**Effect of Days to Fruit Maturity and Post-Harvest Ripening of Fruit on Seed Yield and Quality in Pumpkin**

**ABSTRACT**

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| **Aims:** The study aims to show the effect of stage of fruit harvesting and post harvest ripening of fruit and the combination of both the factors on fruit parameters as well as seed parameters in pumpkin.  **Study design:** Experiment was conducted using FRCBD (Factorial Randomized Complete Block Design)  **Place and Duration of Study:** Department of Seed Science and Technology, B. A. College of Agriculture, Anand Agricultural University, Anand, between September 2024 and April 2025  **Methodology:** This experiment was conducted, where pumpkin fruits were subjected to 3 levels of factor A that is days to fruit maturity and 4 levels of factor B that is post harvest ripening of fruit, factor A included (D1) 50 DAA (Days After Anthesis), (D2) 60 DAA and (D3)70 DAA and factor B included (B1) 0 PHR (Post Harvest Ripening), (B2) 10 PHR, (B3) 20 PHR and (B4) 30 PHR.  **Results:** With respect to fruit parameters pumpkin fruits harvested at 70 DAA (D3) recorded highest fruit parameters such as fruit weight (8.18 kg), fruit length (19.17 cm), fruit diameter (26.13 cm), cavity length (12.3 cm) and flesh thickness (4.65 cm). With respect to seed quality parameters D3B4 that is fruits harvested at 70 DAA and subjected to a ripening period of 30 days PHR recorded highest number of filled seed per fruit of 120.27, effect was found non significant for number of unfillrd seed per fruit, D2B3 that is fruits harvested at 60 DAA and subjected to a ripening period of 20 days PHR recorded highest seed weight per fruit of 26.49 g, D2B3 that is fruits harvested at 60 DAA and subjected to a ripening period of 20 days PHR recorded highest 100 seed weight per fruit of 25.75 g, D3B4 that is fruits harvested at 70 DAA and subjected to a ripening period of 30 days PHR recorded highest germination % of 86.66, D2B4 that is fruits harvested at 60 DAA and subjected to a ripening period of 30 days PHR recorded highest seedling length of 43.50 cm, D3B3 that is fruits harvested at 70 DAA and subjected to a ripening period of 20 days PHR recorded highest seedling dry weight of 1.55 g, D2B2 that is fruits harvested at 60 DAA and subjected to a ripening period of 10 days PHR recorded highest seedling vigour index Ⅰ of 3389, D3B3 that is fruits harvested at 70 DAA and subjected to a ripening period of 20 days PHR recorded highest seedling vigour index Ⅱ of 123.53, effect was found non significant for moisture % and D1B1 that is fruits harvested at 50 DAA and subjected to a ripening period of 0 days PHR recorded highest EC of 0.77.  **Conclusion:** The study demonstrated that the pumpkin fruits subjected to factor A that is 60 & 70 days after anthesis (DAA), factor B that is post harvest ripening period (PHR) of 10, 20 & 30 days recorded highest fruit and seed quality parameters, the present investigation is aimed at addressing the effects of fruit maturity and post-harvest ripening of fruit on seed yield and quality. These insights can contribute to more efficient and productive pumpkin seed production systems, ultimately benefiting growers and the vegetable seed industry. |

*Keywords: Pumpkin, Days after anthesis, Post harvest ripening, Seed quality, Yield*

**1. INTRODUCTION**

Pumpkin (*Cucurbita moschata* Duch. Ex Poir.) is locally known as Kaddu (Hindi) and Kolu (Gujarati). It belongs to the family *Cucurbitaceae* having chromosome number 2n =2x=40. Primary centers of origin are possibly the Northern and Southern America. Pumpkin is a monoecious and cross-pollinated crop in nature. *Cucurbitaceae* is the largest family in vegetable kingdom and includes largest number of edible type species, which consists of 2 sub families, Cucurbitoideae and Zanonioideae, is moderately large, consisting of about 130 genera and 900 species (Jeffrey, 1964).

The cucurbits are distributed primarily in the warmer areas of the world, especially in the tropics and subtropics. They are less frequently encountered in temperate regions because of their frost sensitivity (Gupta and Tsuchiya, 1991). In addition to supplying adequate quantity of antioxidants and micronutrients, vegetable crops play very significant role as source of minerals,vitamins and dietary fibres in human nutrition. In India, the area under vegetable crops is approximately 6.2 million ha with production of 90 million tons and the highest producer of vegetables in the world. India ranks first in the production of cauliflower, second in the production of onion and third in the production of cabbage (Anonymous, 2005).

India is the second largest producer of pumpkin in the world after China. Pumpkin, squash and gourd are grown in India over an area of 0.47 million ha with the production of 4.4millions tonnes (Anonymous, 2010). The average productivity of pumpkin, squashes and gourds is 9.27 t/ha in India, which is lower than the world’s average productivity of 13.41 t/ha. The average productivity of Israel, Netherlands is over 44.70 t/ha, with the highest average productivity of 63.3t/ha in Netherlands (Anonymous, 2010).

The seed plays a crucial role in determining both the yield and quality of a crop. As a result, improving seed production and quality is essential for ensuring higher economic benefits for seed growers. However, there has been insufficient research on optimizing seed quality and yield, particularly regarding factors such as fruit retention, harvest timing (physiological and harvest maturity), and post-harvest ripening (PHR). This study aims to tackle issues like poor seed filling due to inadequate pollination while also establishing optimal harvest stages, PHR practices, and the influence of seed position within the fruit.

**2. materials and methods**

The experimental was conducted in sandy loam soil. The seeds of Anand Pumpkin-1 were used for experiment. Pumpkin fruits were subjected to three levels of harvesting periods that is 50 DAA (Days After Anthesis), 60 DAA and 70 DAA and four levels of post harvest ripening periods that is 0 PHR (Post Harvest Ripening), 10 PHR, 20 PHR, 30 PHR. The effect of 3 levels of harvesting periods and 4 levels of post harvest ripening periods were studied on fruit parameters such as fruit weight (kg), fruit length (cm), fruit diameter (cm), cavity length (cm) and flesh thickness (cm). The seeds were extracted manually from each stage and were kept for sun drying for a period of 48 to 72 hours. After drying seed yield parameters such as number of filled seed per fruit, number of unfilled seed per fruit, seed weight per fruit (g) and 100 seed weight (g) were recorded and seed quality parameters such as germination %, seedling length (cm), seedling dry weight (g), seedling vigour index-Ⅰ, seedling vigour index-Ⅱ, moisture % and electrical conductivity (d S/m) were recorded. Germination %, seedling length and moisture % were computed as per ISTA rules, Seedling Vigour Index-Ⅰ and Seedling Vigour Index-Ⅱ were coputed using procedure suggested by Abdul- Baki and Anderson (1973) and expressed in whole number Electrical conductivity (EC) of seed leachate carried out in three replications of fifty seeds were soaked in 250 ml of deionized water at 20±10℃ for 24 hr and seed leachate was collected in 250 ml beaker (Anonymous, 2011).

**3. results and discussion**

In present study it was found that the stage of fruit harvest have had a significant effect on fruit parameters *viz.,* fruit weight (kg), fruit length (cm), fruit diameter (cm), cavity length (cm) and flesh thickness (cm). The fruits which were harvested at 70 days after anthesis recorded significantly highest fruit weight, fruit length, fruit diameter, cavity length and flesh thickness (8.18 kg, 19.17 cm, 26.52 cm, 11.09 cm and 4.95 cm respectively). The successful development of fruits and seeds in brinjal is driven by the consistent translocation and deposition of photosynthetic assimilates (nutrient reserves) from the maternal plant to these sink organs, ensuring optimal growth and maturation. These findings corroborate earlier research by Sureshbabu *et al.* (2003), Biradar *et al.* (1994), Neto *et al.* (2015), Vinod *et al*. (2014b), Seymen *et al.* (2019), Yoo *et al.* (1996) and Kalyanrao *et al.* (2014).

With respect to seed quality parametrs *viz.,* number of filled seed per fruit (102.04) , seed weight per fruit (19.75 g), 100 seed weight (17.68 g), germination % (82.08 %), seedling dry weight (1.34 g), seedling vigour index-Ⅰ(3052), seedling vigour index-Ⅱ(110.04) were found to be highest in fruits which were harvested at 70 days after anthesis. However seedling length (39.04 cm) was recorded highest in fruits harvested at 60 days after anthesis and number of unfilled seed per fruit (9.35), moisture (12.59 %) and electrical conductivity (0.44 d S/m) were highest in fruits which were harvested at 50 days after anthesis. Physiological maturity in seeds is characterized by complete embryonic development accompanied by peak accumulation of nutritional reserves including carbohydrates, amino acids, phosphorus-containing compounds, dry matter, soluble proteins, organic acids, and nicotinic acid. This developmental stage marks optimal seed quality, as the cessation of seed filling results in maximum viability and vigor - critical traits for successful seedling establishment in agricultural systems. In cucurbit species, the maturation process typically persists until fruit senescence initiates visible color changes from green to yellowish hues, indicating the terminal phase of seed development. The results ontained are in accordance with earlier findings of Ganar *et al.* (2004), Vinod *et al*. (2016b), Vinod *et al*. (2002), Yoo *et al.* (1996) and Hamsaveni *et al.* (2003).

It was found that the post harvest ripening period had a significant effect on seed quality parameters.It was observed that the fruits subjected to a post harvest ripening period of 20 and 30 days showed highest seed quality parameters. Fruits which were subjected to a post harvest ripening period of 30 days recorded highest no of filled seed per fruit (103.96), seedling length (38.86 cm), seedling dry weight (1.26 g), seedling vigour index-Ⅰ(3110) and seedling vigour index-Ⅱ(100.51) and fruits which were subjected to post post harvest ripening period of 20 days recorded highest seed weight per fruit (18.79 g) and 100 seed weight (23.67 g). Seed quality parameters *viz.,* no of unfilled seed per fruit (10.71) and electrical conductivity (0.51) were found highest in fruits subjected to 0 days post harvest ripening period. Germination % (80.18 %) was recorded highest in fruits subjected to 10 days post harvest ripening. Research suggests that seed development and maturation may continue post-harvest in fleshy-fruited species, with ongoing translocation of nutrient reserves from the fruit pulp to developing seeds during this period. This postharvest ripening phase potentially enhances critical seed quality attributes. Concurrently, seed moisture content exhibits a progressive decline throughout maturation, with observations indicating substantial dehydration during extended postharvest periods (e.g., 40 days of fruit ripening). This moisture reduction likely results from physiological drying processes occurring as seeds approach full physiological maturity within the ripening fruit. Similar results were obtained by Krishnamurthy *et al.* (1995). The results ontained are in accordance with earlier findings of Kalyanrao *et al.* (2014), Kumar *et al.* (2014), Gupta *et al.* (2023) and Yoo *et al.* (1996).

The significant effect of interaction effect D×B was seen in only one fruit parameter *viz.,* cavity length (12.91 cm) which is designated as treatment D3B2. With respect to seed prameters interaction effect D×B was found to have a significant effect in number of filled seed per fruit (120.27) designated as D3B4, number of unfilled seed per fruit (21.11) designated as D1B1, seed weight per fruit (26.49 g) designated as D2B3, 100 seed weight (25.75 g) designated as D2B3, germination % (86.66 %) designated as D3B4, seedling length (43.50 cm) designated as D2B4, seedling dry weight (1.55 g) designated as D3B3, seedling vigour index-Ⅰ(3389) designated as D2B2, seedling vigour index-Ⅱ(123.53) designated as D2B3, and electrical conductivity (0.77 dS/m) which is designated as D1B1. The results obtained are in accordance with earlier findings of Kalyanrao *et al.* (2014), Vinod *et al*. (2014b), Seymen *et al.* (2019), Gupta *et al.* (2023) and Yoo *et al.* (1996).

**Table 1. Effect of days to fruit maturity and post harvest ripening of fruit on fruit parameters**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **Fruit weight (kg)** | **Fruit length (cm)** | **Fruit diameter(cm)** | **Cavity length (cm)** | **Flesh thickness (cm)** |
| **Stage of harvest** |  |  |  |  |  |
| **D1** | 4.32 | 15.94 | 22.86 | 11.09 | 3.98 |
| **D2** | 5.22 | 16.86 | 24.29 | 10.99 | 4.31 |
| **D3** | 8.18 | 19.17 | 26.13 | 12.30 | 4.95 |
| **S.Em. ±** | **0.65** | **0.46** | **0.50** | **0.34** | **0.13** |
| **CD0.05** | **0.22** | **1.37** | **1.49** | **1.03** | **0.38** |
| **Post harvest ripening** |  |  |  |  |  |
| **B1** | 5.67 | 17.35 | 24.49 | 11.25 | 4.50 |
| **B2** | 6.28 | 17.44 | 24.06 | 11.51 | 4.06 |
| **B3** | 6.05 | 17.08 | 23.40 | 11.17 | 4.67 |
| **B4** | 5.63 | 17.43 | 25.77 | 11.91 | 4.42 |
| **S.Em. ±** | **0.25** | **0.53** | **0.58** | **0.40** | **0.15** |
| **CD0.05** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **D×B** |  |  |  |  |  |
| **D1R1** | 3.61 | 15.41 | 22.41 | 11.16 | 3.66 |
| **D1R2** | 4.40 | 16.52 | 22.66 | 12.30 | 3.60 |
| **D1R3** | 4.85 | 15.68 | 22.83 | 9.75 | 4.25 |
| **D1R4** | 4.44 | 16.13 | 23.54 | 11.16 | 4.41 |
| **D2R1** | 5.32 | 17.95 | 24.90 | 10.66 | 4.83 |
| **D2R2** | 5.24 | 16.06 | 22.01 | 9.33 | 3.83 |
| **D2R3** | 5.23 | 16.37 | 23.45 | 11.33 | 4.12 |
| **D2R4** | 5.11 | 17.08 | 26.82 | 12.66 | 4.45 |
| **D3R1** | 8.08 | 18.68 | 26.16 | 11.91 | 5.00 |
| **D3R2** | 9.21 | 19.75 | 27.50 | 12.91 | 4.75 |
| **D3R3** | 8.08 | 19.18 | 23.91 | 12.45 | 5.65 |
| **D3R4** | 7.34 | 19.08 | 26.95 | 11.91 | 4.41 |
| **S.Em. ±** | **0.44** | **0.93** | **1.01** | **0.69** | **0.26** |
| **CD0.05** | **NS** | **NS** | **NS** | **2.06** | **NS** |

**Table 2. Effect of days to fruit maturity and post harvest ripening of fruit on seed parameters**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Number of filled seed per fruit** | **Number of unfilled seed per fruit** | **Seed weight per fruit (g)** | **100 seed weight (g)** |
| **Stage of harvest** |  |  |  |  |
| **D1** | 68.81 | 9.35 | 10.60 | 16.23 |
| **D2** | 92.38 | 5.76 | 18.87 | 18.42 |
| **D3** | 102.04 | 6.16 | 19.75 | 17.68 |
| **S.Em. ±** | **1.26** | **0.22** | **0.33** | **0.40** |
| **CD0.05** | **3.55** | **0.62** | **0.94** | **1.15** |
| **Post harvest ripening** |  |  |  |  |
| **B1** | 78.81 | 10.79 | 15.83 | 14.99 |
| **B2** | 84.90 | 6.38 | 14.16 | 14.49 |
| **B3** | 83.31 | 5.46 | 18.79 | 23.67 |
| **B4** | 103.96 | 5.73 | 16.85 | 16.61 |
| **S.Em. ±** | **1.45** | **0.25** | **0.38** | **0.47** |
| **CD0.05** | **4.11** | **0.72** | **1.09** | **0.33** |
| **D×B** |  |  |  |  |
| **D1R1** | 53.33 | 21.11 | 10.27 | 13.71 |
| **D1R2** | 76.66 | 5.66 | 15.43 | 15.38 |
| **D1R3** | 106.44 | 5.61 | 21.79 | 15.90 |
| **D1R4** | 94.05 | 5.54 | 12.92 | 14.72 |
| **D2R1** | 73.50 | 5.83 | 8.92 | 11.24 |
| **D2R2** | 96.33 | 5.77 | 16.24 | 15.36 |
| **D2R3** | 84.88 | 7.55 | 17.34 | 16.89 |
| **D2R4** | 97.55 | 6.88 | 17.34 | 17.21 |
| **D3R1** | 54.36 | 4.94 | 10.31 | 25.24 |
| **D3R2** | 99.00 | 4.72 | 26.49 | 25.75 |
| **D3R3** | 96.57 | 6.72 | 19.57 | 20.02 |
| **D3R4** | 120.27 | 4.77 | 20.28 | 17.91 |
| **S.Em. ±** | **2.52** | **0.44** | **0.67** | **0.81** |
| **CD0.05** | **7.11** | **1.24** | **1.89** | **2.31** |

**Table 3. Effect of days to fruit maturity and post harvest ripening of fruit on Seedling parameters**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Germination %** | **Seedling length (cm)** | **Seedling dry weight (g)** | **Seedling vigour index-Ⅰ** | **Seedling vigour index-Ⅱ** | **Moisture %** | **Electrical conductivity dS/m** |
| **Stage of harvest** |  |  |  |  |  |  |  |
| **D1** | 75.69 | 29.87 | 0.99 | 2284 | 75.44 | 12.59 | 0.44 |
| **D2** | 76.25 | 39.04 | 1.01 | 2991 | 76.50 | 11.06 | 0.32 |
| **D3** | 82.08 | 37.05 | 1.34 | 3052 | 110.04 | 8.56 | 0.27 |
| **S.Em. ±** | **0.70** | **0.41** | **0.02** | **40.77** | **1.95** | **0.34** | **0.007** |
| **CD0.05** | **1.99** | **1.15** | **0.06** | **115.02** | **5.51** | **0.96** | **0.021** |
| **Post harvest ripening** |  |  |  |  |  |  |  |
| **B1** | 76.11 | 31.47 | 0.88 | 2419 | 67.83 | 11.29 | 0.51 |
| **B2** | 80.18 | 36.05 | 1.14 | 2913 | 90.72 | 11.11 | 0.32 |
| **B3** | 75.74 | 34.94 | 1.18 | 2662 | 90.25 | 9.96 | 0.29 |
| **B4** | 80.00 | 38.86 | 1.26 | 3110 | 100.51 | 10.59 | 0.25 |
| **S.Em. ±** | **0.81** | **0.47** | **0.02** | **47.04** | **2.25** | **0.39** | **0.008** |
| **CD0.05** | **2.38** | **1.33** | **0.07** | **132.81** | **6.37** | **NS** | **0.024** |
| **D×B** |  |  |  |  |  |  |  |
| **D1R1** | 72.77 | 25.54 | 0.77 | 1875 | 55.56 | 13.00 | 0.77 |
| **D1R2** | 74.44 | 32.08 | 0.73 | 2396 | 55.02 | 11.91 | 0.43 |
| **D1R3** | 81.11 | 36.77 | 1.15 | 2986 | 92.90 | 8.95 | 0.33 |
| **D1R4** | 80.00 | 34.30 | 1.26 | 2761 | 101.73 | 11.40 | 0.21 |
| **D2R1** | 75.55 | 30.32 | 0.98 | 2300 | 73.57 | 13.13 | 0.43 |
| **D2R2** | 83.33 | 40.57 | 0.96 | 3389 | 78.99 | 10.86 | 0.23 |
| **D2R3** | 81.66 | 37.25 | 1.47 | 3050 | 119.59 | 9.35 | 0.31 |
| **D2R4** | 73.33 | 43.50 | 1.31 | 3203 | 95.69 | 11.12 | 0.34 |
| **D3R1** | 74.44 | 29.42 | 0.96 | 2202 | 70.90 | 12.82 | 0.34 |
| **D3R2** | 73.88 | 40.00 | 1.02 | 2977 | 76.31 | 10.35 | 0.28 |
| **D3R3** | 78.88 | 35.40 | 1.55 | 2806 | 123.53 | 6.71 | 0.24 |
| **D3R4** | 86.66 | 38.80 | 1.20 | 3366 | 104.13 | 9.25 | 0.21 |
| **S.Em. ±** | **1.41** | **0.81** | **0.04** | **81.54** | **3.91** | **0.68** | **0.015** |
| **CD0.05** | **3.99** | **2.31** | **0.12** | **230.04** | **11.03** | **NS** | **0.041** |

**4. CONCLUSION**

The study revealed that the the pumpkin fruits subjected to factor A that is 60 & 70 days after anthesis (DAA) and factor B that is post harvest ripening period (PHR) of 10, 20 & 30 days recorded highest fruit and seed quality parameters. Thus the harvesting period and post harvest ripening period can be combined in a benificial way to improve seed yield and quality in pumpkin.

disclaimer (artificial intelligence)

The authors hereby state unequivocally that no generative artificial intelligence (AI) tools, such as text-to-image generators or big language models (e.g., ChatGPT, Copilot), were used in the writing, editing or drafting of this work. No text creation or modification by AI is used; all content is the original creation of the human author or authors.

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