	5.93	62.53	56.08	6.88	2.11	616689.42	88.35
T_{11} ($CaCl_2$ 0.5%)	6.27	3.14	6.39	68.47	67.09	8.11	2.76	643324.83	90.53
CD(P=0.05)	0.41	0.12	0.16	2.70	1.68	1.44	0.65	16518.87	0.93

NAA=Naphthalene acetic acid; GA_3=Gibberellic acid; IAA=Indole acetic acid; $CaCl_2$=Calcium chloride

obtained from treatment with NAA @ 40 ppm (T_3). The higher level of capsaicin content in NAA treatment might be due to increase in size of fruit particularly the size of the dissepiment which is a major source of capsaicin in the fruit. The higher level of capsaicin content in the fruit in NAA treated plants are in conformity with the report of Patil *et al*. (1985). The effect of NAA on plant growth and increase in fruit set, fruit retention and fruit and seed yield without loss of fruit quality in chilli has also been observed by many workers (Katwale & Saraf 1990; Singh & Lal 1994). Highest value of vitamin C content (115.67 mg $100g^{-1}$ of fruit) was obtained from Ethrel 250 ppm (T_{11}) treated plants which is in conformity with the findings of Nagdy *et al*. (1979) and Kabir *et al*. (1993) in chilli.

Various pre- and post-harvest treatments significantly influenced physiological loss in weight, colour change (from green to red), fruit rotting, vitamin C content and shelf life of fruit during storage (Table 2). PLW of fruits increased with advancement of storage period in all the treatments. Maximum PLW (29.94%) was recorded 9 days after storage (DAS) from treatment $T_3W_2S_1$ (NAA @ 40 ppm treated fruits, packed in perforated polythene bags and stored at ambient condition), while $CaCl_2$ @ 0.5% treated fruits, packed in non-perforated bags and stored under refrigeration at 5°C ($T_{11}W_1S_2$) recorded least value (2.55%) of PLW. The lower PLW in non-perforated polythene packed fruits might also be due to additional covering over the fruit which might have retarded the process of transpiration and respiration. This might also be due to increase in CO_2 concentration and decrease in transpiration rate due to higher relative humidity inside the bags (Gorini & Uncini 1981). The higher PLW in fruits stored in ambient temperature than fruits stored under refrigerated storage is in conformity with the findings of Rona et al. (2003). The treatment $T_{11}W_1S_2$ ($CaCl_2$ @ 0.5% treated fruits, packed in non-perforated bags and stored under refrigeration at 5°C) exhibited minimum change in colour of the fruit from green to red (10%) at 9 DAS. Highest percentage of colour change (86.67%) was observed in fruits treated with

Table 2. Effect of pre- and post-harvest treatments on quality parameters of King chilli fruits

Treatment	Weight of 20 fruits (g)	Physiological loss in weight (%)			Colour change* (%)			Rotting of fruit** (%)			Vitamin C at initial stage (mg100g^{-1} of fruit)	Vitamin C (mg 100g^{-1} of fruit)			Shelf life (Days)
		3 DSA	6 DSA	9 DSA	3 DSA	6 DSA	9 DSA	3 DSA	6 DSA	9 DSA		3 DSA	6 DSA	9 DSA	
T_3 W_1S_1	224.9	2.74	15.28	20.34	26.67	46.67	63.33	10.00	18.33	31.70	42.8	42.1	40.0	38.9	2
		(1.78)	(3.97)	(4.56)	(5.21)	(6.86)	(7.98)	(3.24)	(4.33)	(5.67)					
T_3 W_2S_1	220.1	6.74	19.38	29.94	35.00	63.33	86.67	0.00	11.67	16.67	38.8	37.5	35.9	35.0	4.3
		(2.69)	(4.46)	(5.52)	(5.94)	(7.98)	(9.33)	(0.71)	(3.36)	(3.87)					
T_3 W_1S_2	219.5	0.67	2.49	4.01	1.67	3.33	11.67	0.00	0.00	8.33	48.5	46.2	45.1	44.0	7.3
		(1.08)	(1.73)	(2.12)	(1.25)	(1.79)	(3.36)	(0.071)	(0.71)	(2.94)					
T_3 W_2S_2	223.1	0.77	4.23	5.14	3.33	10.00	16.67	0.00	0.00	5.00	47.2	45.4	43.9	42.8	6
		(1.11)	(2.17)	(2.24)	(1.79)	(3.24)	(4.09)	(0.71)	(0.71)	(2.09)					
T_{11} W_1S_1	240.4	1. 52	14.41	17.74	21.67	33.33	46.67	3.33	13.30	28.33	115.1	113.4	112.1	110.0	2.3
		(1.42)	(3.86)	(4.27)	(4.07)	(5.80)	(6.85)	(1.79)	(3.60)	(5.37)					
T_{11} W_2S_1	230.6	5.70	17.42	27.80	30.00	50.00	76.67	5.00	8.33	15.00	110.5	108.1	107.6	106.1	5.3
		(2.49)	(4.23)	(5.32)	(5.52)	(7.08)	(8.78)	(2.09)	(2.94)	(3.72)					
T_{11} W_1S_2	232.3	0.55	1.92	2.55	1.67	2.06	10.00	0.00	0.00	6.77	123.7	123.2	121.1	120.5	9
		(1.02)	(1.51)	(1.75)	(1.25)	(1.42)	(3.24)	(0.71)	(0.71)	(2.67)					
T_{11} W_2S_2	235.0	0.73	2.99	4.36	1.67	6.67	13.33	0.00	0.00	0.00	118.7	118.0	115.6	114.7	6.9
		(1.11)	(1.87)	(2.21)	(1.25)	(2.39)	(3.60)	(0.71)	(0.71)	(0.71)					
(P=0.05)	0.78	0.14	1.00	1.64	1.43	1.37	0.71	1.14	0.93	0.64	28.32	0.59	0.59	0.57	0.63

Values in parenthesis are angular transformed values; $T_{3=}$NAA 40 ppm; T_{11}=$CaCl_2$ 0.5%; W_1=Non-perforated polythene bags; W_2=Perforated polythene bags; S_1=Stored under room temperature; S_2=Stored under refrigeration condition; DAS=Days after storage; NAA=Naphthalene acetic acid; $CaCl_2$=Calcium chloride.
*Initial fruit colour was light green in all the treatment; **There was no rotting at initial stage in all the treatment

NAA @ 40 ppm, packed in perforated polythene bags and stored under ambient temperature ($T_3W_2S_1$) at DAS. The delayed colour development by $CaCl_2$ treated fruit, might be due to the action of $CaCl_2$ as an antagonist to ethylene which delays ripening of fruits. Non-perforated polythene packing showed slower colour change while fruits packed in perforated polythene packing showed faster colour change which is in agreement with the findings of Gorini & Uncini (1981). Colour change in fruits stored under refrigeration at 5°C was slower than fruits under ambient storage condition. This might be due to the effect of low temperature on the metabolic process within the fruit because low temperature restricts the transmission of respiratory gases where the accumulation of CO_2 around the fruit counteracts with the ethylene action and colour development. A similar effect has also been reported by Miller *et al*. (1986). No rotting was observed in fruits treated with $CaCl_2$ 0.5%, packed in perforated polythene and stored under refrigeration at 5°C ($T_{11}W_2S_2$) at 9 DAS, while fruits treated with NAA @ 40 ppm, packed in non-perforated polythene and stored under ambient condition ($T_3W_1S_1$) resulted in highest rotting (31.70%) at 9 days after storage. Lower rotting percentage in perforated polythene packing than non-perforated polythene packing might be due to development of higher humidity inside the bags that might have activated micro-organisms responsible for the rotting of fruits (Sungmin *et al*. 2001b). Lower fruit rotting percentage under refrigeration storage condition might be due to the effect of low temperature in the refrigerator which might have limited the activity of micro-organisms acting upon the rotting process. Similar results have also been reported by Sungmin *et al*. (2001b).

Highest ascorbic acid content (120.5 mg 100 g^{-1} of fruit) was recorded in the treatment with $CaCl_2$ @ 0.5%, packed in non-perforated polythene and stored under refrigeration at 5°C ($T_{11}W_1S_2$). Fruits packed in non-perforated polythene bags showed higher level of ascorbic acid content which might be due to the slower metabolic process as a result of modified atmosphere inside the packing, thus leading to slower conversion of ascorbic acid. Slower decrease in ascorbic acid content was observed in refrigerated storage condition as compared to ambient condition which is in line with the findings of Jecheon *et al*. (2001). Similarly, longest shelf life (9 days) was recorded in the treatment with $CaCl_2$ @ 0.5%, packed in non-perforated polythene and stored under refrigeration storage condition ($T_{11}W_1S_2$) at 9 DAS. This is probably due to decrease in ethylene production and respiration rate of fruits with $CaCl_2$ treatment before harvest which are responsible for senescence of fruits. As calcium concentration increased with application of $CaCl_2$, fruit decay rate decreased and fruit firmness retention and fruit weight increased, thereby prolonging the shelf life of fruits. Better quality fruits could be obtained from storage under refrigeration condition at 5°C. Lower temperature and higher relative humidity in refrigeration storage condition led to slower transpiration and metabolic process and reduced rate of rotting which might have contributed towards better shelf life of the fruits. Similar effects of longer shelf life of red sweet pepper fruits with the application of $CaCl_2$ have been reported by Sungmin *et al*. (2001a).

The study indicated that highest fresh yield (13.65 t ha^{-1}) and capsaicin content (819421.13 SHU) of fruits were recorded with pre-harvest treatment of NAA @ 40 ppm in King chilli. Whereas, maximum vitamin C content (115.67 mg 100g^{-1} of fruit) was recorded with pre-harvest application of Ethrel 250 ppm. Lowest physiological loss in weight (2.55%) and change in fruit colour (10%), highest value of ascorbic acid content (120.5 mg 100 g^{-1} of fruit) and longest shelf life (9 days) were recorded at 9 days after storage in the treatment with $CaCl_2$ @ 0.5%, packed in non-perforated bags and stored under refrigeration at 5°C. While, no rotting of fruit was recorded at 9 days after storage in the treatment $CaCl_2$ @ 0.5%, packed in perforated polythene bags and stored under refrigeration at 5°C.

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