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Research Article

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Effect of Harvesting Stages on Seed Quality Parameters during Storage

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ABSTRACT

The field experiment was during rabi 2017-18 to determine the effect of harvesting stages on quality of chickpea, wherein six different varieties of chickpea (V_1 = GG 1, V_2 = GG 2, V_3 = GJG 3, V_4 = GG 4, V_5 = GG 5, and V_6 = GG 6) were harvested at different stages (H_1 = Dark green colour pod stage, H_2 = Green to yellow colour pod stage, H_3 = Full yellow colour pod stage, and H_4 = Copper brown colour pod stage). The seeds harvested as per the treatment combinations from the field experiment were stored in the laboratory for eight months and observations viz., moisture content (%), 100 seed weight (g), germination percentage, seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg), seedling vigour index (length), seedling vigour index (mass) and electrical conductivity of seed leachates (ds/m) were recorded initially at the time of storage and after eight months of storage in the laboratory of the Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. Irrespective of the harvesting stages, the moisture content in the seeds, 100 seed weight and electrical conductivity of seed leachates were increased gradually with increased in storage period, while germination, seedling length, seedling fresh and dry weight, and seedling vigour index (length and mass) were decreased gradually with increased in storage period. Irrespective of varieties, the seeds harvested at dark green colour pod stage (H_1) were not germinated at all. Therefore, no any seed quality observations were recorded. Irrespective of varieties, the moisture content in the seeds, 100 seed weight and electrical conductivity of leachates were increased gradually with increased in storage period, while germination, seedling length, seedling fresh and dry weight, and seedling vigour index (length and mass) of seeds harvested at different stages were decreased gradually with increased in storage period. It was suggested that for getting the higher yield and quality of chickpea varieties after eight months of storage, chickpea seed should be harvested at the H_3 (full yellow color pod stage), as the seeds harvested at full yellow color pod stage recorded the germination percentage (84.67 %) even after eight months of storage with good vigour. For maintaining better quality up to the next season sowing, seeds could be stored under proper storage condition, because with increase in storage period, quality of seed deteriorated.

Keywords: *Chickpea, Harvesting stages, Seed production, Seed quality, Storage*

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INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an annual plant of the *Fabaceae* family that is widely cultivated for its typically yellow-brown, pea-like seeds. It is a rich source of quality protein (20–22 %) (Singh et al., 2014). It is one of the most important food legume plants in sustainable agriculture system because of its low production cost, wider adaptation, ability to fix atmospheric nitrogen, and fit in various crop rotations (Singh, 1997). India is the fourth largest producer of chickpea contributing more than 75 per cent of the world production with a total production of 13.12 million tons from an area of 13.57 million hectare and productivity of 967 kg/ha^2. In Gujarat, it was grown in area of 0.16 million hectare with a production 0.18 million tons and productivity of 1116 kg/ha in during 2016-17 (Anonymous, 2019b).

In modern agriculture, success of seed industry and seed programmes depends on how carefully seeds are stored for next planting without loss of seed viability and vigour. Storability of seed is mainly a genetical character and is influenced by pre-storage history of seed, seed maturation, environmental factors during pre and post harvest stages, etc (Mahesha et al., 200l). Early harvested seeds will be immature and poorly developed and as such are poor storers compared to seed harvest at physiological maturity (Singh & Lachanna, 1995). At physiological maturity, seed shall have maximum dry weight, viability and vigour. As such harvesting of seed crop at optimum stage of seed maturation is essential to obtain better seed quality. Moisture content of harvested crop affects seed quality throughout the storage of seed and hence, it determines with which moisture content the crop should be threshed. Harvesting at high moisture content increases the changes of mycofloral infection on seed, while at low moisture content increases mechanical damage to seed (Yadav et al. 2005). Harvest of seed crop at right stage of maturity bear significant influence on seed yield and quality, as seeds harvested at right stage of physiological maturity are higher in seed quality on account of lesser field weathering (Bharud & Patil, 1990). Therefore, there is a need to ascertain the optimum stage of harvesting to obtain higher quality seeds and remain that quality during storage.

MATERIALS AND METHODS

A field experiment was carried out to study the effect of stages of harvesting on seed quality parameters in chickpea at Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh during *Rabi* 2017-18. There were different six varieties (V_1 = GG 1, V_2 = GG 2, V_3 = GJG 3, V_4 = GG 4, V_5 = GG 5 and V_6 = GG 6) of chickpea were sown at 45 x 10 cm distance considered as factor-I. Harvesting was carried out at four different stages *viz.*, H_1 = Dark green colour pod stage, H_2 = Green to yellow colour pod stage, H_3 = Full yellow colour pod stage, H_4 = Copper brown colour pod stage, these four different stages of harvesting were considered as factor-II. The seeds harvested as per the treatment combinations from the field experiment were packed in cloth bag and stored in the laboratory under ambient storage conditions from February 2018 to November 2018. The observations *viz*., moisture content (%), 100 seed weight (g), germination percentage, seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg), seedling vigour index (length), seedling vigour index (mass) and electrical conductivity of seed leachates (ds/m) were recorded initially at the time of storage and after eight months of storage as per standard procedure. The data of all characters studied, were subjected statistical analysis of variance technique following Completely Randomized Design (Factorial) for as described by Cochran and Cox (Cochran & Cox, 1957).

RESULTS AND DISCUSSION

The seed quality parameters depend on the stage at which the seed crop is harvested. The results of the present study on influence of stages of harvest on seed quality in chickpea varieties during storage are presented in Table

1, 2 and 3 and discussed character wise as under.

Moisture content (%) (Table 1)

Different varieties of chickpea exhibited non-significant difference for moisture content during storage period irrespective of harvesting stages. At the time of storage, the moisture content recorded the highest (8.59 %) in GG 2, while it was minimum (8.35 %) in GG 5. The moisture content in the seeds increased in storage period. After eight months of storage, the moisture content, on an average, increased up to 2 per cent and it was noted the maximum (10.57 %) in GG 4 and the minimum (10.15 %) in GG 1. The increase in moisture content of the seeds with increase in storage period might be due to hygroscopic nature of the seed and moisture exchange due to high relative humidity in monsoon season (Harrington, 1972, Robert, 1986). Similar results were also observed by Khatun et al. (2009a) Chormule et al. (2015) and Patel et al. (2018) in chickpea during storage. Irrespective of different varieties tested, different stages of harvest exerted non-significant difference for moisture content initially at the time of storage while it had significance difference at eight months after storage. Initially at the time of storage, the maximum moisture content (8.70 %) was noted in green to yellow colour pod stage (H_2) followed by full yellow colour pod stage (H_3) (8.45 %), dark green colour pod stage (H_1) (8.36 %) and copper brown colour pod stage (H_4) (8.31 %). It was observed that moisture content in the seeds increased after the 8 months storage period. After eight months of storage, the moisture content, on an average, increased to 2 per cent and it was recorded significantly the maximum (10.61 %) in green to yellow colour pod stage (H_2), while for the remaining stages, moisture content was at par with each other with moisture content of 10.31, 10.25 and 10.21 per cent in copper brown colour pod stage (H_4), full yellow colour pod stage (H_3) and dark green colour pod stage (H_1), respectively. The increase in moisture content of the seeds with increase in storage period might be due to hygroscopic nature of the seed and moisture exchange due to high relative humidity in monsoon season (Harrington, 1972, Robert, 1986). Similar results were also observed by Khatun et al. (2009a) Chormule et al. (2015) and Patel et al. (2018) in chickpea. Interaction effect of varieties and stages of harvesting for moisture content was found non-significant for storage period.

100 seed weight (g) (Table 1)

Different varieties of chickpea exhibited significant difference for 100 seed weight during storage period irrespective of harvesting stages. At the time of storage, 100 seed weight recorded significantly the highest (24.16 g) in GG 2 and it was at par with GJG 3 (22.18 g). Significantly the lowest 100 seed weight (18.20 g) was recorded in GG 4. It was observed that 100 seed weight was increased after 8 months storage period. After eight months of storage, 100 seed weight was noted significantly the maximum (25.25 g) in GG 2 followed by GJG 3 (23.78 g) and GG 6 (21.29 g). Significantly the lowest 100 seed weight (19.51 g) was recorded in GG 4. The varieties GG 6, GG 1 and GG 5 were at par with each other with 100 seed weight of 21.29, 21.04 and 20.87 g in that order. The increase in 100 seed weight with increase in storage period might be due to hygroscopic nature of the seed and moisture exchange due to high relative humidity in monsoon season (Harrington, 1972, Robert, 1986). Similar results were also observed by Chormule et al. (2015) in chickpea during storage. The variations observed with respect to 100 seed weight may be due to bigger size of endosperm and embryo and were indicated to be specific to varieties (Chandrashekhar, 2005). Similar reports with respect to seed weight were reported in chickpea earlier by Gnyandev (2009) and Chormule et al. (2015) Irrespective of different varieties tested, different stages of harvest exerted significant difference for 100 seed weight at both the time before and after the storage. Initially at the time of storage, significantly the maximum 100 seed weight (27.68 g) was noted in full yellow colour pod stage (H_3) followed by copper brown colour

pod stage (H_4) (24.88 g), green to yellow colour pod stage (H_2) (22.93 g) and dark green colour pod stage (H_1) (7.58 g). It was observed that 100 seed weight was increased after 8 months storage period. After eight months of storage, the same trend was observed for this trait, as significantly the maximum 100 seed weight (28.79 g) was noted in full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (26.16 g), green to yellow colour pod stage (H_2) (24.11 g) and dark green colour pod stage (H_1) (8.77 g). The increase in 100 seed weight with increase in storage period might be due to hygroscopic nature of the seed and moisture exchange due to high relative humidity in monsoon season (Harrington, 1972, Robert, 1986). Similar results were also observed by Chormule et al. (2015) in chickpea during storage. In the present study, the highest 100 seed weight was recorded in full yellow colour pod stage (H_3) and the lowest in dark green colour pod stage (H_1). In case of chickpea, full yellow colour pod stage (H_3) is considered to be the physiological maturity stage. Therefore, 100 seed weight was increased up to physiological maturity and decreased after physiological maturity. The results are in accordance with the findings of Gnyandev (2009) and Khatun et al. (2010) in chickpea. Interaction effect of varieties and stages of harvesting for 100 seed weight was found non-significant at initially at the time of storage, but it was significant for eight months of storage. After eight months of storage, 100 seed weight was recorded significantly the maximum (31.63 g) in V_2H_3 followed by V_2H_4 (30.98 g) and V_3H_3 (29.33 g) and the lowest (6.30 g) in V_4H_1 combination.

Germination percentage (Table 1)

Different varieties of chickpea exhibited non-significant difference for germination during storage period irrespective of harvesting stages. At the time of storage, germination was recorded the highest (68.83 %) in GG 5 followed by GJG 3 (68.58%), GG 2 (68.33 %), GG 6 (68.17 %), GG 4 (67.92 %) and GG 1 (67.00 %). It was observed that germination was decreased after 8 months storage period. After eight months of storage, germination was noted the maximum (58.42 %) in GJG 3 followed by GG 1 (57.83 %), GG 2 (57.42 %), GG4 (56.83 %), GG 5 (56.58 %) and GG 6 (56.50 %). The differences in germination noticed among varieties may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination (Gnyandev, 2009). Similar results were also observed by Chormule et al. (2015) in chickpea during storage. Irrespective of different varieties tested, different stages of harvest exerted significant difference for germination. The seeds harvested at dark green colour pod stage (H_1) were not germinated at all. At the time of storage, significantly the maximum germination (95.06 %) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (91.56 %) and green to yellow colour pod stage (H_2) (85.94 %). After eight months of storage, same trend was observed, as significantly the maximum germination (84.67 %) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (80.78 %) and green to yellow colour pod stage (H_2) (63.61 %). It was observed that germination was decreased after 8 months storage period. Similar results were also observed by Chormule et al. (2015) in chickpea during storage. It was also observed that the percentage of germination found to increase gradually from dark green colour pod colour (H_1) to full yellow colour pod stage (H_3) and declined thereafter at copper brown colour pod stage (H_4). Reduction in pod and seed weight and ultimately the germination may be related to inbuilt mechanism, cessation and disorganization of cell organelles within few days from full yellow pod colour pod stage of harvest (Mathews, 1973). The results of the present study are in accordance with the findings of Bharud and Patil (1990), Gnyandev (2009) and Khatun et al. (2009a) in chickpea. No germination was noted in the early stage of harvest at dark green colour pod stage (H_1) might be due to undeveloped physiologically immature seeds (Jayaraj, & Kavitha Raju,

1992). Interaction effect of varieties and stages of harvesting for germination was found non-significant during storage.

Seedling length (cm) (Table 2)

Different varieties of chickpea exhibited significant difference for seedling length during storage period irrespective of harvesting stages. At the time of storage, seedling length was recorded significantly the highest (22.95 cm) in GG 5 and it was at par with GG 6 (22.88 cm), GJG 3 (22.77 cm), GG 4 (22.43 cm) and GG 2 (22.41 cm), while it was significantly the lowest in GG 1 (21.93 cm). It was observed that seedling length was decreased after 8 months storage period. After eight months of storage, seedling length was noted significantly the maximum (15.47 cm) in GG 6 and it was at par with GG 5 (15.36 cm), GJG 3 (15.35 cm), GG 4 (15.33 cm) and GG 2 (15.23 cm), whereas it was significantly the lowest (14.68 cm) in GG 1. The differences in seedling length noticed among varieties may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination (Gnyandev, 2009). Similar decreasing trend with storage period was also observed by Chormule et al. (2015), in chickpea during storage. Irrespective of different varieties tested, different stages of harvest exerted significant difference for seedling length. The seeds harvested at dark green colour pod stage (H_1) were not germinated at all and therefore, no seedling length was observed / measured. At the time of storage, significantly the maximum seedling length (32.10 cm) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (30.01 cm) and green to yellow colour pod stage (H_2) (28.13 cm). After eight months of storage, same trend was observed, as significantly the maximum seedling length (22.16 cm) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (20.21 cm) and green to yellow colour pod stage (H_2) (18.58 cm). It was observed that seedling length was decreased gradually with increased in storage period. Similar results were also observed by Chormule et al. (2015), in chickpea during storage. It was also observed that seedling length found to increase gradually up to full yellow colour pod stage (H_3) and declined thereafter at copper brown colour pod stage (H_4). The results of the present study are in accordance with the findings of Gnyandev (2009) and Khatun et al. (2009a), in chickpea. Interaction effect of varieties and stages of harvesting for seedling length was found non-significant for both initial and after 8 months storage.

Seedling fresh weight (mg) (Table 2)

Different varieties of chickpea exhibited significant difference for seedling fresh weight irrespective of harvesting stages. At the time of storage, seedling fresh weight was recorded significantly the highest (596.70 mg) in GG 5 and it was at par with GG 6 (594.97 mg), GJG 3 (594.10 mg), GG 4 (587.38 mg) and GG 2 (586.95 mg), while it was significantly the lowest in GG 1 (583.22 mg). It was observed that seedling fresh weight was decreased after 8 months storage period. After eight months of storage, seedling fresh weight was noted significantly the maximum (402.13 mg) in GG 6 and it was at par with GG 5 (399.32 mg), GG 4 (397.83 mg), GJG 3 (397.43 mg) and GG 2 (395.02 mg), whereas it was significantly the lowest (385.60 mg) in GG 1. The differences in seedling fresh weight noticed among varieties may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination (Gnyandev, 2009). Similar decreasing trend with storage period was also observed by Chormule et al. (2015) in chickpea during storage. Irrespective of different varieties tested, different stages of harvest exerted significant difference for seedling fresh weight. The seeds harvested at dark green colour pod stage (H_1) were not germinated at all and therefore, no seedling fresh weight was observed / measured. At the time of storage, significantly the maximum seedling fresh weight (838.38 mg) was recorded. Similar results were also observed by Chormule et al. (2015), in chickpea during

storage. It was also observed that seedling fresh weight found to increase gradually up to full yellow colour pod stage (H_3) and declined thereafter at copper brown colour pod stage (H_4). The results of the present study are in accordance with the findings of Gnyandev (2009) and Khatun et al. (2009a), in chickpea. Interaction effect of varieties and stages of harvesting for seedling fresh weight was found non-significant.

Seedling dry weight (mg) (Table 2)

Different varieties of chickpea exhibited significant difference for seedling dry weight before and after 8 months of storage irrespective of harvesting stages. At the time of storage, seedling dry weight was recorded significantly the highest (45.90 mg) in GG 5 and it was at par with GG 6 (45.77 mg), GJG 3 (45.70 mg), GG 4 (45.18 mg) and GG 2 (45.15 mg), while it was significantly the lowest in GG 1 (44.85 mg). It was observed that seedling dry weight was decreased after 8 months storage period. After eight months of storage, seedling dry weight was noted significantly the maximum (30.93 mg) in GG 6 and it was at par with GG 5 (30.72 mg), GJG 3 (30.70 mg), GG 4 (30.67 mg), and GG 2 (30.18 mg), whereas it was significantly the lowest (29.78 mg) in GG 1. The differences in seedling dry weight noticed among varieties may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination (Gnyandev, 2009). Similar decreasing trend with storage period was also observed by Chormule et al. (2015) in chickpea during storage. Irrespective of different varieties tested, different stages of harvest exerted significant difference for seedling dry weight before and after storage period. The seeds harvested at dark green colour pod stage (H_1) were not germinated at all and therefore, no seedling dry weight was observed / measured. At the time of storage, significantly the maximum seedling dry weight (64.42 mg) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (60.23 mg) and green to yellow colour pod stage (H_2) (57.04 mg). After eight months of storage, same trend was observed, as significantly the maximum seedling dry weight (44.49 mg) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (40.36 mg) and green to yellow colour pod stage (H_2) (37.14 mg). It was observed that seedling dry weight was decreased after 8 months storage period. Similar results were also observed by Chormule et al. (2015). in chickpea during storage. It was also observed that seedling dry weight found to increase gradually up to full yellow colour pod stage (H_3) and declined thereafter at copper brown colour pod stage (H_4). The results of the present study are in accordance with the findings of Gnyandev (2009) and Khatun et al. (2009a) in chickpea. Interaction effect of varieties and stages of harvesting for seedling dry weight was found non-significant.

Seedling Vigour Index (Length) (Table 3)

Irrespective of harvesting stages, different varieties of chickpea exhibited significant difference for seedling vigour index (length) initially at the time of storage, but the result was non-significant after eight months after storage. At the time of storage, seedling vigour index (length) was recorded significantly the highest (2111.10) in GG 5 and it was at par with GJG 3 (2086.20), GG 6 (2084.40), GG 2 (2046.00) and GG 4 (2036.60), while it was significantly the lowest in GG 1(1963.00). It was observed that seedling vigour index (length) was decreased after 8 months storage period. After eight months of storage, seedling vigour index (length) was noted the maximum (1204.60) in GJG 3 followed by GG 6 (1176.80), GG 2 (1175.10), GG 4 (1171.40), GG 5 (1168.80) and GG 1 (1138.00). The differences in seedling vigour index (length) noticed among varieties may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination (Gnyandev, 2009). Similar decreasing trend with storage period was also observed by Chormule et al. (2015) in chickpea during storage. Irrespective of

different varieties tested, different stages of harvest exerted significant difference for seedling vigour index (length) before and after storage period. The seeds harvested at dark green colour pod stage (H_1) were not germinated at all and therefore, no seedling vigour index (length) was observed / measured. At the time of storage, significantly the maximum seedling vigour index (length) (3051.78) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (2747.21) and green to yellow colour pod stage (H_2) (2149.17). After eight months of storage, same trend was observed, as significantly the maximum seedling vigour Index (length) (1876.78) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (1632.02) and green to yellow colour pod stage (H_2) (1181.01). It was observed that seedling vigour index (length) was decreased after 8 months storage period. Similar results were also observed by Chormule et al. (2015), in chickpea during storage. It was also observed that seedling vigour index (length) found to increase gradually up to full yellow colour pod stage (H_3) and declined thereafter at copper brown colour pod stage (H_4). The results of the present study are in accordance with the findings of Samarah and Abu-Yahya (2008), Gnyandev (2009) and Khatun et al. (2009a) in chickpea. Interaction effect of varieties and stages of harvesting for seedling vigour index (length) was found non-significant at the time of storage and significant after eight months of storage. It was observed that seedling vigour Index (length) was decreased after 8 months storage period. Similar results were also observed by Chormule et al. (2015) in chickpea during storage. After eight months of storage, seedling vigour index (length) was recorded significantly the maximum (1931.00) in V_3H_3 and it was par with V_6H_3 (1905.67) and V_5H_3 (1903.23) and the lowest (0.00) in the treatment combinations of all the varieties harvested at dark green colour pod stage (H_1).

Seedling Vigour Index (Mass) (Table 3)

Irrespective of harvesting stages, different varieties of chickpea exhibited non-significant difference at both the time initial and after 8 months storage. At the time of storage, seedling vigour index (mass) was recorded the highest (4222.30) in GG 5 followed by GJG 3 (4187.00), GG 6 (4168.70), GG 2 (4121.60), GG 4 (4101.00) and GG 1 (4015.30). It was observed that seedling vigour index (mass) was decreased after 8 months storage period. After eight months of storage, seedling vigour index (mass) was noted the maximum (2409.20) in GJG 3 followed by GG 6 (2353.60), GG 4 (2342.70), GG 5 (2337.60), GG 2 (2331.90), and GG 1 (2308.10). The differences in seedling vigour index (mass) noticed among varieties may be ascribed to differences in accumulation of reserve food material in seed and its efficient utilization during germination (Gnyandev, 2009). Similar decreasing trend with storage period was also observed by Chormule et al. (2015) in chickpea during storage. Irrespective of different varieties tested, different stages of harvest exerted significant difference for seedling vigour index (mass). The seeds harvested at dark green colour pod stage (H_1) were not germinated at all and therefore, no seedling vigour index (mass) was observed / measured. At the time of storage, significantly the maximum seedling vigour index (mass) (6124.12) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (5514.74) and green to yellow colour pod stage (H_2) (4904.67). After eight months of storage, same trend was observed, as significantly the maximum seedling vigour index (mass) (3767.28) was recorded in the seeds harvested at full yellow colour pod stage (H_3) followed by copper brown colour pod stage (H_4) (3259.33) and green to yellow colour pod stage (H_2) (2361.88). It was observed that seedling vigour index (mass) was decreased after 8 months storage period. Similar results were also observed by Chormule et al. (2015), in chickpea during storage. It was also observed that seedling

vigour index (mass) found to increase gradually up to full yellow colour pod stage (H_3) and declined thereafter at copper brown colour pod stage (H_4). The results of the present study are in accordance with the findings of Samarah and Abu-Yahya, (2008), Gnyandev, (2009) and Khatun et al. (2009a). in chickpea. Interaction effect of varieties and stages of harvesting for seedling vigour index (mass) was found non-significant at the time of storage and significant after eight months of storage.

Electrical conductivity of seed leachates (dS/m) (Table 3)

Irrespective of harvesting stages, different varieties of chickpea exhibited non-significant difference for electrical conductivity of seed leachates. At the time of storage, electrical conductivity of seed leachates was recorded the highest (1.179 dS/m) in GG 1 followed by GG 4 (1.177 dS/m), GG 6 (1.174 dS/m), GG 2 (1.174 dS/m), GJG 3 (1.173 dS/m) and GG 5 (1.172 dS/m). It was observed that electrical conductivity of seed leachates was increased after 8 months storage period. After eight months of storage, electrical conductivity of seed leachates was noted the maximum (1.434 dS/m) in GG 4 followed by GJG 3 (1.430 dS/m), GG 1 (1.428 dS/m), GG 5 (1.426 dS/m), GG 2 (1.426 dS/m) and GG 5 (1.420 dS/m). The difference in electrical conductivity values recorded among varieties indicates that though membrane permeability is lost during seed ageing, the nature and extent of membrane damage may not be similar for all the varieties and thus differences in electrical conductivity values are bound to occur (Kurdikeri, 1991). Irrespective of different varieties tested, different stages of harvest exerted significant difference for electrical conductivity of seed leachates. At the time of storage, significantly the maximum electrical conductivity of seed leachates (1.878 dS/m) was recorded in the seeds harvested at dark green colour pod stage (H_1), while significantly the lowest electrical conductivity of seed leachates (0.846 dS/m) was noted in the seeds harvested at full yellow colour pod stage (H_3). The remaining two stages recorded at par values for this trait initially at the time of storage. After eight months of storage, significantly the maximum electrical conductivity of seed leachates (2.247 ds/m) was recorded in the seeds harvested at dark green colour pod stage (H_1) followed by the seeds harvested at green to yellow pod colour stage (H_2) (1.252 dS/m), copper brown colour pod stage (H_4) (1.159 dS/m) and full yellow colour pod stage (H_3) (1.052 dS/m). It was observed that electrical conductivity of seed leachates was increased after 8 months storage period. It was also observed that electrical conductivity of seed leachates found to decrease gradually from dark green colour pod colour (H_1) to full yellow colour pod stage (H_3) and increased thereafter at copper brown colour pod stage (H_4). The results of the present study are in accordance with the findings of Biddle and King (1978) in vining peas, and Agarwal and Kharlukhi (1985) and Marcos-Filho et al. (1994). in soybean. Interaction effect of varieties and stages of harvesting for electrical conductivity of seed leachates was found non-significant.

Table 1: Influence of stages of harvest on moisture content (%), 100 seed weight (g) and germination percentage in chickpea varieties during storage

Treatments	Moisture content (%)		100 seed weight (g)		Germination percentage	
	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage
Varieties (V)						
GG 1 (V_1)	8.51 (16.96)	10.15 (18.57)	20.13	21.04	67.00 (53.42)	57.83 (46.23)
GG 2 (V_2)	8.59 (17.04)	10.38 (18.79)	24.16	25.25	68.33 (54.74)	57.42 (46.06)
GJG 3 (V_3)	8.40 (16.84)	10.28 (18.69)	22.18	23.78	68.58 (55.16)	58.42 (46.79)
GG 4 (V_4)	8.51 (16.95)	10.57 (18.96)	18.20	19.51	67.92 (54.42)	56.83 (45.69)
GG 5 (V_5)	8.35 (16.77)	10.36 (18.76)	19.72	20.87	68.83 (55.53)	56.58 (45.51)

GG 6 (V_6)	8.36 (16.80)	10.37 (18.78)	20.20	21.29	68.17 (54.71)	56.50 (45.50)
S. Em±	0.14	0.09	0.70	0.24	0.63	0.37
C. D. at 5%	NS	NS	1.98	0.69	NS	NS
Harvesting stages (H)						
Dark green colour pod stage (H_1)	8.36 (16.80)	10.21 (18.64)	7.58	8.77	0.00 (0.00)	0.00 (0.00)
Green to yellow colour pod stage (H_2)	8.70 (17.15)	10.61 (19.00)	22.93	24.11	85.94 (68.05)	63.61 (52.90)
Full yellow colour pod stage (H_3)	8.45 (16.89)	10.25 (18.66)	27.68	28.79	95.06 (77.42)	84.67 (66.97)
Copper brown colour pod stage (H_4)	8.31 (16.74)	10.31 (18.72)	24.88	26.16	91.56 (73.20)	80.78 (63.98)
S. Em±	0.11	0.08	0.57	0.20	0.51	0.30
C. D. at 5%	NS	0.21	1.62	0.57	1.46	0.86
Varieties (V) x Harvesting stages (H)						
V_1 x H_1	8.65 (17.10)	10.21 (18.62)	6.11	6.63	0.00 (0.00)	0.00 (0.00)
V_1 x H_2	8.64 (17.09)	10.20 (18.61)	22.91	24.04	83.67 (66.15)	67.33 (55.13)
V_1 x H_3	8.49 (16.93)	10.04 (18.47)	27.81	28.49	92.33 (73.95)	83.33 (65.89)
V_1 x H_4	8.27 (16.70)	10.14 (18.56)	23.68	25.01	92.00 (73.60)	80.67 (63.90)

Treatments	**Moisture content (%)**		**100 seed weight (g)**		**Germination percentage**	
	Initial at the time of storage	**8 months after storage**	**Initial at the time of storage**	**8 months after storage**	**Initial at the time of storage**	**8 months after storage**
V_2 x H_1	8.55 (17.00)	10.16 (18.57)	10.90	11.83	0.00 (0.00)	0.00 (0.00)
V_2 x H_2	8.90 (17.35)	10.44 (18.85)	25.62	26.57	86.67 (68.58)	63.67 (52.91)
V_2 x H_3	8.22 (16.65)	10.38 (18.78)	30.72	31.63	95.00 (77.16)	85.00 (67.19)
V_2 x H_4	8.70 (17.15)	10.56 (18.95)	29.40	30.98	91.67 (73.24)	81.00 (64.14)
V_3 x H_1	8.34 (16.78)	10.02 (18.44)	10.97	12.76	0.00 (0.00)	0.00 (0.00)
V_3 x H_2	8.58 (17.03)	10.54 (18.93)	24.38	25.99	87.00 (68.87)	66.33 (54.52)
V_3 x H_3	8.56 (17.01)	10.48 (18.88)	27.87	29.33	96.30 (79.01)	86.67 (68.74)
V_3 x H_4	8.12 (16.55)	10.10 (18.52)	25.50	27.01	91.00 (72.76)	80.67 (63.90)
V_4 x H_1	8.13 (16.55)	10.27 (18.68)	5.10	6.30	0.00 (0.00)	0.00 (0.00)
V_4 x H_2	8.82 (17.27)	10.72 (19.10)	21.11	22.29	85.00 (67.25)	62.00 (51.95)
V_4 x H_3	8.59 (17.04)	10.64 (19.03)	24.57	25.97	94.33 (76.52)	84.33 (66.67)
V_4x H_4	8.50 (16.95)	10.64 (19.03)	22.03	23.47	92.33 (73.90)	81.00 (64.14)
V_5x H_1	8.39 (16.83)	10.62 (19.01)	7.45	8.56	0.00 (0.00)	0.00 (0.00)
V_5 x H_2	8.69 (17.14)	10.75 (19.13)	20.95	22.04	86.67 (68.88)	62.00 (51.93)

V_5 x H_3	8.43 (16.87)	10.00 (18.42)	27.12	28.74	96.67 (79.63)	84.33 (66.67)
V_5 x H_4	7.88 (16.24)	10.05 (18.48)	23.38	24.14	92.00 (73.62)	80.00 (63.43)
V_6 x H_1	8.09 (16.52)	10.11 (18.53)	4.93	6.54	0.00 (0.00)	0.00 (0.00)
V_6 x H_2	8.56 (17.00)	11.02 (19.38)	22.60	23.74	86.67 (68.56)	60.33 (50.94)
V_6 x H_3	8.40 (16.83)	9.97 (18.40)	27.97	28.55	95.67 (78.23)	84.33 (66.67)
V_6 x H_4	8.40 (16.83)	10.39 (18.79)	25.32	26.31	90.33 (72.06)	81.33 (64.38)
Mean	8.46 (16.89)	10.35 (18.76)	20.77	21.96	68.14 (54.67)	57.27 (45.96)
S. Em±	0.27	0.18	1.39	0.49	1.26	0.74
C. D. at 5%	NS	NS	NS	1.38	NS	NS
CV %	2.78	1.68	11.61	3.84	3.98	2.77

Table 2: Influence of stages of harvest on seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg) in chickpea varieties during storage

Treatments	Seedling length (cm)		Seedling fresh weight (mg)		Seedling dry weight (mg)	
	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage
Varieties (V)						
GG 1 (V_1)	21.93	14.68	583.22	385.60	44.85	29.78
GG 2 (V_2)	22.41	15.23	586.95	395.02	45.15	30.18
GJG 3 (V_3)	22.77	15.35	594.10	397.43	45.70	30.70
GG 4 (V_4)	22.43	15.33	587.38	397.83	45.18	30.67
GG 5 (V_5)	22.95	15.36	596.70	399.32	45.90	30.72
GG 6 (V_6)	22.88	15.47	594.97	402.13	45.77	30.93
S. Em±	0.19	0.14	3.49	3.65	0.27	0.27
C. D. at 5%	0.55	0.41	9.92	10.38	0.77	0.77
Harvesting stages (H)						
Dark green colour pod stage (H_1)	0.00	0.00	0.00	0.00	0.00	0.00
Green to yellow colour pod stage (H_2)	28.13	18.58	740.80	484.80	57.04	37.14
Full yellow colour pod stage (H_3)	32.10	22.16	838.38	577.74	64.42	44.49
Copper brown colour pod stage (H_4)	30.01	20.21	783.03	522.34	60.23	40.36
S. Em±	0.16	0.12	2.85	2.98	0.22	0.22
C. D. at 5%	0.45	0.33	8.10	8.48	0.62	0.63
Varieties (V) x Harvesting stages (H)						
V_1 x H_1	0.00	0.00	0.00	0.00	0.00	0.00
V_1 x H_2	27.13	18.10	718.13	481.27	55.60	36.87
V_1 x H_3	31.27	21.07	835.60	557.07	63.87	43.13
V_1 x H_4	29.30	19.57	779.13	504.07	59.93	39.13

Treatments	Seedling length (cm)		Seedling fresh weight (mg)		Seedling dry weight (mg)	
	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage
V_2 x H_1	0.00	0.00	0.00	0.00	0.00	0.00
V_2 x H_2	27.73	18.50	738.40	481.00	56.80	36.27
V_2 x H_3	32.13	22.17	835.47	576.33	64.27	44.33
V_2 x H_4	29.77	20.23	773.93	522.73	59.53	40.13
V_3 x H_1	0.00	0.00	0.00	0.00	0.00	0.00
V_3 x H_2	28.60	18.77	752.27	487.93	57.87	37.53
V_3 x H_3	32.20	22.27	837.20	578.93	64.40	44.53
V_3 x H_4	30.27	20.37	786.93	522.87	60.53	40.73
V_4 x H_1	0.00	0.00	0.00	0.00	0.00	0.00
V_4 x H_2	27.77	18.70	739.27	486.20	56.87	37.40
V_4 x H_3	32.23	22.30	838.07	579.80	64.47	44.60
V_4x H_4	29.70	20.33	772.20	525.33	59.40	40.67
V_5x H_1	0.00	0.00	0.00	0.00	0.00	0.00
V_5 x H_2	28.93	18.73	752.27	487.07	57.87	37.47
V_5 x H_3	32.37	22.57	841.53	586.73	64.73	45.13
V_5 x H_4	30.50	20.13	793.00	523.47	61.00	40.27
V_6 x H_1	0.00	0.00	0.00	0.00	0.00	0.00
V_6 x H_2	28.63	18.67	744.47	485.33	57.27	37.33
V_6 x H_3	32.40	22.60	842.40	587.60	64.80	45.20
V_6 x H_4	30.50	20.60	793.00	535.60	61.00	41.20
Mean	22.56	15.24	590.55	396.22	45.42	30.50
S. Em±	0.39	0.29	6.97	7.30	0.54	0.54
C. D. at 5%	NS	NS	NS	NS	NS	NS
CV %	2.96	3.26	2.05	3.19	2.05	3.08

Table 3: Influence of stages of harvest on Seedling Vigour Index (Length), Seedling Vigour Index (Mass), Electrical conductivity of seed leachates (dS/m) in chickpea varieties during storage

Treatments	Seedling Vigour Index (Length)		Seedling Vigour Index (Mass)		Electrical conductivity of seed leachates (dS/m)	
	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage	Initial at the time of storage	8 months after storage
Varieties (V)						
GG 1 (V_1)	1963.00	1138.00	4015.30	2308.10	1.179	1.428
GG 2 (V_2)	2046.00	1175.10	4121.10	2331.90	1.174	1.426
GJG 3 (V_3)	2086.20	1204.60	4187.00	2409.20	1.173	1.430
GG 4 (V_4)	2036.60	1171.40	4101.00	2342.70	1.177	1.434
GG 5 (V_5)	2111.10	1168.80	4222.30	2337.60	1.172	1.420
GG 6 (V_6)	2084.40	1176.80	4168.70	2353.60	1.174	1.426
S. Em±	27.37	14.56	48.85	28.29	0.004	0.009
C. D. at 5%	77.84	NS	NS	NS	NS	NS
Harvesting stages (H)						
Dark green colour pod stage (H_1)	0.00	0.00	0.00	0.00	1.878	2.247
Green to yellow colour pod stage (H_2)	2419.17	1181.01	4904.67	2361.88	0.989	1.252
Full yellow colour pod stage (H_3)	3051.78	1876.78	6124.12	3767.28	0.846	1.052

Copper brown colour pod stage (H_4)	2747.21	1632.02	5514.74	3259.53	0.986	1.159
S. Em±	22.35	11.89	39.89	23.10	0.003	0.007
C. D. at 5%	63.56	33.80	113.42	65.67	0.010	0.021
Varieties (V) x Harvesting stages (H)						
V_1 x H_1	0.00	0.00	0.00	0.00	1.892	2.249
V_1 x H_2	2270.13	1217.57	4651.60	2480.80	0.993	1.248
V_1 x H_3	2886.13	1755.80	5895.60	3593.93	0.843	1.048
V_1 x H_4	2695.90	1578.80	5513.80	3157.60	0.987	1.167

Treatments	**Seedling Vigour Index (Length)**		**Seedling Vigour Index (Mass)**		**Electrical conductivity of seed leachates (dS/m)**	
	Initial at the time of storage	**8 months after storage**	**Initial at the time of storage**	**8 months after storage**	**Initial at the time of storage**	**8 months after storage**
V_2 x H_1	0.00	0.00	0.00	0.00	1.881	2.252
V_2 x H_2	2402.93	1177.60	4922.53	2308.73	0.985	1.252
V_2 x H_3	3052.70	1884.33	6105.40	3768.67	0.849	1.046
V_2 x H_4	2728.27	1638.60	5456.53	3250.20	0.980	1.155
V_3 x H_1	0.00	0.00	0.00	0.00	1.867	2.243
V_3 x H_2	2488.30	1244.60	5035.27	2489.20	0.990	1.260
V_3 x H_3	3101.93	1931.00	6203.87	3862.00	0.843	1.063
V_3 x H_4	2754.43	1642.87	5508.87	3285.73	0.989	1.154
V_4 x H_1	0.00	0.00	0.00	0.00	1.889	2.251
V_4 x H_2	2362.97	1158.20	4837.27	2316.40	0.986	1.254
V_4 x H_3	3040.97	1880.63	6081.93	3761.27	0.849	1.059
V_4x H_4	2742.30	1646.57	5484.60	3293.13	0.984	1.172
V_5x H_1	0.00	0.00	0.00	0.00	1.865	2.240
V_5 x H_2	2509.00	1161.87	5018.00	2323.73	0.990	1.249
V_5 x H_3	3129.20	1903.23	6258.40	3806.47	0.843	1.045
V_5 x H_4	2806.33	1610.00	5612.67	3220.00	0.988	1.148
V_6 x H_1	0.00	0.00	0.00	0.00	1.876	2.244
V_6 x H_2	2481.67	1126.20	4963.33	2252.40	0.987	1.247
V_6 x H_3	3099.77	1905.67	6199.53	3811.33	0.849	1.051
V_6 x H_4	2756.00	1675.27	5512.00	3350.53	0.985	1.160
Mean	2054.54	1172.45	4135.88	2347.17	1.175	1.427
S. Em±	54.75	29.11	97.71	56.57	0.008	0.018
C. D. at 5%	NS	82.78	NS	160.86	NS	NS
CV %	4.62	4.30	4.09	4.17	1.22	2.15

CONCLUSION

For getting the higher yield and quality of chickpea varieties at the time of storage and after eight months of storage, chickpea seed should be harvested at the H_3 (full yellow color pod stage), as the seeds harvested at full yellow color pod stage recorded the germination percentage (84.67 %) even after eight months of storage with good vigour. For maintaining better quality up to the next season sowing, seeds could be stored under proper storage condition, because with increase in storage period, quality of seed deteriorated.

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