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Effect of Fruit Maturity Stages and Post Harvest Ripening Period on Seed Quality of Bitter Gourd (*Momordica charantia* L.)

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ABSTRACT

The present experiment was conducted to ascertain the effect of different fruit maturity stages and post harvest ripening period on seed quality of bitter gourd in the laboratory of Department of Seed Science and Technology, University of Agricultural Sciences, Raichur during the year 2018. The experiment consisted of three stages of fruit maturity (M_1: Partial yellow, M_2: Half yellow and M_3: Complete yellow) and four different post harvest ripening periods (R_1 (0 days), R_2 (3 days), R_3 (6 days) and R_4 (9 days) and their combinations. The experiment was laid down in two FCRD (Factorial Completely Randomized Design) with four replications. The results obtained revealed that among the various fruit maturity stages M_3 (Complete yellow) recorded significantly higher seed quality parameters and among the various ripening period studied, R_2 (3 days) were found to be best and among the interaction, the M_3R_1 (complete yellow 0 days) recorded significantly higher seed quality parameters in bitter gourd compared to other treatments.

Keywords: Bitter gourd, Seed quality, Fruit maturity stages and Ripening period

BITTER GOURD is the most important vegetable crop grown throughout the state of Karnataka in garden land. Good quality seed is a pre requisite for getting high productivity. Hence there is a growing demand for the production of quality seeds in this crop. Seed quality is influenced by the stage of harvest. Usually the fruits are allowed to ripe on the plant and seeds are extracted from these riped fruits. In many crops, physiological maturity of seed is attained well before the ripening of fruits. Seeds have maximum dry weight, germination and vigour at physiological maturity stage. Further, in bitter gourd, fruit splitting and seed loss occur if fruits are allowed to retain on the plant and ripe fully (Devi *et al*., 2009).

Seed production is highly technically skilled job and involves huge labour and financial risk. The seed crop may be raised successfully but if not harvested at appropriate stage may lead to complete loss of seed yield and quality on account of field weathering besides heavy financial loss. Hence, among several cultural practices, harvesting of the fruits at right stage of maturity assumes greater importance for obtaining higher seed yield and quality as the fruits develop and attain physiological maturity at different times owing to indeterminate flowering habit. Generally, fruits harvested at physiological maturity produces high quality seed in terms of germination and vigour compared to fruits harvested at earlier or later stages of maturity. On the contrary, early harvesting prior to physiological maturity drastically lowers seed yield and quality on account of under developed and immature seeds.

In bitter gourd, seed loss will occur due to fruit splitting, if fruits are allowed to ripe fully on the plant. Therefore, standardization of the optimum fruit maturity stage and post harvest ripening period is very much required for obtaining high quality hybrid seeds. Post harvest storage of fruits improves germinability in many cucurbits. It is also argued that seeds obtained from fruits harvested even before attainment of physiological maturity and allowed for post harvest fruit ripening for few days may also produce good quality seeds in cucumber. The principle purpose of seed storage is to preserve economically important crop seeds from one season to another. The seeds of bitter gourd are known to loose viability and vigour slowly, than many kinds of seeds belonging to orthodox group (Shanthappa *et al*., 2006).

Information on effect of fruit maturity stages and post harvest ripening period on seed quality of bitter gourd is very scanty. Therefore, the present study was undertaken to investigate the effect of fruit maturity stages and post harvest ripening period on seed quality of bitter gourd.

Material and Methods

The fruits were harvested at different stages as per the treatment details and were labeled separately and kept for post harvest ripening under room temperature in the laboratory of Department of Seed Science and Technology, College of Agriculture, UAS, Raichur. The experiment consisted of 12 treatments laid out in 2 FCRD (Two factorial completely randomized design) in four replications with three stages of fruit maturity *viz*., M_1: Partial yellow (25-50 %), M_2: Half yellow (50-75 %) M_3: Complete yellow (75-100 %) as main factor and four ripening period *viz*., R_1: 0 days, R_2: 3 days, R_3: 6 days and R_4: 9 days as sub factor. Further, the seeds were extracted from the fruits at the end of ripening period, washed and dried thoroughly up to safer moisture level and were used for assessing various seed quality parameters. The experimental data was analyzed as per Panse and Sukhatme (1967).

The seed quality parameters *viz.,* moisture content (%), seed germination (%), seedling vigour index (SVI) and dehydrogenase enzyme activity (OD value) were recorded as per the procedure given below.

Moisture content (%)

The test was conducted in duplicate on two independently drawn five gram working samples (ISTA, 2013). The weight of the cup in grams along with lid was taken (M_1) and then five gram of seed material was added to the cup (M_2). The samples were incubated in hot air oven at high constant temperature at 130p c for 1 hour. Samples were kept inside the oven only after attainment of the desired temperature and also the lid was placed below the cup while drying. After completion of drying period, the moisture cups were removed and kept in the desiccators with silica gel for 15-20 minutes and then the weight was taken (M_3). The moisture percentage was calculated using the below mentioned formula :

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M_1 : Weight (g) of empty aluminium cup along with lid

M_2 : Weight (g) of aluminium cup with lid + sample before drying

M_3 : Weight (g) of aluminium cup with lid + sample after drying

Seed germination (%)

The standard germination test was carried out by following between paper method as per ISTA procedure. Hundred seeds in four replications were taken from each treatment and placed on germination paper uniformly. The rolled towels were kept in a germination chamber maintained at 25 ± 2p C temperature and 90 ± 5 percent relative humidity. Then the first count was taken on 4th day and final count on 14th day. The number of normal seedlings from each replications were counted and the mean germination was expressed in percentage (ISTA, 2013).

Seedling vigour index (SVI)

The seedling vigour index - I and II were calculated by employing the formula given by Abdul-Baki and Anderson, 1973.

SVI-I = Germination (%) x Mean seedling length (cm)

Whereas, SVI- II was calculated by using formula,

SVI-II = Germination (%) x Seedling dry weight (mg)

Dehydrogenase enzyme activity (OD value)

Representative samples of 25 seeds were taken from each treatment and preconditioned by soaking in water for 16 hours at room temperature. Seeds were taken randomly and excised longitudinally by bisecting through embryo. Then the seeds were steeped in 0.25 per cent solution of 2, 3, 5 - tripenyl tetrazolium chloride (TZ) solution and kept in dark for 18 hours for staining. Later on, the stained seeds were thoroughly washed with distilled water and soaked in 10 ml of methoxy ethanol (methyl cellosolve) solution overnight for destaining or extracting red colour. The intensity of

red colour was measured using ELICO UV-VIS spectrophotometer using blue filter at 480 nm with methoxy ethanol as the blank. The OD value obtained was reported as the dehydrogenase enzyme activity (Kittock and Law, 1968).

Results and Discussion

In the present study, fruit weight differed significantly due to maturity stages and post harvest ripening period whereas, interaction effect between maturity stages and post harvest ripening period was non significant (Table 1). Among the maturity stages, fruit weight was higher (90.8 g) in M_1 (Partial yellow) while, it decreased as the maturity stage advanced (M_2, 86.0 and M_3, 82.9 g). Likewise, fruit weight showed decreasing trend on increasing the duration of post harvest ripening period in which higher fruit weight (123.9 g) was with R_1 (0 days) while, the lowest fruit weight (62.4 g) was noticed in R_4 (9 days). Although the interaction between different maturity stages and post harvest ripening were non significant but numerically higher fruit weight (131.7 g) was recorded in M_1R_1 (complete yellow 0 day) and lowest fruit weight (61.7 g) in M_3R_4 (complete yellow 9 days). This was mainly due to immature fruits (green or tender stage) with more moisture content as a result fruit weight will be higher and it decreases when the fruit start to mature or dry. During the course of storage, there was loss in fruit weight (over 9 days period) due to water evaporation, which resulted in dehydration of fruits leaving pithy pulp and seed mass intact. The results are supported by several research findings of Alan and Eser (2008) in pepper where they were reported loss in fruit weight after 20 days of ripening period when fruits were harvested at 80 DAA. Vasudevan *et al*. (2008) in fenugreek, Kortse and Oladiran (2013) in citrullus and Murugesan and Vanagamudi (2005) in ash gourd also reported decrease in fruit weight after one year of storage.

Effect of maturity stages and post harvest ripening on number of seeds per fruit was found to be non significant whereas, numerically seed number was higher (21.9) in M_3 (complete yellow) and R_1-0 days (21.9) (Table 1). The seeds were immature in early harvested fruits than fully matured fruit, but the seeds continued to develop and acquire full shape and size during post harvest ripening period. The seed weight per fruit and 100 seed weight differed significantly due to different maturity stages and post harvest ripening period. Significantly higher seed weight per fruit and 100 seed weight was obtained from maturity stage in M_3- complete yellow (7.9 g and 17.4 g) and among the ripening period the higher seed weight (7.8 g) per fruit and 100 seed weight (17.4 g) was obtained in R_2 (3 days). Among the interactions higher seed weight per fruit and 100 seed weight (8.4 and 18.1 g) was recorded by M_3R_1- complete yellow 0 days. In this treatment, fruits harvested at early maturity stage had immature seeds hence weight was less, whereas, the fruits harvested at fully matured stage, the seeds were completely developed and recorded higher weight. This could be due to better accumulation of food reserves in fully matured seeds. Once the early harvested fruits are kept for ripening, seeds will continue to develop inside the fruit with accumulated food reserves in the fruits there by increases its size. Since the seeds remain moistened inside the fruit and tend to respire, the consumption of accumulated reserves could results in some reduction of dry matter. Similar results were also reported by Murugesan and Vanagamudi (2005) in ash gourd and Alan and Eser (2008) observed decrease in seed dry weight as the ripening period increases in pepper.

Seed quality characters *viz*., seed moisture content (%), germination (%), dehydrogenase enzyme activity (OD value), shoot length (cm), root length (cm), seedling dry weight (mg), seedling vigour index - I and II were significantly affected by different stages of harvest, post harvest ripening period and their interactions in the present investigation.

Seed moisture content is the key factor that decides the seed quality upon storage. Seed moisture content decreases as the dry matter accumulation increases. In the present investigation, highest seed moisture (15.0 %) was observed in M_1 (Partial yellow) , wherein the tissues were still green and seed was underdeveloped with more of water content. So the seed moisture content in early harvested fruits will

TABLE 1

Effect of fruit maturity stage and post harvest ripening period on fruit and seed characters in bitter gourd

Treatment	Fruit weight (g)	Number of seeds per fruit	Seed weight per fruit (g)	100 seed weight (g)	Seed moisture content (%)
Fruit maturity stages (M)					
M_1	90.8	21.7	6.9	16.7	15.0 (22.8)
M_2	86.0	21.1	7.5	17.0	13.8 (21.8)
M_3	82.9	21.9	7.9	17.4	11.5 (19.8)
Mean	86.6	21.6	7.4	17.0	13.4 (21.5)
S.Em±	1.4	1.0	0.1	0.1	0.1
C.D at 1%	4.1	NS	0.3	0.3	0.4
Post harvest ripening period (R)					
R_1	123.9	21.9	7.1	16.8	23.4 (28.9)
R_2	86.7	21.8	7.8	17.4	12.9 (21.0)
R_3	73.3	21.4	7.6	17.3	9.9 (18.3)
R_4	62.4	21.1	7.3	16.6	7.6 (16.0)
Mean	86.6	21.6	7.4	17.0	13.4 (21.5)
S.Em±	1.6	1.1	0.2	0.2	0.2
C.D at 1%	4.9	NS	0.6	0.6	0.6
Interaction (M×R)					
M_1R_1	131.7	21.0	5.9	15.6	24.9 (29.9)
M_1R_2	91.7	22.0	6.8	16.7	15.6 (23.3)
M_1R_3	76.7	22.3	7.6	17.5	11.0 (19.4)
M_1R_4	63.3	21.3	7.4	16.8	8.4 (16.8)
M_2R_1	121.7	22.3	6.9	16.7	23.3 (28.9)
M_2R_2	85.0	21.0	8.3	17.7	13.1 (21.2)
M_2R_3	75.0	20.7	7.7	17.3	10.5 (18.9)
M_2R_4	62.3	20.3	7.1	16.4	8.3 (16.7)
M_3R_1	118.3	22.3	8.4	18.1	22.0 (28.0)
M_3R_2	83.3	22.3	8.2	17.7	10.0 (18.4)
M_3R_3	68.3	21.3	7.4	17.1	8.1 (16.5)
M_3R_4	61.7	21.7	7.3	16.7	6.0 (14.2)
Mean	86.6	21.6	7.4	17.0	13.4 (21.5)
S.Em±	3.3	1.9	0.3	0.3	0.3
C.D at 1%	NS	NS	1.1	1.1	1.2

Legend :

M_1: Partial yellow (25-50%) R_1: Ripening period (0^{th} day) R_3: Ripening period (6^{th} day)

M_2: Half yellow (50-75%) R_2: Ripening period (3^{th} day) R_4: Ripening period (9^{th} day) M_3: Complete yellow (75- 100%)

NS: Non Significant

Note: Figures in parenthesis indicate arc sign transformed values

definitely have higher seed moisture. Among the ripening period, higher seed moisture was noticed in R_1- 0 days (23.4 %) and the seeds extracted from the fruits on the day of harvest also will have more moisture than those of other periods. Among the interaction, highest seed moisture (24.9 %) was observed in M_1R_1 (complete yellow 0 days). Seeds harvested from fully mature fruit on the day of harvest showed higher seed moisture, this might be due to complete maturity of fruits. The seeds present inside the pulp will possess more moisture and hence the moisture content was higher in this interaction. Similar findings were reported by Devaraju *et al*., 2013 in cucumber where the moisture content goes on decreasing from 20 DAA to 60 DAA.

In the present investigation among different maturity stages, maximum germination (70.1 %) was noticed in M_3 (complete yellow) while, M_1 (partial yellow) recorded lowest seed germination (64.8 %) (Table 2). Similar findings were reported by Devi *et al*. (2009) in bitter gourd and Maruthi *et al*. (2014) in bottle gourd. At physiological maturity, seeds are said to be completely developed due to maximum accumulation of food reserves, amino acids, phosphorous active substances, dry matter, sugar, water soluble proteins, acids and nicotinic acid levels in the seeds. On the contrary, all seed quality parameters were low in early harvested fruits (M_1), due to presence of immature seeds and under developed seeds with lesser food reserves and nutrients in the seeds. Among the ripening period, R_2 (3 days) recorded maximum seed germination (73.5 %) while, R_4- 9 days (58.4 %) recorded lowest seed germination. The seed quality parameters enhanced significantly with increase in the post harvest fruit ripening periods up to 9 days beyond which all seed quality parameters decreased gradually with progressive increasing ripening period (3 days). This might be due to better development of seeds on account of greater accumulation of food reserves in the seeds resulting in higher vigour and germination. Kalyanrao *et al*. (2014) in bottle gourd reported that seed quality was best at 60 days after harvest in winter squash.

Among the interactions M_3R_1 (complete yellow 0 days) recorded highest germination (86.5 %) and other quality attributes. This might be due to complete development of seed organs and maximum dry matter accumulation in the seeds as compared to early harvested ones.

The maturity stages and post harvest ripening period significantly increased the dehydrogenase enzyme activity. Significantly higher enzyme activity (0.561 OD value) was observed in M_3 (complete yellow) and R_2- 3 days (0.581 OD value). This might be due to complete accumulation of food reserves so that during germination more hydrolytic enzymes gets activated which helps in breakdown of macromolecules making them available to the growing embryo. With the progress of ageing period, a decline in dehydrogenase enzyme activity was observed irrespective of the treatment. Among the interactions, higher enzyme activity (0.677 OD value) was reported in M_3R_1 (complete yellow 0 days) (Table 2) wherein the seeds were completely developed with proper accumulation of food reserves, which upon planting under congenial conditions regulates more hydrolytic enzymes which results in more vigorous seedlings. Maruthi *et al*. (2014) in bottle gourd reported that seeds extracted from fruits after 4 weeks of ripening resulted in high enzyme activity.

Significantly higher values of shoot length (21.9 cm) and root length (15.1 cm), were observed in M_3 (complete yellow) stage while, among the ripening periods, higher shoot length (22.4 cm), root length (15.3 cm) were observed in R_2 (3 days). Among interactions, higher shoot length (26.7 cm), root length (17.9 cm) was recorded by M_3R_1 (Complete yellow 0 days) (Table 2). This might be due to the accumulation of more dry matter and photo assimilates in matured fruit that provides more nutrition to the developing seedling, thus promoted more elongation of the seedling and roots. These results are in line with Tirakannanavar *et al*. (2007) in bitter gourd, who reported highest shoot length from fruits harvested at orange red stage as compared to early or later stages of maturity. Devaraju *et al.* (2013) reported that 50 DAA and physiological maturity showed higher seedling length in cucumber.

TABLE 2

Effect of fruit maturity stage and post harvest ripening period on seed quality parameters in bitter gourd

Treatment	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II	Dehydrogenase enzyme activity (OD value)
Fruit maturity stages (M)							
M_1	64.8 (53.6)	20.7	14.2	784.8	2262	50855	0.531
M_2	66.1 (54.4)	21.7	14.3	805.3	2380	53230	0.552
M_3	70.1 (56.9)	21.9	15.1	864.6	2594	60608	0.561
Mean	67.0 (54.9)	16.7	14.5	818.2	2405	54819	0.488
S.Em±	1.1	0.3	0.2	7.0	44	1547	0.006
C.D at 1%	3.0	0.6	0.5	27.0	127	5951	0.018
Post harvest ripening period (R)							
R_1	67.3 (55.1)	21.4	14.7	829.9	2430	55852	0.545
R_2	73.5 (59.0)	22.4	15.3	840.5	2771	61777	0.581
R_3	68.7 (56.0)	22.0	15.2	836.1	2556	57440	0.578
R_4	58.4 (49.8)	19.9	12.9	766.4	1916	44758	0.488
Mean	67.0 (54.9)	16.7	14.5	818.2	2405	54819	0.488
S.Em±	1.2	0.3	0.2	8.1	51	1787	0.007
C.D at 1%	3.1	0.6	0.6	24.2	146	6872	0.022
Interaction (M×R)							
M_1R_1	52.3 (46.3)	16.7	12.3	700.8	1517	36652	0.429
M_1R_2	64.0 (53.1)	19.8	13.6	752.5	2138	48160	0.517
M_1R_3	73.8 (59.2)	24.6	16.4	861.8	3026	63601	0.630
M_1R_4	69.3 (56.4)	21.6	14.4	824.2	2495	57117	0.548
M_2R_1	63.3 (52.7)	20.9	13.9	776.6	2203	49159	0.530
M_2R_2	80.0 (63.4)	24.3	16.1	870.0	3232	69600	0.647
M_2R_3	66.3 (54.5)	21.8	14.9	826.5	2433	54797	0.565
M_2R_4	54.8 (47.8)	19.8	12.2	748.3	1754	41007	0.466
M_3R_1	86.5 (68.4)	26.7	17.9	1012.4	3858	87573	0.677
M_3R_2	76.5 (61.0)	23.1	16.3	898.9	3014	68766	0.578
M_3R_3	66.0 (54.3)	19.7	14.2	820.2	2237	54133	0.539
M_3R_4	51.3 (45.7)	18.2	12.0	726.9	1549	37290	0.450
Mean	67.0 (54.9)	16.7	14.5	818.2	2405	54819	0.488
S.Em±	3.1	0.5	0.4	14.1	88	3095	0.013
C.D at 1%	6.1	1.5	1.2	54.1	254	11902	0.038

Legend :

M_1: Partial yellow (25-50%) R_1: Ripening period (0^{th} day) R_3: Ripening period (6^{th} day)

M_2: Half yellow (50-75%) R_2: Ripening period (3^{th} day) R_4: Ripening period (9^{th} day)

M_3: Complete yellow (75- 100%)

NS: Non Significant

Note: Figures in parenthesis indicate arc sign transformed values

Among the maturity stages, significantly higher seedling dry weight (mg), seedling vigour index I and II (864.6 mg, 2594 and 60608, respectively) were obtained in M_3 stage (complete yellow). Among the ripening periods, maximum seedling dry weight (840.5 mg), seedling vigour index I and II (2771 & 61777, respectively) were observed in R_2 (3 days). Among the interactions, M_3R_1 (complete yellow 0 days) recorded highest seedling dry weight (1012.4 mg) (Table 2), seedling vigour index I and II (3858 & 87573, respectively) (Table 2). The probable reason for increase in seedling vigour index might be due to enlarged embryos, higher rate of metabolic activity & respiration, better mobilization & utilization of metabolites to growing points and higher activity of enzymes. Maruthi *et al*. (2014) in bottle gourd reported that seeds extracted from fruits after 4 weeks of ripening resulted in high dry weight and vigorous seedlings. Devaraju *et al.* (2013) reported that 50 DAA and physiological maturity shows higher seedling dry weight and vigour index in cucumber.

The fruits harvested at complete yellow (M_3) stage and seed extracted after three days (R_2) of post harvest ripening period found to be superior in terms of seed quality.

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