

**INNOVATIVE PRACTICES TO ENHANCE SEED  
YIELD AND QUALITY OF SINGLE CROSS HYBRID  
MAIZE (*Zea mays* L.) NAH-2049 [NITHYASHREE]**

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**DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY  
UNIVERSITY OF AGRICULTURAL SCIENCES  
BENGALURU**

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*Affectionately dedicated  
to my*

*Beloved Parents,  
Sri. D.M. Basavaraju  
&  
Smt. H.M. Yashoda*

*Beloved Brother  
Mr. D.B. Gowri Shankar*

*Beloved person  
Miss.B.A. Mamatha*

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BENGALURU 560 065**

**CERTIFICATE**

This is to certify that the thesis entitled **INNOVATIVE PRACTICES TO ENHANCE SEED YIELD AND QUALITY OF SINGLE CROSS HYBRID MAIZE (*Zea mays* L.) NAH -2049 [NITHYASHREE]** submitted by **Mr. JITHENDRA, D.B., I.D. No. PAL 0252** in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SEED SCIENCE AND TECHNOLOGY** to the **UNIVERSITY OF AGRICULTURAL SCIENCES, BENGALURU**, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

**Bengaluru  
July, 9<sup>th</sup> 2012**

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**[JITHENDRA D.B.]**


**“Innovative practices to enhance seed yield and quality of single cross hybrid maize (*Zea mays* L.) NAH -2049 [Nithyashree]”**

**ABSTRACT**

A field and laboratory experiments were conducted at National Seed Project and Department of Seed Science and Technology, GKVK, UAS, Bangalore respectively during Kharif 2011-2012 to assess the response of fertilizer treatments and spacing on growth, seed yield and quality of single cross maize hybrid NAH-2049. Experimental results revealed that fertilizer application at (T<sub>9</sub>) 225:112.5:60 NPK kg ha<sup>-1</sup>+ZnSO<sub>4</sub> at 10 kg ha<sup>-1</sup>+ Boron spray (1%)+*A. chroococcum*+*B. megaterium*+ *G. fasciculatum* recorded significant plant height in both male and female parent (134.90 and 152.80 cm), cob weight (135.40 g), hybrid seed yield (3237.65 kg ha<sup>-1</sup>) and germination per cent (98%) superior over other fertilizer treatments. Among the planting geometry higher hybrid seed yield (2836.90 kg ha<sup>-1</sup>) was recorded in (S<sub>1</sub>) 75X30 cm planting geometry compared to 60X30 cm (2765.09 kg ha<sup>-1</sup>). Growth, seed yield and quality attributes viz., number of leaves per plant (13.30), days to 50 per cent tasseling and silking (45.33 and 46.67 days), pith weight (34.27 g), 100 seed weight (35.61 g) and seedling dry weight (90.57 mg) were observed in fertilizer application at 225:112.5:60 NPK kg ha<sup>-1</sup>+10 kg ZnSO<sub>4</sub>+ Boron spray (1%) + *A. hroococcum*+ *B. megaterium*+ *G. fasciculatum*with planting geometry of 75X30cm. Significant pollen viability per cent (89.89%) was recorded in fertilizer treatment (150:75:40 NPK kg ha<sup>-1</sup>)+ZnSO<sub>4</sub> spray(2%)+ Boron spray (1%) in the male parent (MAI-105). Interaction effect of treatment T<sub>9</sub>S<sub>1</sub> and non aged hybrid seeds showed significant difference for higher shoot length (15.79 cm), root length (20.46 cm) and seedling vigour index I and II (3290 and 8996).

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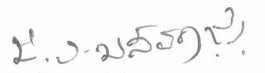
ಮೆಕ್ಕೆ ಬೋಳದ ಸಂಕರಣ ತಳಿ ಎನ್.ಎ.ಎಚ್-2049 (ನಿತ್ಯಶ್ರೀ) ಯ ಬೀಜ ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟ  
ಹೆಚ್ಚಿಸಲು ನವೀನ ಪದ್ಧತಿಗಳು  
ಪ್ರಬಂಧದ ಸಾರಾಂಶ

ಮೆಕ್ಕೆಬೋಳದ ಸಂಕರಣ ತಳಿಯಾದ ಎನ್.ಎ.ಎಚ್ -2049 (ನಿತ್ಯಶ್ರೀ) ಯ ಗುಣಮಟ್ಟದ ಮೇಲೆ ಸಸ್ಯ ಸಾಂದ್ರತೆ ಮತ್ತು ತಾಯಿ ಸಸ್ಯ ಪೋಷಣೆಯ ಪ್ರಭಾವದ ಅಧ್ಯಯನವನ್ನು ೨೦೧೧-೧೨ನೆಯ ಸಾಲಿನಲ್ಲಿ ರಾಷ್ಟ್ರೀಯ ಬೀಜ ಪ್ರಾಯೋಜನೆ ಮತ್ತು ಬೀಜ ವಿಜ್ಞಾನ ಮತ್ತು ತಂತ್ರಜ್ಞಾನ ವಿಭಾಗ, ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾಲಯ ಬೆಂಗಳೂರಿನಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಫಲಿತಾಂಶಗಳ ಪ್ರಕಾರ ರಸಗೊಬ್ಬರ ಉಪಚಾರದ ಸಂಯೋಜನೆಗಳ ಪೈಕಿ T<sub>9</sub>:225:112.5:60 ಸಾರಜನಕ: ರಂಜಕ: ಪೊಟ್ಯಾಶ್ ಕೆ.ಜಿ. ಪ್ರತಿ ಹೆಕ್ಟೇರ್ ಗೆ +10 ಕೆ.ಜಿ.ಸತುವಿನ ಸಲ್ಫೇಟ್ + ಬೋರಾನ್ ಸಿಂಪರಣೆ (1%)+ ಅಜೋಟೊಬ್ಯಾಕ್ಟರ್+ಬಿ. ಮೆಗಾತೀರಿಯಂ+ಜೆ. ಫ್ಯಾಸಿಕ್ಯುಲೆಟಂ ಸಂಯೋಜನೆಯು ಹೆಚ್ಚಿನ ಬೆಳವಣಿಗೆ, ಬೀಜ ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ಅಂಶಗಳನ್ನು ಅಂದರೆ ಹೆಚ್ಚಿನ ಸಸ್ಯದ ಎತ್ತರ (134.90 ಸೆಂ.ಮೀ), ಎಲೆಗಳ ಸಂಖ್ಯೆ(11.98), ಹೂ ಬಿಡಲು ಕನಿಷ್ಠ ದಿನಗಳು (46.83 ಮತ್ತು 51.00), ತನೆಯ ಉದ್ದ (14.74 ಸೆಂ.ಮೀ.),ತನೆಯ ವ್ಯಾಸ (12.16 ಸೆಂ.ಮೀ), ತನೆಯ ತೂಕ (135.40 ಗ್ರಾಂ), ತನೆಯ ದಿಂಡಿನ ತೂಕ (32.33ಗ್ರಾಂ.),೧೦೦ ಬೀಜಗಳ ತೂಕ(35.18 ಗ್ರಾಂ), ಪ್ರತಿ ಗಿಡದ ಬೀಜ ಇಳುವರಿ (114.20 ಗ್ರಾಂ), ಸಂಕರಣ ಬೀಜ ಇಳುವರಿ (3237.65 ಕಿ.ಗ್ರಾಂ/ಹೆಕ್ಟೇರ್), ಬೀಜಗಳ ಕುಡಿಯೊಡೆಯುವಿಕೆ ಪ್ರಮಾಣ(98%), ಮೊಳಕೆಯ ಉದ್ದ (19.03), ಮೊಳಕೆಯ ಶಕ್ತಿ ಸೂಚ್ಯಂಕ I ಮತ್ತು II (3240 ಮತ್ತು 8547) ಮತ್ತು ಒಟ್ಟು ಡಿಹೈಡ್ರೋಜಿನೇಸ್ (1.45) ಚಟುವಟಿಕೆಯನ್ನು ಹೊಂದಿವೆ. ಗಿಡಗಳ ಅಂತರವುಉಪಚಾರಗಳನ್ನುಅವಲೋಕಿಸಿದಾಗ, ಸಂಕರಣ ಬೀಜ ಇಳುವರಿಯು, 75X30 ಸೆಂ.ಮೀ.ನಲ್ಲಿ (2836.90 ಕಿ.ಗ್ರಾಂ/ಹೆಕ್ಟೇರ್) 60X30ಸೆಂ.ಮೀ. (2765.09ಕಿ.ಗ್ರಾಂ/ಹೆಕ್ಟೇರ್) ಗಿಂತ ಹೆಚ್ಚು ದಾಖಲಾಗಿರುತ್ತದೆ, ರಸಗೊಬ್ಬರ (T<sub>9</sub>) 225:112.5:60 ಸಾರಜನಕ:ರಂಜಕ:ಪೊಟ್ಯಾಶ್ ಪ್ರತಿ ಹೆಕ್ಟೇರ್ ಗೆ +10 ಕೆ.ಜಿ.ಸತುವಿನ ಸಲ್ಫೇಟ್ + ಬೋರಾನ್ ಸಿಂಪರಣೆ (1%)+ ಅಜೋಟೊಬ್ಯಾಕ್ಟರ್+ಬಿ. ಮೆಗಾತೀರಿಯಂ+ಜೆ. ಫ್ಯಾಸಿಕ್ಯುಲೆಟಂ ಮತ್ತು ಗಿಡಗಳ ಅಂತರ ಉಪಚಾರದ ಸಂಯೋಜನೆಯ ಪೈಕಿ (75 X 30 ಸೆಂ. ಮೀ) ಗಮನಾರ್ಹವಾಗಿ ಹೆಚ್ಚಿನ ಬೆಳವಣಿಗೆ, ಬೀಜ ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ಅಂಶಗಳನ್ನು ಅಂದರೆ ಹೆಚ್ಚಿನ ಎಲೆಗಳ ಸಂಖ್ಯೆ(13.30), ಹೂ ಬಿಡಲು ಕನಿಷ್ಠ ದಿನಗಳು (45.33ಮತ್ತು 46.67), ತನೆಯ ದಿಂಡಿನ ತೂಕ(34.27 ಗ್ರಾಂ), ೧೦೦ ಬೀಜಗಳ ತೂಕ(35.61 ಗ್ರಾಂ)ಮತ್ತುಮೊಳಕೆ ಒಣ ತೂಕ(90.57 ಮಿ.ಗ್ರಾಂ) ಹೊಂದಿದ್ದವು.ಗಂಡು ತಳಿ MAI 105 ರ ಹೆಚ್ಚಿನ ಪ್ರತಿಶತ (89.89%) ಪರಾಗ ರೇಣುವಿನ ಜೀವಿತಾವಧಿಯು ರಸಗೊಬ್ಬರ ಉಪಚಾರದ ಸಂಯೋಜನೆಯಾದ (150:75:40 ಎನ್ ಪಿ ಕೆ/ಹೆಕ್ಟೇರ್ +ಸತುವಿನ ಸತುವಿನ ಸಲ್ಫೇಟ್ ಸಿಂಪರಣೆ (2%) + ಬೋರಾನ್ ಸಿಂಪರಣೆ (1%) ಗಮನಾರ್ಹವಾಗಿ ಹೆಚ್ಚಾಗಿ ಕಂಡುಬಂದಿರುತ್ತದೆ.ಉಪಚಾರದ ಸಂಯೋಜನೆಗಳು ಮತ್ತು ವೇಗೋತ್ಕರ್ಷಿತ ಬೆಳವಣಿಗೆ ಅವದಿಯಲ್ಲಿನ ಪರಸ್ಪರ ಕ್ರಿಯೆಯಲ್ಲಿ ಸಂಕರಣ ತಳಿಗಳು ಗಮನಾರ್ಹ ವ್ಯತ್ಯಾಸವನ್ನು ತೋರಿಸಿರುತ್ತವೆ. ಅವುಗಳಲ್ಲಿ ಶೂನ್ಯ ದಿನಗಳ ವೇಗೋತ್ಕರ್ಷಿತ ಬೆಳವಣಿಗೆ ಅವದಿಯಲ್ಲಿನ ಸಂಕರಣ ಬೀಜಗಳು ಮತ್ತು ರಸಗೊಬ್ಬರ ಉಪಚಾರದ ಸಂಯೋಜನೆ T<sub>9</sub>S<sub>1</sub>ಯು ಹೆಚ್ಚಿನ ಚಿಗುರು ಉದ್ದ (15.79 ಸೆಂ.ಮೀ), ಬೇರು ಉದ್ದ (20.46 ಸೆಂ.ಮೀ) ಮತ್ತು ಮೊಳಕೆಯ ಶಕ್ತಿ ಸೂಚ್ಯಂಕ I ಮತ್ತು IIನ್ನು (3290 ಮತ್ತು 8996) ಹೊಂದಿವೆ.

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# *Introduction*

## I. INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crop. It has higher yield potential than any other cereals and many times it is referred to as "miracle crop" or the "queen" of cereals. Maize is grown both as food for man and fodder for animal. Maize being a C<sub>4</sub> plant, has the higher potential for synthesis of carbohydrate. Dr. Norman E. Borlaug believes that maize has the highest yield potential among cereals. In the last two decades there was a revolution in rice and wheat and the next few decades will be known as maize era.

In India during 2010-11, maize was cultivated an area of 8.49 m ha with a production of 21.28 m t with the productivity of 2507 kg ha<sup>-1</sup>. In India Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Karnataka, Andhra Pradesh, Gujarat and Maharashtra are the major maize growing states. In Karnataka, maize occupies an area of 9.4 lakh ha with a production of 27.30 lakh tonnes. The average yield is 2783 kg ha<sup>-1</sup> which is for higher than average yield of country. The substantial increase in the yield of maize has been largely attributed to development of improved varieties, hybrids and improved cultural practices. (Source: Directorate of Economics & Statistics, Department of Agriculture and cooperation 2011).

Crossing between two desirable inbreds as a male and female parents and deriving F<sub>1</sub> or hybrid from the cross is called a single cross hybrid. In India, single cross hybrids cover about 20 per cent of the total area. Thus, Indian maize program has now given focus on single cross hybrids and since 1990, a total number of 56 single cross maize hybrids have been released.

The reasons for modern maize varieties and hybrids have spread relatively slowly compared to wheat and rice relates to the biological

properties of these species. Rice and wheat are self-pollinated crops and when they reproduce each generation of plants retain the genetic and physiological identity of the previous generation. This means that the farmers can set aside part of their harvest for use as seed in future cropping season as long as they are careful to avoid mixing the seeds of different varieties and they can meet the demand of other farmers. During the green revolution in rice and wheat, modern varieties of these crops quickly spread from farmer-to-farmer through seed exchanges.

Hybrid seed production of maize crop influenced largely by several agronomic and management factors, among which planting ratio, staggered sowing and levels of nitrogen application are important. The poor seed yield noticed in many maize hybrids is mainly attributed to the nicking problem existed between male and female parents. Even in well synchronized plots, the seed yield was found to be far less from expectation which may be due to various reasons like wind direction, velocity and availability of insufficient viable pollens to female parent. Therefore, one of the basic requirements in hybrid seed production is to find out optimum planting ratio and plant population to provide sufficient quantity of viable pollens to the seed parent during flowering period for ensuring increased pollination and fertilization to obtain higher hybrid seed set and yield.

In hybrid maize seed production, plant nutrients like organic and inorganic fertilizers are known to be potential to enhance seed crop productivity of maize hybrid. By modifying morphological and physiological characteristics in enhancing source to sink relationship ultimately realizing higher yield of quality hybrid seeds. The foliar application of micronutrients enhances the pollen tube growth leads to higher seed set. Application of biofertilizers increases the soil nutrient uptake to the plants (Singh, 2006), *Azotobacter* inoculation to non-

legume crops enhanced seed germination of rice, wheat and maize etc, and also the nitrogen requirement of cereal crops could be reduced by *Azotobacter* application.

Maize pollen is considered desiccation intolerant relative to pollen from other species, since it loses viability rapidly as moisture content decreases (Luna *et al.*, 2001). Pollen grains are most important material for increasing seed set, the availability of pollen may be limited due to biotic and abiotic factors, non-synchrony. Pollen viability is not only affected by environmental factors during the transport from anther to the stigma, but pollen development inside the anther may also be disturbed by same factors. Drought stress during pollen development of cereals, for example, specifically reduces male reproductive performance (Saini, 1997). Likewise, temperature stress during floral development may affect reproductive performance. In order to improve the pollen viability in maize foliar application of major and micro nutrient explored.

Delouche and Baskin (1973) demonstrated that seed ageing process can be accelerated by temperature and humidity increase and elaborated consequently a method to test the storage capacity of the seeds. The temperature and humidity conditions that could influence, after harvest, the vigour of the seed and would estimate the unfavourable effect of these factors using the accelerated ageing method. The loss of viability and vigour in seed can affect the yield of crop in two ways firstly a decline in seed vigour leading to sub-optimal plant population per unit area and secondly low vigour seed may results in poor performance of a surviving plants. There are many studies on seed vigour but restricted to various aspects of laboratory studies. The difference in vigour as affected by the various factors is often not detected in the ordinary germination test. Therefore, the need for specific vigour tests are there application is very much essential to determine the vigour of hybrid maize seeds.

Keeping these views in mind, the present investigation entitled **“Innovative practices to enhance seed yield and quality of single cross hybrid maize (*Zea mays* L.) NAH - 2049 (Nithyashree)”** was carried out at National Seed Project, UAS, GKVK, Bengaluru during *kharif*, 2011-12 with the following specific objectives:

1. To study the effect of plant density and mother plant nutrition on growth, seed yield and quality of maize hybrid
2. To study the pollen viability in male parent of maize hybrid
3. To study the seed ageing on seed quality of maize hybrid

# *Review of literature*

## II. REVIEW OF LITERATURE

A comprehensive review of literature is inevitable for any scientific investigation. A proper understanding of the problem requires a thorough review of the existing knowledge of the problem. The literature pertaining to the hybrid seed production technologies *viz.*, plant density, plant nutrition, pollen viability and accelerated ageing in maize are presented in this chapter. The available literatures on the above topics in maize are very meagre and hence, the related reviews on other crops are also included.

### 2.1 Effect of plant density and spacing on growth, yield and quality of maize

One of the basic requirements in production of hybrid seeds is used to optimum plant population and planting ratios of pollen parent to seed parent to get higher seed set and yield. The pattern of planting ratio contribute substantially for the uniform supply of pollen to all the seed parent rows in achieving higher seed set and yield. An adequate availability of inter and intra row spacing is necessary for enhancing metabolic activities of the plant which intern influence the plant growth. This would be achieved by efficient utilization of biological resources such as solar energy, water and nutrients.

#### 2.1.1 Growth, yield and quality parameters

Khadar and Kassem (1972) showed that in the white - seeded single cross of maize inbred lines Giza 55 and Giza 50 when planted in alternate rows in the ratios of 1:2, 1:3 and 1:4 (Giza 55 being the pollen parent), the plots having a 1:3 ratio gave significantly higher yields than the plot with 1:2 and 1:4 ratios. Krishnamurthy *et al.* (1974) observed in maize that lower plant population (55,000 plants ha<sup>-1</sup>) had 292 g dry

matter accumulation per plant as against 253 g plant<sup>-1</sup> at higher population of 83,000 plants ha<sup>-1</sup>.

Nayeem (1977) reported that the ideal planting ratio in sorghum hybrid was found to be two to six female rows alternated by two male rows. He opined that the number of female rows were determined on the basis of size of the male ear heads, duration of its flowering and amount of pollen production. Vidyabhushanam (1977) stated that optimum planting ratio of female to male rows was 4:2 or 6:2 and further opined that, the number of female rows had to be determined on the basis of size of male ear heads, the duration of its flowering, amount of pollen produced and the wind velocity. He also stated that economizing of male parent at rows was an unwise step in hybrid sorghum seed production.

Patil and Goud (1980) obtained maximum seed weight per ear in CSH-8R seed production by planting four female to two male rows compared to all other ratios like 10:2, 12:2 and 16:2 during *rabi* season at Dharwad. Further, they have reported higher number of seeds (287) per ear, ear weight (31.39 g) and seed set (47.73 %) were obtained with 2:4 pollen to seed parent row ratio. But lower ear weight (20.80 g) and yield parameters decreased with increase in the female parent row ratio.

In a study on the influence of planting ratio in sorghum seed production Singh and Katare (1981) observed significant variation in seed yield due to planting ratios. A significant higher seed yield of 20.43 q ha<sup>-1</sup> was recorded with 2:1 planting ratios followed by 4:2 and 6:2 planting ratio which recorded 19.29 and 17.25 q ha<sup>-1</sup> respectively. The lowest seed yield of 13.09 q ha<sup>-1</sup> was obtained in 8:2 planting ratio. Prasad (1981) revealed that the yield and growth characters were higher in Deccan 101 than Deccan hybrid. Deccan101 produced significantly higher yields than Deccan hybrid (7165 and 2886 kg ha<sup>-1</sup> respectively).

The Deccan hybrid had higher grain crude protein (8.54%) than Deccan 101 (8.08 %).

Setty (1981) observed that plant height in maize significantly increased with increase in plant density. Maximum plant height of 200 cm was recorded with 80,000 plants ha<sup>-1</sup>, which was significantly higher than 192 cm with 40,000 plants ha<sup>-1</sup>. Satyanarayana and Seetharam (1983) noticed that the different parental ratios adopted did not affect the quality of sunflower hybrid seed. They also reported the increased yields of BSH-1 with increased male to female ratio from 1:1 to 1:4. The highest yield of 1.37 t ha<sup>-1</sup> was obtained with a planting ratio of 1:4.

Krishnaveni and Ramaswamy (1985) conducted the experiment on parental lines of CO-H-1 hybrid maize and obtained higher hybrid seed yield of 2697 kg ha<sup>-1</sup> with 60 X 25 cm spacing as compared to seed yield (1925 kg ha<sup>-1</sup>) in closer spacing of 45 X 30 cm. Three planting ratios of 6:1 (control), 8:1 and 12:1 were studied by Hussaini and Sarada (1987) for the production of double cross hybrid seed of maize. One row of the pollen parent on either side of 12 rows of the seed parent lines gave uniform seed set per unit area of cobs in all the rows and increased seed yield by 17.7 percent compared to control.

Reddy *et al.* (1987) observed that the cob length, seeds per cob, shelling percentage, 1000 seed weight and seed yield per cob decreased from 17.98 to 17.26 cm, 311.3 to 246.9, 75.47 to 74.56, 292.2 to 271.3 g and 87.23 to 62.9 g respectively with increase in plant population from 59,200 to 88,000 plants ha<sup>-1</sup>. In a field trial conducted during summer 1984 at Hebbal, Bangalore sorghum hybrid CSH-1 grown with female: male plant ratios of 4:2 (standard), 6:2, 8:2, 10:2 and 12:2. The number of seeds per panicle and mean seed yield per panicle were greater with the first 3 ratios than with the two highest ratios. A ratio of 8:2 produced the highest seed yield (1.7 t ha<sup>-1</sup>) (Reddy *et al.*, 1989).

Lu (1991) studied the effect of row ratios (1:3 and 1:4 male and female rows) and the densities of (4000, 5000 and 6000 plants ha<sup>-1</sup>) in the F<sub>1</sub> hybrid Youdon 14 made by the reciprocal crosses of maize inbred lines Huangzou of early maturing and MO17 of intermediate maturity. The F<sub>1</sub> seed yield increased with density of female plants in range of 4000-6000 plants per mu (1mu= 0.067 ha), productive cobs per unit area is increased by 50% at a density of 6000 plants compared with that of 4000 plants/mu, showing different row ratios had significant effect on hybrid seed yield.

Khot and Umrani (1992) observed more seed yield (45.86 q/ha) at a spacing of 75 X 30 cm (440000 plants) and 98.56 per cent seed recovery in African tall maize. The next best spacing was 60 X 45 cm produced 41.51 q/ ha. However, the seed quality parameters of 75 X 30cm seeds like germination (93 %), vigour index (3359) and seedling dry weight (68 mg) higher as compare to 60 X 45 cm.

Jabeen *et al.* (1993) evaluated the production of Pearl millet (*Pennisetum glaucum*) hybrid MH 179 (MS 81 A X ICP 451) with male and female rows grown in the row ratios of 1:4, 1:5, 1:6, 2:6, 2:8, 2:10 or 2:12 during 1992-93. Seed setting was not affected by row ratios. The highest seed yield (2.17 t/ha) was obtained with male: female row ratio of 2:12. Pucaric *et al.* (1994) concluded that the five inbred lines of maize having the plant densities at 50000, 72000 and 103000 plants ha<sup>-1</sup> with a 70 cm or 45 cm row width. The parameters like seed yield (22.34 q ha<sup>-1</sup>), leaf area index (r=0.89) and yield components were higher at 45 cm compare to row width of 70cm.

Planting of maize at 80 X 45 cm yielded 52.3q ha<sup>-1</sup>, which was significantly higher over all other treatments except 90 X 30 cm spacing. East West direction of row has also yielded 7 q ha<sup>-1</sup> more of maize and it was significantly higher to north west direction (Anon.,1996a). The

optimum plant density and fertilizer provides better condition for maximum light interception right from early periods of crop growth, in turn enhance the productivity per unit area. Maize is presently cultivated with the recommended plant density of 55,555 plant ha<sup>-1</sup>, though there are some reports that maize responds better even upto 90,000 to 1,00,000 plants ha<sup>-1</sup>, (Singh *et al.*,1997).

Yadav and Singh (2000) investigated the effect of row spacing (45, 60 and 75 cm) on LM5 female and LM6 male inbred lines of single cross hybrid "Paras". The increased row spacing influenced the flowering behaviour of both the inbred and they augmented the flowering to establish their synchronization which ultimately increased seed yield and improved seed quality. Among the spacing, 75 x 20 cm gave maximum yield in single cross maize hybrid.

Gollar and Patil (2000) observed the response of maize genotypes (Deccan 103 and D-23) to various plant densities *viz.*, 55,555 (60 x 30 cm), 74,074 (45 x 30 cm), 83,333 (60 x 20 cm), 1,11,111 (45 x 20 cm and 30 x 30 cm) plants ha<sup>-1</sup> was studied at two locations Konnur and Dharwad during *rabi* season. The seed yield of maize increased by 14, 21, 33 and 34.1 percent with increased in plant density of 74,074, 83,333, 1,11,111 and 1,11,111 plants ha<sup>-1</sup> respectively.

Yadav and Singh (2000) studied the effect of three fertilizer levels *viz.*, 90 kg N + 45 kg P<sub>2</sub>O<sub>5</sub> 120 kg N + 60 kg P<sub>2</sub>O<sub>5</sub> and 150 kg N+75 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and with a row spacing of 45, 60 and 75 cm of single cross maize hybrid. The increased fertilizer doses and row spacing had influenced synchronisation with increased seed yield and quality.

In an experiment Ashok Gaur *et al.* (2003) studied the effect of pollen parent producing plant densities and estimated the incidence of ergot (*Claviceps fusiformis*) and smut (*Tolyposporium penicillariae*) under

different planting ratios of male and female parents of Pusa 23 hybrids of Pearl millet. Seed of D-23 (male parent) and 841-A (female) were sown in row ratios of 1:4, 1:8, 2:4, 2:8 and 2:12. Disease incidence was also low in plot where male and female parents were sown at a row ratio of 2:4. Thus, they concluded that in a planting design where pollen rows were in adequate proportion with the seed parent, the seed quality was better due to fewer incidences of ergot and smut. The highest yield was obtained in plots where the planting ratio was 1:8.

Barbieri *et al.* (2005) studied the effect of four row spacings (60, 70, 80 and 90 cm) and 5 plant populations (50,000, 55,000, 60,000, 65,000 and 70,000 plants/ha) on two corn hybrids (MD-2001 and MD-2002). It was noticed that there was increased kernel productivity and industrial yield at the row spacing of 60 cm and plant population of 65,000 plants/ha in the hybrids MD-2001 and MD-2002 respectively.

Muniswamy *et al.* (2007) studied that seed yield and quality were increased with increase in spacing from 10 cm (18.48 q/ha) to 30 cm (24.95 q/ha) and nitrogen levels from 80 kg (18.23 q/ha) to 160 kg/ha (23.90 q/ha). Seed quality in terms of 1000 seed weight (281.7 g) and seedling vigour index (3372) was significant due to spacing and nitrogen levels although germination percent was not significant.

Chutima Koshawatana *et al.* (2010) studied the compact planting technique and planting ratio of 4:1 (female : male) in Nakhon Sawan 3 maize hybrid seed production, results showed that compact planting increased yield by 12-28 per cent compared with female to male row planting ratio of 4:1 and compact planting between 75 cm female rows produced the highest yield of 2,381 kg ha<sup>-1</sup> compared with planting between female rows at 85 cm, 65 cm and planting female to male rows at a ratio of 4:1 produced a yield of 2,288, 2,081 and 1,856 kg ha<sup>-1</sup> respectively. The compact planting delayed the time to 50 per cent pollen

shedding from 64 days (planting female to male rows at a ratio of 4:1) to 65, and 66 days in compact planting between rows of 85 cm, 75 cm and 65 cm, respectively.

## **2.2 Effect of mother plant nutrition on growth, yield and quality parameters**

The literature pertaining to effect of plant nutrition on growth, yield and quality parameters are reviewed and presented under following headings.

### **2.2.1 Role of nitrogen, phosphorus and potassium**

Nitrogen is one of the major components of nucleic acid, co-enzymes and membranes. It is involved in many of the metabolic processes *viz.*, cell division, photosynthesis, protein synthesis and expansion of shoot and root growth in plants and has active role during vegetative growth.

Phosphorus is an important constituent of nucleoproteins, involved in high energy transfer compounds such as ADP, ATP and plays a key role in energy transfer in the metabolic processes.

Potassium regulates and maintains electrochemical equilibrium in cells and other compartments and involved in enzyme activities. It also participates in carbohydrate metabolism, protein synthesis, regulation activities of various essential elements, functions of stomata and water relations in the plant system.

#### **2.2.1.1 Effect of nitrogen, phosphorus and potassium fertilizer on growth, yield and quality parameters**

Rai (1961) noticed early tasseling, silking and maturity by 9 to 16 days with application of 88 kg N ha<sup>-1</sup> as compared to no nitrogen

application. Shah *et al.* (1971) reported that increasing levels of nitrogen application reduced the days to silking. Mandloi *et al.* (1972) noticed 6 to 10 days early silking with application of 160 kg N ha<sup>-1</sup>. Halemani *et al.* (1980) observed that plant height of maize increased from 130 to 193 cm with increase in nitrogen level from 0 to 240 kg ha<sup>-1</sup>.

Kapoor and Rana (1981) advocated the application of 120 kg N ha<sup>-1</sup> and 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> is the optimum dose of fertilizer for maize hybrid in Jalandhar district, Punjab. Krishnaveni and Ramaswamy (1985) in a field experiment with the parental lines of CO-H-1 maize hybrid, they revealed that application of nitrogen significantly influenced the plant height (128.5 cm), length of cob (16.4 cm), width of cob (13.7 cm), number of seed row<sup>-1</sup> (35), total number of seeds cob<sup>-1</sup> (466), seed weight cob<sup>-1</sup> (94.2 g), shelling percentage (83.3 %) and seed yield (2697 kg ha<sup>-1</sup>). However, application of P and K significantly increased the seed weight per cob and seed yield.

Thanki *et al.* (1988) observed the seed yield of 4.71, 5.23 and 5.34 t ha<sup>-1</sup> with 60, 120 and 100 kg N ha<sup>-1</sup>, respectively and 4.33, 5.33 and 5.32 t ha<sup>-1</sup> with 0, 30 and 60 kg P<sub>2</sub>O<sub>5</sub>, respectively and 4.87 and 5.32 t ha<sup>-1</sup> with 0 and 60 kg K<sub>2</sub>O ha<sup>-1</sup> in a maize hybrid Ganga safed-1. The application of 180: 60: 60 kg NPK ha<sup>-1</sup> recorded higher yield 6.21 t ha<sup>-1</sup> followed by 5.92 t ha<sup>-1</sup> with 120:30:60 kg NPK ha<sup>-1</sup>. El-Noemani *et al.* (1990) in field trials with 60, 90 and 120 kg N/ha on growth and yield of maize cv. Hybrid 202 observed that increasing nitrogen upto 90 kg increased number of leaves per plant in both years of study.

Prasad and Singh (1990) reported in maize that nitrogen application in general resulted in reduction of number of days to 50 per cent silking and tasseling and significantly increased the cobs per plant, cob weight, 1000 grain weight and cob length. Potassium application hastens silking in corn, but does not shorten the total production cycle

which gives scope for longer period of grain filling and thus yield increased (Anon., 1990).

Odoemah (1991) reported that the hybrids of maize differing in all the seed quality traits, with increased dose of nitrogen (120 kg N/plot), the parameters like seed vigour (3689), field emergence (89%) and seed yield (2.88 t ha<sup>-1</sup>) were higher compare to the control (90 kg N/plot). Albegov (1992) observed with the increased in fertilizer rate, there was increase in the photosynthetic potential (leaf area duration) and coefficient of PAR (photo-synthetically active radiation) in maize genotypes. Eghball *et al.* (1995) noticed that higher seed yield and reduced number of days to 50% tasseling and silking with increased level of nitrogen application rate (0 to 180 kg ha<sup>-1</sup>) without manure, but no response to fertilizer application was observed when manure were applied.

Anon (1996b) revealed that increasing the levels of Phosphorous (0, 20, 40 and 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>), we can increase the yield significantly, by adding 60kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, the yield level is increased upto 24.20 q ha<sup>-1</sup> compare to the yield level of 13.3 q ha<sup>-1</sup> (without phosphorous application) in hybrid maize. Yadav and sikh (2000) studied the effect of different fertilizer levels (90:45:0, 120:60:0 and 150:75:0 kg NPK ha<sup>-1</sup>) on seed production and quality of LM5 and LM6 inbred lines of single cross hybrid 'paras'. They revealed that 150:75:0 kg NPK ha<sup>-1</sup> gave highest seed yield and seed quality compare to the other traits.

Channabasavanna *et al.* (2002) reported that application of 100% NPK produced taller plants (199.8 cm), cob length (18.2 cm), cob girth (15.6 cm) and 100 seed weight (28.3 g), thus increasing the seeds cob<sup>-1</sup> (389) and seed weight cob<sup>-1</sup> (111.3 g). Maurya *et al.* (2004) reported that plant height, number of green leaves, leaf area index and dry matter production increased significantly with higher levels of nitrogen upto 150 kg ha<sup>-1</sup>.

Parasuraman (2006) observed the significant influence of integrated use of soil application of inorganic, organic nutrients and foliar feeding of micro nutrients on yield attributes (cob length, cob girth, cob weight and test weight) of COH-3 maize hybrid. The seed and stover yield were maximum at 135:62.5:50 Kg NPK ha<sup>-1</sup> compare to control. Ummed Singh *et al.* (2006) reported application of 40 kg N + 30 kg P<sub>2</sub>O<sub>5</sub> + 10 t FYM + *Azotobacter* + VAM significantly enhanced the plant height and dry matter accumulation over other treatment. Further this treatment also increased the number of cobs plant<sup>-1</sup>(1.27), cob length (15.23cm), cob diameter (10.35 cm), and 1000 grain weight (298.54 g) over the control.

Singh *et al.* (2006) reported that application of 100% RDF increased in maize plant height (8.17 %) dry matter accumulation per plant (12.90 %) and N, P and K uptake by 20.49, 39.32 and 18.09 per cent respectively, than 50% RDF. In maize, application of farm yard manure (15 t ha<sup>-1</sup>) + urea (260 kg ha<sup>-1</sup>) recorded significantly higher plant height (197.50cm), numbers of cobs per plant (1.127), number of grains per cobs (514.43), 1000-grains weight (327.54 g), grains yield (6.13 t ha<sup>-1</sup>) and harvest index (38.17 %) compared to the sole application of FYM and urea (Syed Talat Hussain Shah *et al.*, 2009).

Narayanaswamy and Siddaraju (2011) revealed that the application of NPK at 150:75:45 kg ha<sup>-1</sup> recorded significantly highest field emergence (89.5%), plant height at harvest (202.45 cm), stem girth (2.0 cm), cob length (15.28 cm), processed seed yield (3673 kg ha<sup>-1</sup>), seed recovery (90.60%),test weight (140.46 gm),germination (94%) and vigour index (2657) compared to NPK at 90:45:45 kg ha<sup>-1</sup>. The results showed that spacing of 60 x 20 cm sown with the fertilizer level of NPK at 150:75:45 kg ha<sup>-1</sup> showed significantly highest processed seed yield

(4250 kg ha<sup>-1</sup>), seed recovery (92.42%), test weight (144.26 gm), germination (96%) and vigour index (3131).

Sandeep Dangi *et al.* (2012) observed that by application of fertilizer level 150:75:37.50 kg NPK per ha recorded significantly higher plant height (221.08 cm), early tasseling (57.32 days), silking (60.53 days), higher cob length (17.58 cm), number of seeds per cob (358.4), 100 seed weight (11.64 g), recovery percent (96.64) and seed yield (25.87 q/ha). The seed quality parameters viz. germination (92.26%), root length (22.25 cm), shoots length (21.87cm) and vigour index (4218) was also higher with F<sub>3</sub>.

### **2.2.2 Effect of Boron and Zinc micro nutrient fertilizers on growth, yield and quality parameters**

Boron (B) is an important micronutrient. It has an important role in pollen germination, pollen tube growth, sugar transportation and transfer of nutrients from leaves to reproductive organs, and increases pollination and seed development. While B requirements for optimum plant nutrition are low as compared with those of the primary nutrients, the need for B is especially significant during tasseling and silking stages. Zinc plays an important role in chlorophyll synthesis, auxin synthesis, water uptake, photosynthesis and improving crop yield.

#### **2.2.2.1 Effect of Boron on growth, yield and quality parameters**

The literature pertaining to boron in relation to maize is scarce. However, the available literature on maize as well as literature pertaining to influence of boron on crop growth and seed yield of various crops is reviewed and presented as below.

Peterson and Gregor (1966) revealed that boron application in corn either to soil or foliar spray, resulted in accumulation of higher leaf boron

concentration in plants by foliar spray compared to the broadcasting method. Verma *et al.* (1973) observed that one ppm boron significantly increased the fresh and dry weight of root (28.5 g and 6.25 g, respectively) in tomato crop. Takkar and Randhawa (1978) indicated that the boron helps in biosynthesis of protein, carbohydrates, increased activities of ribonuclease, amylase and decreased the activities of enzymes like catalase, phosphatase and invertase in maize plants.

Agarwal *et al.* (1981) reported that the boron deficiency causes delay in tassel formation and decrease in pollen production capacity in maize, results poor seed set in cob. Sharma (1995) concluded that boron showed pronounced beneficial effect on 1000-seed weight (3.94 g) and germination percentage (96.5) with 20 kg boron per ha compared to 10 kg boron per ha (3.41 g and 94.33%, respectively) in tomato crop. Application of recommended dose of NPK + Boron at 2 kg per ha has significantly increased the test weight, seed germination and vigour index of soybean over the control (Deosarkar *et al.*, 2002).

Ziaeyan and Rajaiea (2009) reported that calcareous soils of southern Iran with low levels of available Zn and B, soil application of 16- 24 kg ha<sup>-1</sup> of zinc sulfate and foliar application of B solution containing 0.1 percent of boric acid (1000 L ha<sup>-1</sup>) applied for enhancement of grain yield (26%) and reduction of grain-free cob in corn.

Sittichai Lordkaew *et al.* (2010) conducted a series of trials on maize plants subject to B<sub>0</sub> (nil added B) and B<sub>20</sub> (20µM added B) treatments, B<sub>0</sub> plants produced 0.4 grain ear<sup>-1</sup> compared with 410 grains ear<sup>-1</sup> in B<sub>20</sub> plants, and the symptoms of B deficiency was observed only in B<sub>0</sub> plants, which exhibited symptoms of narrow white to transparent lengthwise streaks on leaves, multiple but small and abnormal ears with

very short silk, small tassels with some branches emerging dead, and small, shrivelled anthers devoid of pollen.

#### **2.2.2.2 Effect of Zinc on growth, yield and quality parameters**

Gupta and Ram (1968) concluded that soil application of  $\text{ZnSO}_4$  at 21.5 kg per  $\text{ha}^{-1}$  along with RDF of NPK fertilizer given higher yield (3.5 q  $\text{ha}^{-1}$ ) compare to the yield (2.9 q  $\text{ha}^{-1}$ ) with the soil application of  $\text{MnSO}_4$  at 43 kg per  $\text{ha}^{-1}$  along with RDF of NPK fertilizer in hybrid maize Ganga-101.

Sinha and Singh (1977) reported that maize responded significantly to application of Zinc upto 5 kg per ha resulting in increased grain and straw yield. Whereas, 10 kg Zn per ha decreases yields. However, Zinc application resulted in progressive increase in concentration in grain and straw. The highest grain yield of 5.6 t  $\text{ha}^{-1}$  was recorded with the application of 100 % NPK in combination with *Azospirillum* at 2 kg  $\text{ha}^{-1}$  and Zn sulphat at 20 kg  $\text{ha}^{-1}$  compared to the yield of 4.7 t  $\text{ha}^{-1}$  obtained with 100 % NPK alone (Anon.,1997b)

Latif *et al.* (1983) in maize cv. Akbar given with a basal dressing of 167 kg N and 111 kg  $\text{P}_2\text{O}_5$  per ha with 0, 5.6, 11.2, 16.8 and 22.4 kg  $\text{ZnSO}_4$  per ha applied to the soil or as a foliar spray at 8-10 leaf stage indicated that the plant height, cob length and breadth, number of grains per cob, 1000 grains weight and yield was increased with  $\text{ZnSO}_4$  regardless of the method of application.

Devarajan *et al.* (1988) showed that application of  $\text{ZnSO}_4$  with or without FYM significantly increased dry matter yield, grain and stover yield of maize. The highest grain and stover yields were obtained with the application of 25 kg  $\text{ZnSO}_4$  along with FYM at 25 t per ha compare to the control (without FYM). Hussain *et al.* (1989) recorded higher hundred seed weight (0.56 g) from the treatment with zinc (0.1%) as against soil

application of Devimicro Shakti at 5 kg per ha in chilli. Toma *et al.* (1992) observed the long term application of NPK fertilizer to maize in crop rotations resulted in increased availability of phosphorous in soil, ZnSO<sub>4</sub> at 15 kg ha<sup>-1</sup> with 120:120:90 kg NPK ha<sup>-1</sup> the grain yield increased by 1.75 t ha<sup>-1</sup>.

Sharma *et al.* (1992) revealed that application of ZnSO<sub>4</sub> at 30 kg ha<sup>-1</sup> recorded a highest yield of 10.67 q ha<sup>-1</sup>, application of ZnSO<sub>4</sub> at 15 kg ha<sup>-1</sup>(10.36 q ha<sup>-1</sup>).so, ZnSO<sub>4</sub> where as the not influenced the yield of maize. Rathore Singh and Kripal Singh (1997) studied the effect of phosphorus and Zinc on seed yield and yield attributes of maize. The results indicated that Zinc application has relative advantage in increasing yield attributes over varying dose of phosphorus.

Ramu and Reddy (2007) studied that foliar application of zinc (ZnSO<sub>4</sub> @ 0.5%) and iron (FeSO<sub>4</sub> @ 0.25%) increases the plants height, LAI (leaf area index), seed yield, protien content and dry matter at the time of tasselling and silking. Maralian Habib (2009) revealed that the foliar application of iron and zinc treatments *ie.*, control (no Zn and Fe application), 150 g Zn.ha<sup>-1</sup> as ZnSO<sub>4</sub>, 150 g Fe.ha<sup>-1</sup> as Fe<sub>2</sub>O<sub>3</sub>, and a combination of both Zn and Fe, Results showed that combination foliar application of Zn and Fe increased seed yield (8954 kg ha<sup>-1</sup>) and its quality compared with control (7665 kg ha<sup>-1</sup>) in wheat.

Kanwal *et al.* (2010) reported that zinc fertilization improved grain yield and Zn content of maize hybrids compared to synthetic variety. Hybrid (FHY-421) produced maximum grain yield when Zn was applied at the rate of 18 kg ha<sup>-1</sup> compared to variety (Golden), which produced maximum when Zn was applied at the rate of 6 kg ha<sup>-1</sup>. Moreover, internal Zn requirement of maize hybrid was higher than synthetic variety.

Hamidreza Mobsser *et al.* (2012) reported that the effect of application of iron and Zinc on three flint Corn (704,770 and 7020) and four fertilizer treatment (F<sub>1</sub>= control, F<sub>2</sub>= Zinc sulphate, F<sub>3</sub>= iron sulphate and F<sub>4</sub>= iron sulphate + Zinc sulphate), the results showed that there was no significant effect on Wight of 100 seeds, function of seed, biologic function harvest index, and protein percentage among the fertilizer treatment and three flint Corn.

### **2.2.3 Effect of biofertilizers on growth, yield and quality parameters**

#### **2.2.3.1 *Azotobacter spp.***

It is an aerobic, heterotrophic, free living nitrogen fixing bacteria, isolated and described by Beijerinck (1901). In addition to fixing nitrogen asymbiotically, it is also known to produce plant growth hormones and fungistatic substances. The organism grows well in nitrogen free medium utilizing molecular nitrogen for its cell protein synthesis. The dead cells on subsequent mineralization contribute towards the nitrogen availability of plants (Goswami 1976). Apte and Shende (1981) observed that the application of *A. chroococcum* had a stimulatory effect on seed germination, growth and yield of cotton, wheat, and maize. The stimulatory effect varied with the strains and the conditions under which seed germination was tested.

Sudhir and Shende (1982) reported that in maize application of *Azotobacter chroocoecum* + 80 kg N + 10 t FYM recorded higher grain yield (29.5 q ha<sup>-1</sup>) when compare to no application of FYM, *Azotobacter chroocoecum* and nitrogen (14.3 q ha<sup>-1</sup>). Singh (2006) reported that *Azotobacter* inoculation to non-legume crops enhanced seed germination of rice, maize, wheat, jowar etc, and also suggested that the nitrogen requirement of cereal crops could be reduced by *Azotobacter* application.

Biari *et al.* (2008) reported the effect of plant growth promoting rhizobacteria (PGPR) belonging to the genera *Azospirillum* and *Azotobacter* on growth and nutrient uptake of maize (*Zea mays*) in the field experiment. The treatment A<sub>1</sub>Z<sub>1</sub> (*Azotobacter* sp. Strain 5+ *Azospirillum* sp. strain 21) showed higher shoot dry weight (359.72 g plant<sup>-1</sup>). The maximum cob dry weight (260.06 g plant<sup>-1</sup>) and grain dry weight (204.72 g plant<sup>-1</sup>) was recorded in A<sub>0</sub>Z<sub>1</sub> (control + *Azospirillum* sp. strain 21) treatment.

Naveed *et al.* (2008) reported that application of organic and bio-fertilizer significantly improved the growth and yield of maize. The plant height and cob weight (9 and 23%), total biomass (11.4 and 39.3%) and grain yield and 1000 grain weight (14.2 and 7.0%) was increased over control.

#### **2.2.3.2 Phosphate solubilising bacteria (PSB)**

Gaur and Alagawadi (1987) recorded significant increase in root nitrogen activity, dry matter and seed yields of rice and sorghum due to combined inoculation of *Azospirillum brasilense* and phosphate solubilizing *Pseudomonas striata* or *Bacillus polymyxa* as compared to single inoculation of either organisms or control. Significant increase in the yield of sorghum due to combined inoculation of *Azospirillum brasilense* and phosphate solubilizing bacteria (*Pseudomonas striata* and *Bacillus polymyxa*) was reported by Alagawadi and Gaur (1988).

Prathibha *et al.* (1994) observed that the inoculation with mixture of *A. Brasilense* and *P. patida* promoted maize growth at the early stage (23 and 35.6% increase in shoot and root dry weight, respectively) compared to control. Jeevansab (2000) recorded significantly higher number of seeds (194.8) per fruit, seed weight (1.44 g) per fruit and 100-seed weight (0.75 g) with the application of *Azospirillum* + RDF as

compared to 50 per cent RDF (175.8, 1.32 g and 0.72 g, respectively) in caspium. Shashidhar (2000) noticed that *Azospirillum* + phosphobacteria recorded higher 1000- seed weight (5.93 g) which was significantly superior over 50 per cent RDF (5.40 g) in chilli. Balyan *et al.* (2006) revealed that seed inoculation of maize with *Azotobacter* + PSB significantly influenced the plant height (6.07%), N uptake (15.82%), P uptake (21.54%) and K uptake (15.49%).

### **2.2.3.3 VAM fungi**

*VA mycorrhiza* are wide spread in natural soils and their beneficial effect on plant growth in phosphorus (P) deficient soils is believed to be due to uptake and translocation of phosphorus by fungal hyphae. Mycorrhizal colonization also known to supply along with phosphorus (P) other nutrients like Nitrogen (N), Potassium (K), Zinc (Zn), copper (Cu), Iron (Fe), Manganese (Mn) to the plants. Vigorous growth, higher shoot biomass and shoot P content were observed in mycorrhizal maize (Sanni, 1976).

Jackson (1972) observed and recorded that 50 per cent increase in the yield of corn in natural field condition by placement of VA mycorrhizal inoculum 5 cm below the seed. Khan (1975) observed three times increase in yield of wheat grown under field conditions by inoculation of soils with VA-mycorrhizal fungus (*Glomus fasciculatum*). He also showed that mycorrhizal effect was eliminated by application of fertilizer indicating that fungus does not improve the growth in soil having enough available P.

Khan (1988) concluded that mycorrhiza greatly improved nitrogen and zinc contents in rice plants during their growth. VA mycorrhizal inoculation resulted in an increased dry matter production in all the crop plants. Hasanpour *et al.* (2012) reported that the wheat crop Inoculation

with mycorrhiza fungi, Azotobacter and the dual inoculation (fungus + bacteria), given significantly increased grain yields to 5936 (21.6%), 5532 (13.3%), and 5733 kg/ha (17.5%), respectively. In addition, the maximum LAI (leaf area index) was higher in all three inoculation treatments compared to no inoculation. The dual inoculation treatment was the best treatment in terms of yield, leaf production and grain protein in both normal and drought conditions.

### **2.2.3.3 Combination of inorganic and biofertilizers on growth, yield and quality**

The higher grain yield of 5.6 t ha<sup>-1</sup> was recorded with the application of 100 percent NPK in combination with *Azospirillum* at 2 kg ha<sup>-1</sup> and zinc sulphate at 20 kg per ha compared to the yield of 4.7 t ha<sup>-1</sup> obtained with 100 percent NPK alone (Anon.,1997a). El-Kholy *et al.* (2005) studied the associative influence of *Azospirillum brasilense* and *Rhodotorula glutinis* in the presence of low rates of NPK and sulphur on maize crop. The nutrient elements was more compare to the control due to the contents of maize grains nitrogen, phosphorus, potassium sulphur, zinc, iron and manganese.

Ganapathy and Savalgi (2006) studied the effect of micronutrients enriched *Azospirillum* biofertilizer on growth, nutrient uptake and yield of maize crop. The results revealed that seed treatment of *Azospirillum* grown in broths containing combination of micronutrients like Zn + Fe + Mo, Zn + Mo, Fe + Mo and Zn alone gave significantly higher root length (18.24 cm), increased dry matter production (277.72 g), improved nutrient uptake (161.32 mg), higher endorhizosphere *Azospirillum* population and also significant increase of grain and stover yield.

Mudenoor *et al.* (2007) observed that *Azospirillum* + Zn + Fe + Mo resulted in higher nitrogen uptake (731.1 to 740 mg/plant) over control

(349.3 to 393.0 mg/ plant) in maize, and soil application of micronutrient (Zn, Fe and Mo) enriched with seed treatment (*Azospirillum*) biofertilizers that enhanced the nutrient uptake resulted in higher yield. Mohammad *et al.*(2009) revealed that in maize var. SC-604 application of phosphate solubilisation microorganisms (PSM) and plant growth promoting rhizobacteria (PGPR) along with NPK (NPK+PSM+PGPR) given significantly higher cob weight (12.9 t ha<sup>-1</sup>), seed number per cob (699.8), seed yield (10.27 t ha<sup>-1</sup>), biological yield(18.26 t ha<sup>-1</sup>) and harvest index (55.72%) compared to control (NPK).

Manoochehr Farboodi *et al.*(2011) revealed that in maize application of *Azotobacter* (seed inoculum) + 225 kg N + 10 t FYM ha<sup>-1</sup> recorded higher biomass, kernel weight and chlorophyll content which was significantly on par with *Azotobacter* (seed inoculum) + 150 kg N + 10 t FYM ha<sup>-1</sup> when compared to no application of FYM, *Azotobacter chroocoecum* and nitrogen.

### **2.3 *In vitro* pollen viability studies**

Daniel (1949) reported that the average duration of male flowering on maize plants was 7-9 days and difference between the beginning of pollen shedding and the appearance of the stigma was 1.61 days.

Vietez *et al.* (1952) reported that a 2% TZ solution at 50° C provided a quick index of viability of maize pollen. Psareva (1954) confirmed that maize pollen had good viability for two to three days after flowering. Lenkov (1962) reported that pollen of all maize varieties retained the variability under laboratory conditions for 24 hours, but viability decreased after two to three days. Among the varieties, pollens of Wisconsin and Nebraska retained the viability in storage.

Nemilienko (1970) reported that maize pollen remained fully viable for six to eight hours in the field and partially for 24 – 30 hours and

pollen viability of the hybrids was longer than the varieties. Leonova (1972) found that maize pollen remained viable for 12 hours under field conditions. Golovin (1973) reported that the pollen of maize hybrids retained a satisfactory capacity of fertilization for 10-12 hours compared with four to six hours in the maize inbred lines.

In sunflower, Seetharam and Kusuma kumari (1974) conducted *in vitro* studies to know the germination and viability of pollens and observed that pollen remained viable for a short period after anthesis at 8.00 a.m. under field conditions. The pollen viability reduced to 90.58 per cent by 9.30 a.m. and 77.82 per cent by 12 noon at Bangalore condition.

Temperature and relative humidity plays an important role in maintenance of pollen viability. In most systems, low temperature and low humidity prolong pollen viability (Stanley and Linkens, 1974). Khamis *et al.* (1976) in maize studies involving inbreds and hybrids reported that, the short period of anthesis was associated with a lower seed yield. An increase in the duration of pollen production in the male parents gave an increase in yield in the hybrids.

Garg *et al.* (1979) found that germination capability, the size and the fertility of pollen grains of rice were considerably improved as a result of boron application at 2.5 ppm concentration. Higher concentration of boron was quite inhibitory. Besides these, the yield of seeds per plant, the number of grains per panicle and bulk weight of thousand seeds, also exhibited virtually the same trend of variation. They also reported that inclusion of boron in the nutrient solution with optimum level included some stimulatory effects on the pollen vitality and there by improved the seed yield of rice plant. Boron stimulated enzymatic activity and nitrogen metabolism which may be linked with improvements in pollen fertility and growth. High doses of boron caused high respiration

and depression in the enzymatic activity at cellular level also affecting the translocation and availability of sugars. Such conditions lead to physiological deterioration and adversely affected the pollen vitality.

Herrero and Johnson (1980) ascertained that prolonged anther storage at temperatures higher than 32 °C resulted in a significant decrease of pollen germination of maize genotypes. All genotypes had a lower germination at 38 °C than 32 °C or 27 °C and several genotypes exhibited no germination after 48 hours at 38 °C. Deficiency of boron in pollen grains of maize resulted in decrease in activity of enzymes like catalase, acid phosphatase and invertase but increased the activity of ribulonuclease and amylase (Agarwal *et al.*, 1981).

Presolka (1989) reported that pollen viability was maintained for 24 hours after separation from the tassels in three maize inbred lines of maize. The highest fertilization percentage was achieved by pollination with fresh pollen shown 11.00 to 14.00 hour. Sharma *et al.*, (1990) noticed that zinc deficiency decreased pollen viability in maize (*Zea mays* L. cv. G2), showed that normal zinc supply to zinc-deficient plants before the pollen mother cell stage of anther development, the vegetative yield of plants and pollen fertility could be recovered to a large extent, but the recovery treatment was not effective when given after the release of microspores from the tetrads.

Marschner (1990) postulated that high concentrations of boron are required in the stigma and style for the physiological inactivation of callose by the formation of borate-callose complexes in the cells of the stigma and style of the interface with the pollen tube wall. Donaire (1991) reported that boron stimulated germination of pollen and hydrogen ion extrusion. He also observed that boron is very important in maintaining an acid pH during germination. Sharma *et al.* (1991) observed that manganese-deficient plants developed visible deficiency symptoms and

showed poor tasseling, delayed anther development, fewer and smaller pollen grains with reduced cytoplasmic contents.

Thomas *et al.* (2004) studied the effect of glyphosate application on pollen viability of maize crop. They noticed that reduced the pollen viability when glyphosate treatment at 6-8 leaf stage or later. Further they also observed distinct morphological alteration large vacuoles and low starch accumulation under electron microscope. Westgate and Fonseca (2005) indicated that maize pollen grains are released from anthers at about 55–60% moisture content, and that subsequent desiccation is a function of air temperature, RH and time. Pollen viability decreased linearly with pollen moisture content to zero -30%.

#### **2.4. Effect of Accelerated aging (AA) on seed quality**

Ageing is an universal and continuous physiological phenomenon occurring in seeds. This process occurs progressively at varying rates leading to the loss of viability, vigour and other physiological and biochemical changes within the seeds.

Accelerated aging technique was first developed by Delouche and Baskin (1973) at the Seed Technology Laboratory, Mississippi State University, USA. Accelerated aging was initially developed as a test to estimate the longevity of seeds in commercial storage. Extensive studies with soyabean in the USA have standardized many laboratory variables that influence AA (Tomes, 1985; Tomes *et al.*, 1988) and the test is recommended for soyabean seed by Association of Official Seed Analysts (AOSA, 1983). Surveys of seed testing laboratories in north America have shown that the AA test is one of the most frequently used vigour test (Tekrony, 1983; Ferguson, 1990)

In Accelerated aging test, seeds are exposed for specified period (1 to 10 days) to the high temperature (40-45°C) and relative humidity (95-

100%) depending upon the species which causes rapid deterioration. The test is based on the fact that the high vigour seed lots will withstand these extreme stress conditions and deteriorate at a slower rate than low vigour seed lots. Seed lots with a high survival percentage after ageing are considered to be sound, while those with a low survival are poor in quality Delouche and Baskin (1973).

Accelerated aging is a device to evaluate the relative storage potential of seeds of different lots and genotypes of sorghum (Abdullah and Vanderlip 1972). Gelmond *et al.* (1978) obtained six different vigour levels of sorghum seeds from an identical lot through accelerated ageing for various periods and suggested that this treatment could represent natural storage conditions.

Padma and Muralimohan Reddy (1998) found that laboratory germination test, cold germination test, NaCl stress test and controlled deterioration test had positive and highly significant correlation with field emergence. Controlled deterioration test detected the seed lots with poor emergence potential better than other tests. They concluded that laboratory germination test and controlled deterioration test can be utilised for vigour determination in maize seed lots. There was a sharp decline in germination, seedling vigour index, protein content and activity of dehydrogenase and peroxidase enzyme, while electrical conductivity and sugar concentration in seed leachate increased with ageing in sunflower (Pallavi *et al.* 2003).

#### **2.4.1 Accelerated aging on germination**

Dey and Mukherjee (1986) reported that maize seeds stored at 100% relative humidity and 40°C temperature showed a steady decline in per cent germination with time. In maize, for the seeds stored for 0, 3, 6, 9, 12, 15 days the corresponding germination percentage was 100, 85,

65, 58, 50 and 45, respectively. Drochioiu *et al.* (1993) observed decrease in germination percentage with increase in the period of accelerated aging treatment in maize hybrid seeds.

Narayanaswamy and Manjunatha (1996) studied that seed lots of maize hybrids DHM-103 to assess the natural ageing on seed quality parameters in seed aged for 5, 10, 14, 18 and 22 months, they revealed that the five month old seed lot recorded higher germination (89.85 %) and vigour index (3760) followed by 10, 14, 20 and 22 months old seed lots respectively. Santipracha *et al.* (1997) subjected seeds of single cross, double cross and three way cross hybrid maize to accelerated aging at nearly 100 per cent relative humidity and temperature of 42, 43 and 44 °C for 48, 72 and 96 hours at each temperature. They reported single cross seed showed a gradual and sequential reduction in germination and vigour as accelerated aging temperature and duration increased. Whereas seed from double cross and three way cross showed a sharp reduction in germination only at 43 and 44 °C for 96 hours. Speed of germination had the most response to accelerated aging.

#### **2.4.2 Accelerated aging on viability and vigour**

Desai (1976) reported that the maize seed lot that maintain germination even after accelerated aging will also maintain higher germination in storage under normal condition. On the other hand those lots severely reduced in germination after accelerated aging treatments decline rapidly in germination during storage. Chen *et al.* (1990) reported that the maize varieties representing four endosperm types subjected to accelerated aging at 40 °C temperature and 95 per cent relative humidity for four to fourteen days, germination percentage, germination rate index and viability decreased with length of aging. Cruz-Garcia *et al.* (1995) reported that accelerated aging shown decreased seed germination

capacity and seedling vigour in two maize cultivars, Chalqueno and CPM-2.

Fawad *et al.* (2002) compare the performance of various seed vigour tests for evaluating seed vigour of subtropical corn cultivars. Seed quality traits like standard germination and accelerated aging tests. The decline in seed vigour was more pronounced for subtropical hybrids than for temperate hybrids. Lovato *et al.* (2005) observed the effect of three cold test temperatures on seed vigour of a large number of maize seed lots in comparison with the standard germination test and accelerated ageing (AA) test and to determine the relationship between all tests and field emergence. The AA test is likely to be as effective as the 10°C cold test for assessing maize seed lot vigour. However, for cool tolerant varieties, a cold test at 7.5 or 5°C may be necessary to detect vigour differences among seed lots.

#### **2.4.3 Accelerated aging on seedling length**

Hussaini *et al.* (1988) observed that when yellow grained single cross maize seed subjected to accelerated aging at 40 °C temperature and 85±2 % relative humidity significantly declined germination percentage (16), root length (8.1 cm), shoot length (10.9 cm), dry matter (76.7 g), test weight (18 g) and grain yield (22.2 q/ha) with increase in the period of accelerated aging. Ramamoorthy *et al.* (1989) reported the relative response of maize inbreds and their hybrids to accelerated aging at 40 ± 1°C temperature and 98 ± 2% relative humidity for varying durations. They observed that the germination percentage, root length, shoot length, and dry matter decreased gradually with increase in the treatment period.

Ramlal *et al.* (1995) reported reduction in per cent germination, root length, shoot length, vigour index, and dry matter accumulation

with the increasing the length of the accelerated aging period (0-8 days) in maize cv. Deccan 103 seeds. Basu *et al.* (2004) studied that parental line seeds of five commercial maize hybrids produced in winter season were subjected to natural storage (0, 4 and 8 months) and accelerated ageing (40°C, 100% RH, 7 days) conditions. Simple vigour tests, based on seedling traits especially coleoptile length, reliably assessed the seed quality and storability of maize parental line seeds. Accelerated ageing test though proved its potential for predicting seed storability but failed to simulate effect of natural ageing.

#### **2.4.4 Accelerated aging on seed membrane degradation**

The most basic factor for loss of viability is disruption of membrane system. For breakdown or changes in property of seed membrane, which lead to more leaching effects for cells of seeds.

Brandock and Mathews (1970) reported that the weaker the membrane system, the larger would be the quantity of electrolyte leached from seeds and the greater the conductivity. The leachates exudate as measured by EC was shown too associated with loss of vigour and viability. Ching and Schoolcraft (1968) concluded that a loss in membrane permeability under unfavorable conditions of storage lead to increased leaching out of seeds constituents and thus loss in viability. Similarly, Dey and Mukharjee (1988) reported that electrolyte leakage increased with storage period.

Agarwal and Sinha (1980) have reported increased seed leachate and electrical conductivity is due to membrane degradation in wheat, pulses and all vegetable seeds. Ghosh *et al.* (1981) reported that deteriorated seeds are physiologically and bio-chemically inactive and support the concept that seed ageing may be associated with loss of membrane integrity. Deswal and Sheoran (1993) reported the membrane

damage in tomato seed. So tissue becomes more leaky, dehydrogenase become less active and the ability to incorporate leucine, uracil and phosphate into metabolites decline. Damage to cellular membrane and other essential organelle by auto-oxidation has been put forward as a possible reason for seed senescence (Saha *et al.*, 1990). Seed deterioration due to ageing strongly affected the oxidative properties of mitochondria, which were badly impaired in ATP production where outer and inner membrane integrity was identified as the primary target for desiccation and ageing stress (Benamar, *et al.*, 2003).

#### **2.4.5 Accelerated aging on field emergence**

Deshpande *et al.* (1991) found that the germination percentage, field emergence percentage and vigour index decreased in aged maize seeds, whereas, electrical conductivity of seed leachate was increased, compare to fresh seed lot. Ajayi *et al.* (2001) revealed that maize physiological seed quality was evaluated in laboratory tests and field trials at three planting dates. Using differences in field performance at the different dates, index of seed ageing was computed. Maturity of seed planted affected kernel size and consequently, grain yield, of the resultant crop, irrespective of maturity stage, however, seedling growth traits, interval between flowering stages, morphological traits, number of harvestable ears and grain yield were the traits most affected by seed ageing.

Ajayi *et al.* (2005) found that the understanding the changes in maize seed composition with the development of seed quality. Seed quality tests used were warm germination test for viability, accelerated ageing test for storage quality and two types of cold test (rolled towel test, tray method) for physiological quality. However, the maximum level of these quality components like germination percentage, mean seedling length and field emergence was attained three to seven weeks before

maximum seedling dry weight. High seed quality was associated with high proportion of starch but low proportions of protein and total soluble sugars.

# *Material and Methods*

### **III. MATERIAL AND METHODS**

The field and laboratory experiments were conducted to study the effect of planting density, plant nutrition, pollen viability and accelerated ageing on growth, seed yield and quality of hybrid maize NAH-2049 investigations were undertaken at the National Seed Project and Department of Seed Science and Technology, GKVK, University of Agricultural Sciences, Bengaluru during *kharif*, 2011.

The details of the materials used and methods adopted during the course of investigations are presented in this chapter.

#### **3.1 General description**

##### **3.1.1 Experimental site**

The field experiments were conducted during *kharif*, 2011 at the National Seed Project and laboratory experiment was conducted at Department of Seed Science and Technology, University of Agricultural Sciences, GKVK, Bengaluru 65, which is situated at 12° 15' North latitude and 77° 35' East longitude and at an altitude of 930 meters above the mean sea level.

##### **3.1.2 Characteristics of the experimental site**

The soil of experimental plot was red sandy loam, with pH (6.3) and the electrical conductivity was (0.12 dS/m<sup>-1</sup>) at 25 °C. The nutrients level of soil is presented in APPENDIX I.

The soil is red sandy clay loam with slightly acidic (pH 6.26) and the electrical conductivity was normal (0.12 mhos/cm at 25°C). The nitrogen (285.28 kg/ha) was low, whereas the phosphorus was high (52.44 kg/ha) and the potash was medium (75.96 kg/ha). The organic carbon (0.31%) was low with boron (0.45 kg/ha), calcium (2.4 meq/100

g), magnesium (1.62 meq/100g), and sulphur (3.91 ppm) and these found to be slightly below the normal.

### **3.1.3 Climatic Conditions**

The meteorological data for the crop growth period from (June to November 2011) were recorded at the agro meteorological unit GKVK presented in APPENDIX II.

#### **3.1.3.1 Normal climatic conditions of GKVK**

The normal annual rainfall of the station is 1027.6 mm. The major portion of it is received during July to November with two peaks in the months of September (201.9 mm) and October (171.0 mm). The mean maximum air temperature ranges from 29.6°C to 26.6°C and mean minimum air temperature ranges from 19.5°C to 16.6°C. The highest mean maximum temperature is recorded during June (29.6°C) followed by July (28.2°C). Lowest mean minimum temperature was observed during November (16.6°C).

The mean monthly relative humidity ranges from 73.5 per cent in August to 69 per cent in June. The mean daily maximum sunshine hours are maximum during November (6.6 hr) followed by (6.2 hr) in October.

#### **3.1.3.2 Weather condition during the crop growth period**

The total rainfall received during the crop growth period was 599.3 mm as against 741.1 mm of the normal. The rainfall during the crop growth period was less than the normal in the month of June, July, September, October and November, whereas, it was more than the normal in month of August.

The mean maximum temperature during the period of experimentation ranged from 26.6<sup>o</sup> C (November) to 29.1<sup>o</sup> C (June), while the minimum temperature ranged from 15.9<sup>o</sup> C (November) to 19.5<sup>o</sup> C (June). The mean relative humidity varied from 71 per cent (June) to 74.5 per cent (August). The mean monthly daily bright sunshine hours ranged from 3.3 in August, 2011 to 6.6 in November, 2011.

#### **3.1.4 The previous crop of the experimental site**

The experimental site during summer season was kept fallow and in previous *kharif* – 2010, season sunflower was sown.

#### **3.1.5 Seed source**

Freshly harvested seeds of parental lines SKV-50 and MAI-105 of single cross maize hybrid NAH 2049 were obtained from National Seed Project, GKVK, University of Agricultural Sciences, Bengaluru-65.

### **3.2 Details of the experiment**

The study included field and laboratory experiments to comply with the objectives and the study was divided into three experiments based on objectives studied and is explained as follows.

**Objective I: Studies on plant density and mother plant nutrition on seed yield and quality of maize hybrid NAH 2049”.**

**A. Design** : Factorial RCBD

**B. Hybrid** : NAH 2049 (SKV-50 X MAI-105)

**C. Replications** : 3

**D. Treatments** : 18

**E. First factor** : Fertilizer levels (T)

- T<sub>1</sub>** : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @10 kg
- T<sub>2</sub>** : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @10 kg + Boron spray (1%)
- T<sub>3</sub>** : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @10 kg + Boron spray (1%)
- T<sub>4</sub>** : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub>** : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)
- T<sub>6</sub>** : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)
- T<sub>7</sub>** : T<sub>1</sub> + *Azotobacter* +PSB+VAM + Boron spray (1%)
- T<sub>8</sub>** : T<sub>2</sub>+ *Azotobacter* +PSB+VAM
- T<sub>9</sub>** : T<sub>3</sub>+*Azotobacter* +PSB+VAM

**F. Second factor: Spacing (S):** S<sub>1</sub> = 75 x 30 cm

S<sub>2</sub> = 60 x 30 cm

### 3.2.1 Design and plan of layout

The experimental site was laid out in factorial RCBD with three replications as per the plan and layout given (Fig.3 1).

Growth and vigour of the plants with wider spacing 75 X 30 cm with planting ratio of 3:1 (Plate 1)

General view of the experiment as influenced by fertilizer levels and spacing (Plate 2)

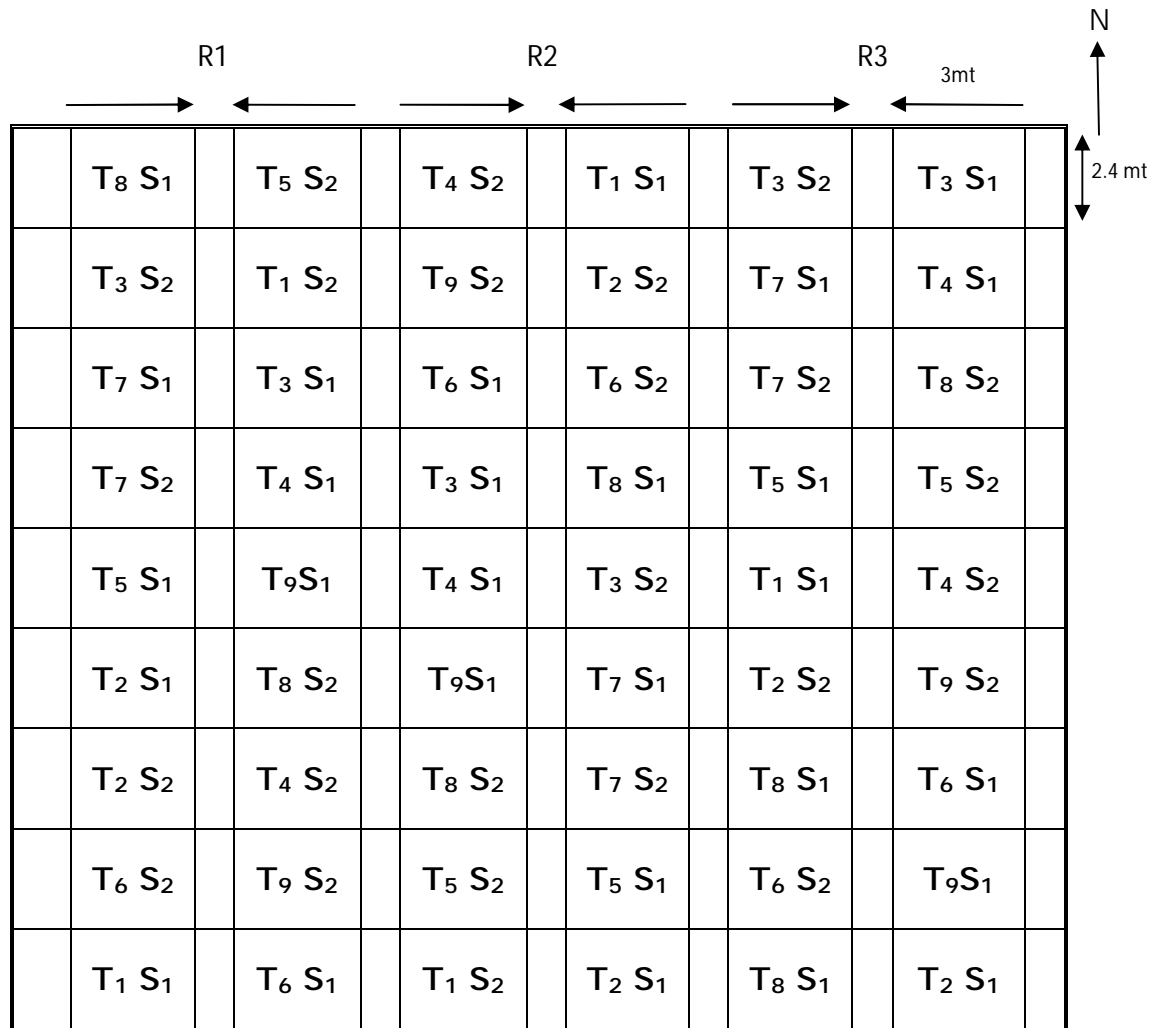


Fig.3.1. Plan and layout of the experimental plot



**Plate 1 : Growth and vigour of the plants with wider spacing 75 X 30 cm with planting ratio of 3:1**



**Plate 2 : General view of the experiment as influenced by fertilizer levels and spacing**

### G. Treatment combinations

T <sub>1</sub> S <sub>1</sub>	T <sub>7</sub> S <sub>1</sub>	T <sub>4</sub> S <sub>2</sub>
T <sub>2</sub> S <sub>1</sub>	T <sub>8</sub> S <sub>1</sub>	T <sub>5</sub> S <sub>2</sub>
T <sub>3</sub> S <sub>1</sub>	T <sub>9</sub> S <sub>1</sub>	T <sub>6</sub> S <sub>2</sub>
T <sub>4</sub> S <sub>1</sub>	T <sub>1</sub> S <sub>2</sub>	T <sub>7</sub> S <sub>2</sub>
T <sub>5</sub> S <sub>1</sub>	T <sub>2</sub> S <sub>2</sub>	T <sub>8</sub> S <sub>2</sub>
T <sub>6</sub> S <sub>1</sub>	T <sub>3</sub> S <sub>2</sub>	T <sub>9</sub> S <sub>2</sub>

H. Plot size: 3.0 m x 2.4 m = 7.2 m<sup>2</sup>

I. planting ratio: 3:1 (Female : Male)

J. Sowing season: *kharif* 2011 under protective irrigation.

**Experiment II: To study the pollen viability in male parent of hybrid maize.**

#### Acetocarmine Test:

For determination of pollen viability the pollen grains were placed on a glass slide containing 2-3 drops of 2 per cent acetocarmine solution. They were mixed using needle and observed under stereomicroscope. Viability of pollens were recorded based on staining pattern, pollen grains which stained dark red, recorded as viable and unstained were non-viable.

#### A. Treatment details:

T<sub>1</sub> : (0.331 :0.165 :0.088 NPK g / pot)

T<sub>2</sub> : (0.331 :0.165 :0.088 NPK g / pot) + 0.022 g ZnSo<sub>4</sub>

T<sub>3</sub> : (0.331 :0.165 :0.088 NPK g / pot) + ZnSo<sub>4</sub> spray (2%)

T<sub>4</sub> : (0.331 :0.165 :0.088 NPK g/pot) + 0.022 g ZnSo<sub>4</sub> + Boron spray (1%)

T<sub>5</sub> : (0.331 :0.165 :0.088NPK g/pot)+ZnSo<sub>4</sub> spray (2%)+Boron spray (1%)

- B. **Replications** : 4  
C. **Design** : RCBD

**Experiment III: To study the seed ageing on seed quality of hybrid maize.**

Seeds produced from first experiment was subjected for accelerated ageing by exposing seeds to  $40 \pm 1^{\circ}\text{C}$  temperature and 95 percent relative humidity for 0, 2, 4 and 6 days to know the relative storability.

- A. **Seed samples** : 18  
B. **Ageing periods** : 4 (0, 2, 4 and 6 days)  
C. **Replications** : 3  
D. **Design** : Factorial CRD

### **3.3 Cultural practices**

#### **3.3.1 Land preparation**

The land was prepared by deep ploughing two times and crushed all clods and then soil was brought to fine tilth. The plots were laid out with small bunds and irrigation channels with ridges and furrows opened at 1m between replications and 50 cm between the treatments.

#### **3.3.2 Fertilizers**

At the time of sowing 50 per cent of the recommended nitrogen and entire phosphate and potassium were applied in the form of urea, single super phosphate and murate of potash respectively. The remaining 50 per cent of nitrogen was top dressed at 30 DAS.

### **3.3.2.1 Seed treatment and soil application of biofertilizers**

Parental lines were treated with 12.5 g per half kg of seeds with *Azotobacter chroococcum* and Phosphate Solubilizing Bacteria (PSB) strain *B.megaterium*. *Glomus fasciculatum* (50 g/ plot) was applied at the time of sowing for respective treatments.

### **3.3.2.2 Foliar application of micronutrients**

As per the treatment details, 2 gram of ZnSO<sub>4</sub> dissolved in one hundred ml of water in a container to make the concentration of 2 per cent ZnSO<sub>4</sub> solution. Similarly, 1 gram of borax is also dissolved in hundred ml of water in another container to make 1 per cent borax solution. Then both the micronutrient solutions were used to spray. These solutions were sprayed as per the treatment details before floral initiation in both the parents by using knapsack sprayer.

### **3.3.3 Sowing**

As per the treatments, furrows were opened in flat bed and ridges and furrows were made in ridges and furrows male and female seeds were hand dibbled as per treatment schedule listed in objective I and seeds were dibbled as per the spacing allotted (75 X 30 cm and 60 X 30 cm) and 3:1 (female: male) planting ratio to the treatment.

### **3.3.4 Gap filling and thinning**

Wherever the seed failed to germinate gaps were filled after 10 DAS (days after sowing) to maintain optimum plant population and thinning was attended 15 DAS to maintain only one seedling per hill.

### **3.3.5 Irrigation**

Irrigation was given before and after sowing to ensure good germination, crop stand and irrigation was provided at all critical stages of crop growth period.

### **3.3.6 Weeding**

The crop was hand weeded on 25<sup>th</sup> and 40<sup>th</sup> DAS and kept the plots free from weeds. Earthingup was done between 30-35 days after sowing followed by top dressing with remaining dose of nitrogen fertilizer.

### **3.3.7 Plant protection**

The Furadon 3G granules were applied in leaf whorls to control shoot fly on 20<sup>th</sup> day after sowing. The endosulfan 35EC @ 35 ml in 18 liter of water was sprayed twice on 40<sup>th</sup> and 55<sup>th</sup> days after sowing to control the insect pest. Bird scaring was attended from milky stage to till harvest of the crop.

### **3.3.8 Detasseling**

The removal of tassels in female parent (SKV-50) was done before anthesis. The process of detasseling was continued for 8-10 days.

### **3.3.9 Harvesting**

The crop was harvested on 110 DAS. Cobs were removed from the plants and sun dried satisfactorily to bring down the moisture.

## **3.4 Details of the collection**

All the growth and yield observations were collected from the central rows of the plot area reserved for sampling after eliminating the border rows.

### **3.4.1 Biometrical observations**

#### **3.4.1.1 Plant height (cm)**

The plant height was recorded at 30, 60, and 90 days after sowing on the randomly tagged five plants in each treatment. It was measured from the ground level to base of fully opened leaf of the plant by using metric scale and average expressed in centimeter for each treatment and replication.

#### **3.4.1.2 Number leaves per plant**

The number of green leaves per plant at 30, 60, and 90 DAS in each plot was counted manually on earlier tagged five plants. The average was computed and expressed as number of leaves per plant.

#### **3.4.1.3 Number of days taken for 50 per cent tasseling**

Number of days taken for 50 per cent tasseling from the date of sowing was recorded based on the emergence of tassel in 50 per cent of the plants of pollen parent (MAI-105) in each plot and expressed in days.

#### **3.4.1.4 Number of days taken for 50 per cent silking**

Number of days taken for 50 per cent silking from the date of sowing was recorded based on the appearance of silks in 50 per cent of the plants of seed parent (SKV-50) in each plot and expressed in days.

### **3.4.2 Observations on yield components**

#### **3.4.2.1 Cob length (cm)**

The length of cob was measured from the base to tip by using scale and mean of ten cobs was expressed in cm.

#### **3.4.2.2 Cob diameter (cm)**

Cob diameter was recorded by using slide calipers and mean of ten cobs was expressed in cm.

#### **3.4.2.3 Cob weight (g)**

The weight of the individual cob after drying to uniform moisture content (13%) was recorded and the mean of ten cobs was expressed in grams per cob.

#### **3.4.2.4 Number of rows per cob**

The number of rows per cob was counted from each of ten cobs and average was expressed as number of rows per cob.

#### **3.4.2.5 Seed weight per cob (g)**

After shelling ten cobs, the seed was cleaned and reduced to 12 percent moisture content and weighed individually and the average of ten cobs was expressed in grams.

#### **3.4.2.6 Pith weight (g)**

Weight of rind alone obtained from each cob was expressed in grams.

#### **3.4.2.7 100 seed weight (g)**

The 100 seed weight was recorded in eight replications from each treatment as per the procedure given by ISAT (Anon., 1993). The average weight was recorded in grams.

#### **3.4.2.8 Seed yield (g/plant<sup>-1</sup>)**

The seed after hand shelling weighed from each plant and expressed as seed yield gram per plant.

#### **3.4.2.9 Seed yield (kg plot<sup>-1</sup>)**

The seed after hand shelling was weighed from each treatment and replication and was expressed as seed yield kg per plot.

#### **3.4.2.10 Seed yield (kg/ha<sup>-1</sup>)**

The total seed yield per hectare was computed from net plot seed yield and expressed in kg per hectare.

### **3.5.3 Observations on seed quality parameters**

#### **3.5.3.1 Germination percentage**

One hundred seeds of four replicates were drawn at random from each treatment and the germination test was conducted using between paper (BP) methods as per ISTA (2010). The rolled towels were incubated in germination chamber maintained at  $25 \pm 1^{\circ}\text{C}$  and 90 per cent relative humidity. The germinated seedlings were evaluated on seventh day at final count and percentage germination was expressed based on normal seedlings.

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds put for germination}} \times 100$$

#### **3.5.3.2 Root length and shoot length (cm)**

Ten normal seedlings were selected at random from each treatment. The root length was measured from point of attachment of seed to the tip of the longest root and shoot was measured from the point of attachment of seed to the growing meristmatic tip and expressed in cm.

### **3.5.3.3 Mean seedling dry weight (g)**

Ten seedlings from each treatment and replication were used for seedling length were kept in the hot air oven at  $85 \pm 1^{\circ}\text{C}$  for 24 hours. The dry weight (mg) was recorded and expressed as mean dry weight (g/seedling).

### **3.5.3.4 Seedling vigour Index I and II**

The seedling vigour index was calculated as per the formula given by Abdul Baki and Anderson (1973).

$\text{SVI-I} = \text{Germination (\%)} \times \text{Mean seedling length (cm)}$

$\text{SVI-II} = \text{Germination (\%)} \times \text{Mean seedling dry weight (mg)}$

### **3.5.3.5 Electrical conductivity ( $\text{dSm}^{-1}$ )**

Three replications of five grams of seeds from each treatment were weighed up to two decimal places. The seeds were treated with acetone for five minutes and were washed thoroughly with distilled water. The surface sterilized seeds were soaked in 25 ml of distilled water and incubated for 24 hours. Then the steeped water from the soaked seeds were collected and electrical conductivity of the leachate was measured in the digital conductivity meter model. After subtracting the EC of the distilled water from the value obtained from the seed leachate, the actual EC due (the leachate) to electrolyte was measured and expressed in  $\text{ms/ppm}$  at  $25 \pm 1^{\circ}\text{C}$  temperature.

### **3.5.3.6 TDH activity**

Twenty seeds from each treatment were preconditioned by soaking in water for 24 hours. Then ten pre imbibed seeds were randomly selected in each sample, seed was cut longitudinally and soaked in 2ml of 0.5 per cent Tetrazolium solution. They were incubated at  $25.1^{\circ}\text{C}$  in dark for 6hours and then washed thoroughly with distilled water. The

red colour (Formazan) developed was eluted from the stained embryos by soaking in 5ml of 2 Methoxy ethanol in a screw capped vials until all the seeds discoloured. The extract was decanted and the colour intensity was measured in Spectrometer (model SL171) at 480nm with suitable blank. The TDH was expressed in terms of OD value (Perl *et al.*, 1978).

#### **3.5.3.7 Seed health (%)**

Detection and identification of seed mycoflora was done by blotter paper method (TP) as per ISTA procedures (Anon., 2010). Twenty five seeds each from four replications were placed equidistantly in sterile glass petridishes of 15 cm diameter containing 2 moist blotter paper (Whatman No. 1). Then the petridishes were incubated at 20°C for seven days with 12 hours light and 12 hours dark cycles. After incubation, seeds were examined under steriobinocular microscope for the presence of infection. The infected seeds are identified and expressed as percentage of total infection.

#### **3.5.3.8 Field emergence (%)**

Four hundred seeds selected randomly from each treatment were used for the field emergence studies. The seeds were sown in four replications on a well prepared raised seed bed and adequate soil moisture was maintained. Emergence count was recorded on the eighth day of sowing and emergence percentages were calculated taking into account the number of seedlings emerged out of the soil surface.

$$\text{Field emergence (\%)} = \frac{\text{Number of seedling emergence at 7}^{\text{th}} \text{ day}}{\text{Total number of seeds sown}} \times 100$$

### **3.6 Statistical analysis**

The data were statistically analyzed as per the method outlined by Sundararaj *et al.* (1972) by adopting the analysis of variance technique appropriate to the level of treatments. Critical differences were calculated at 5 per cent level, where 'F' test was significant.

# *Experimental Results*

## IV. EXPERIMENTAL RESULTS

The field experiment entitled “Innovative practices to enhance seed yield and quality of single cross maize hybrid NAH-2049 (Nithyashree)” was conducted during *kharif*, 2011 at National Seed Project and laboratory experiment carried out at Department of Seed Science and Technology, University of Agricultural Sciences, GKVK, Bengaluru-65. The results of field and laboratory experiment have been presented in detail.

### 4.1 Studies on the plant density and mother plant nutrition on growth, seed yield and quality of maize hybrid NAH- 2049 (Nithyashree)

#### 4.1.1 Growth parameters

##### 4.1.1.1 Plant height (cm)

The results on the plant height as influenced by the fertilizer levels, spacing and interactions on parents of NAH-2049 (Nithyashree) *viz.*, SKV-50 and MAI-105 are presented in (Table 4.1 to 4.4).

##### 4.1.1.1.1 Plant height (cm) at 30, 60 and 90 DAS on female parent (SKV-50)

Data on plant height of female parent (SKV-50) as influenced by fertilizer levels, spacing and interactions are presented in (Table 4.1 and 4.2).

**a) Fertilizer levels:** Significant differences were noticed in the plant height at 30 DAS among the application of fertilizer levels (Table 4.1). T<sub>9</sub> recorded higher plant height of 36.17 cm followed by T<sub>8</sub> (34.37 cm), T<sub>6</sub> (33.37 cm), T<sub>3</sub> (33.30 cm), T<sub>7</sub> (30.87 cm), T<sub>4</sub> (30.63 cm), T<sub>2</sub> (30.07 cm), T<sub>5</sub> (30.00 cm) and T<sub>1</sub> (28.65 cm).

**Table 4.1: Effect of fertilizer levels and spacings on plant height (cm) at 30, 60 and 90 days after sowing in female parent (SKV-50) of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	28.65	93.13	114.32
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	30.07	101.30	123.50
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	33.30	111.70	127.87
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	30.63	104.43	124.33
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	30.00	118.40	130.87
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	33.37	121.97	132.87
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	30.87	122.92	134.00
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	34.37	124.18	134.77
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	36.17	127.72	134.90
<b>F test</b>	*	*	*
<b>S.Em ±</b>	<b>1.086</b>	<b>3.071</b>	<b>1.394</b>
<b>CD @ 5%</b>	<b>3.120</b>	<b>8.825</b>	<b>4.005</b>
<b>Spacing (S)</b>			
<b>S<sub>1</sub>: 75 X 30 cm</b>	33.66	115.41	130.45
<b>S<sub>2</sub>: 60 X 30 cm</b>	30.21	112.53	126.76
<b>F test</b>	*	NS	*
<b>S.Em ±</b>	<b>0.512</b>	-	<b>0.657</b>
<b>CD @ 5%</b>	<b>1.471</b>	-	<b>1.888</b>

Significant difference was observed in the plant height at 60 DAS among the fertilizer levels, T<sub>9</sub> recorded higher plant height 127.72 cm followed by T<sub>8</sub> (124.18 cm), T<sub>7</sub> (122.92 cm), T<sub>6</sub> (121.97 cm), T<sub>5</sub> (118.40 cm), T<sub>3</sub> (111.70 cm), T<sub>4</sub> (104.43 cm), T<sub>2</sub> (101.30 cm), and T<sub>1</sub> (93.13 cm).

Significant difference were recorded in the plant height at 90 DAS among the fertilizer levels, T<sub>9</sub> recorded higher plant height 134.90 cm followed by T<sub>8</sub> (134.77 cm), T<sub>7</sub> (134.00 cm), T<sub>6</sub> (132.87 cm), T<sub>5</sub> (130.87 cm), T<sub>3</sub> (127.87 cm), T<sub>4</sub> (124.33 cm), T<sub>2</sub> (123.50 cm), and T<sub>1</sub> (114.32 cm).

**b) Spacing:** Significant difference were noticed in the plant height at 30 DAS in both the spacing's, S<sub>1</sub> has recorded plant height of 33.66 cm compare to S<sub>2</sub> with 30.21 cm are presented in Table 4.1.

Non significant results were recorded for plant height in female parent (SKV-50) due to spacing at 60 DAS. Whereas, S<sub>1</sub> has recorded plant height of 115.41 cm compare to S<sub>2</sub> with 112.53 cm.

Significant differences were noticed in the plant height at 90 DAS in both the spacing's, S<sub>1</sub> has recorded plant height of 130.45 cm compare to S<sub>2</sub> with 126.76 cm.

**c) Fertilizer levels x spacing:** Plant height differed non-significantly due to interaction of Fertilizer levels X Spacing (T X S) at 30, 60 and 90 DAS in female (SKV-50) parent are presented in Table 4.2.

#### **4.1.1.1.2 Plant height (cm) at 30, 60 and 90 DAS on male parent (MAI-105)**

Data on plant height of male parent (MAI-105) as influenced by fertilizer levels, spacing and interactions are presented in (Table 4.3 and 4.4).

**Table 4.2: Plant height (cm) of female parent (SKV-50) as influenced by the interaction of fertilizer levels and spacings at 30, 60 and 90 days after sowing on hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Plant height (cm)					
	30 DAS		60 DAS		90 DAS	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	30.47	26.83	94.27	92.00	120.27	108.37
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	32.47	27.67	103.60	99.00	125.87	121.13
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	34.93	31.67	116.27	107.13	128.40	126.27
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	33.07	28.20	104.27	104.60	126.07	123.67
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>- spray (2%) + Boron spray (1%)</b>	31.53	28.47	119.13	117.67	133.67	128.07
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	35.00	31.73	122.70	121.23	133.43	132.30
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> + PSB+VAM + Boron spray (1%)</b>	32.67	29.07	122.20	123.63	135.00	133.00
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	35.00	33.73	127.57	120.80	135.87	133.67
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	37.80	34.53	128.73	126.70	135.47	134.33
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>S.Em ±</b>	-	-	-	-	-	-
<b>CD @ 5%</b>	-	-	-	-	-	-

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

**a) Fertilizer levels:** Significant differences were noticed in the plant height at 30 DAS among the fertilizer levels (Table 4.3). T<sub>9</sub> recorded higher plant height 44.27 cm followed by T<sub>8</sub> (41.13 cm), T<sub>6</sub> (40.23 cm), T<sub>7</sub> (38.97 cm), T<sub>3</sub> (38.60 cm), T<sub>5</sub> (38.20 cm), T<sub>4</sub> (35.13 cm), T<sub>2</sub> (35.03 cm), and T<sub>1</sub> (33.10 cm).

Significant differences were observed in the plant height at 60 DAS among the fertilizer levels, T<sub>9</sub> recorded higher plant height 140.40 cm followed by T<sub>7</sub> (138.50 cm), T<sub>8</sub> (138.42 cm), T<sub>6</sub> (135.40 cm), T<sub>5</sub> (133.17 cm), T<sub>3</sub> (128.47 cm), T<sub>4</sub> (117.57 cm), T<sub>2</sub> (109.93 cm), and T<sub>1</sub> (102.97 cm).

Significant differences were recorded in the plant height at 90 DAS among the fertilizer levels, T<sub>9</sub> recorded higher plant height 152.80 cm followed by T<sub>8</sub> (150.53 cm), T<sub>7</sub> (147.67 cm), T<sub>6</sub> (147.13 cm), T<sub>5</sub> (144.88 cm), T<sub>3</sub> (138.07 cm), T<sub>4</sub> (135.80 cm), T<sub>2</sub> (135.48 cm), and T<sub>1</sub> (129.45 cm).

**b) Spacing:** Significant differences were noticed in the plant height at 30 DAS in both the spacing's, S<sub>1</sub> has recorded plant height of 39.70 cm compare to S<sub>2</sub> with 36.90 cm are presented in Table 4.3.

Non significant results were recorded for plant height in male parent (MAI-105) due to spacing at 60 DAS. Whereas, S<sub>1</sub> has recorded plant height of 128.42 cm compare to S<sub>2</sub> with 125.99 cm.

Significant differences were noticed in the plant height at 90 DAS in both the spacing's, S<sub>1</sub> has recorded plant height of 145.12 cm compare to S<sub>2</sub> with 139.73 cm.

**c) Fertilizer levels X Spacing:** Plant height differed non-significantly due to interaction of fertilizer levels and spacing at 30, 60 and 90 DAS in male (MAI-105) parent are presented in Table 4.4.

**Table 4.3: Effect of fertilizer levels and spacings on plant height (cm) at 30, 60 and 90 days after sowing in male parent (MAI-105) of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
<b>T<sub>1</sub> :RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	33.10	102.97	129.45
<b>T<sub>2</sub>:(187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	35.03	109.93	135.48
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	38.60	128.47	138.07
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	35.13	117.57	135.80
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub>@ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	38.20	133.17	144.88
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	40.23	135.40	147.13
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	38.97	138.50	147.67
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	41.13	138.42	150.53
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	44.27	140.40	152.80
<b>F test</b>	*	*	*
<b>S.Em ±</b>	<b>1.24</b>	<b>2.56</b>	<b>2.37</b>
<b>CD @ 5%</b>	<b>3.58</b>	<b>7.36</b>	<b>6.82</b>
<b>Spacing (S)</b>			
<b>S<sub>1</sub>: 75 X 30 cm</b>	39.70	128.42	145.12
<b>S<sub>2</sub>: 60 X 30 cm</b>	36.90	125.99	139.73
<b>F test</b>	*	NS	*
<b>S.Em ±</b>	<b>0.59</b>	-	<b>1.11</b>
<b>CD @ 5%</b>	<b>1.69</b>	-	<b>3.215</b>

**Table 4.4: Plant height (cm) of male parent (MAI-105) as influenced by the interaction of fertilizer levels and spacings at 30, 60 and 90 days after sowing on hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Plant height (cm)					
	30 DAS		60 DAS		90 DAS	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> :RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	32.60	33.60	104.93	101.00	134.77	124.13
<b>T<sub>2</sub>:(187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	34.53	35.53	111.73	108.13	136.17	134.80
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	39.33	37.87	118.73	127.87	137.40	138.73
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>spray (2%)</b>	37.13	33.13	135.60	116.40	136.47	135.13
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub>@ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>-spray (2%) + Boron spray (1%)</b>	41.67	34.73	129.07	130.73	147.97	141.80
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	41.27	39.20	136.27	134.53	150.60	143.67
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	40.67	37.27	139.47	137.53	151.33	144.00
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	43.67	38.60	139.10	137.73	155.20	145.87
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	46.40	42.13	140.87	139.93	156.20	149.40
<b>F test</b>	NS	NS	NS	NS	NS	NS
<b>S.Em ±</b>	-	-	-	-	-	-
<b>CD @ 5%</b>	-	-	-	-	-	-

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

#### 4.1.1.2 Number of leaves per plant

The data on the number of leaves per plant as influenced by the fertilizer levels, spacing and interactions on parents of NAH-2049 (Nithyashree) viz., SKV-50 and MAI-105 are presented in (Table 4.5 to 4.8).

##### 4.1.1.2.1 Number of leaves per plant at 30, 60 and 90 DAS on female parent (SKV-50)

**a) Fertilizer levels:** Non significant results were recorded with number of leaves per plant in female (SKV-50) parent due to application of fertilizers at 30 DAS (Table 4.5). However, T<sub>9</sub> recorded higher number of leaves per plant in female parent (5.20) and T<sub>1</sub> has recorded lower number of leaves per plant in female parent (4.43).

Significant difference were observed in the number of leaves per plant at 60 DAS among the fertilizer levels, T<sub>9</sub> recorded higher number of leaves per plant 10.07 followed by T<sub>8</sub> (9.53), T<sub>6</sub> (9.43), T<sub>7</sub> (9.33), T<sub>5</sub> (9.23), T<sub>4</sub> (8.97), T<sub>3</sub> (8.70), T<sub>2</sub> (8.52), and T<sub>1</sub> (8.17).

Non significant results were recorded with number of leaves per plant in female (SKV-50) parent due to application of fertilizers at 90 DAS. However, T<sub>9</sub> recorded higher number of leaves per plant in female parent (11.98) and T<sub>1</sub> has recorded lower number of leaves per plant in female parent (10.77).

**b) Spacing:** Significant differences were noticed in the number of leaves per plant at 30 DAS in both the spacing's, S<sub>1</sub> has recorded number of leaves per plant of 5.04 compare to S<sub>2</sub> with 4.61 are presented in Table 4.5.

**Table 4.5: Effect of fertilizer levels and spacings on number of leaves per plant at 30, 60 and 90 days after sowing in female parent (SKV-50) of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Number of leaves per plant		
	30 DAS	60 DAS	90 DAS
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	4.43	8.17	10.77
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	4.70	8.52	10.88
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	4.80	8.70	11.10
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	4.77	8.97	11.30
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	5.00	9.23	11.32
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	4.53	9.43	11.40
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	4.93	9.33	11.58
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	5.10	9.53	11.63
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	5.20	10.07	11.98
<b>F test</b>	<b>NS</b>	<b>*</b>	<b>NS</b>
<b>S.Em ±</b>	<b>-</b>	<b>0.30</b>	<b>-</b>
<b>CD @ 5%</b>	<b>-</b>	<b>0.87</b>	<b>-</b>
<b>Spacing (S)</b>			
<b>S<sub>1</sub>: 75 X 30 cm</b>	5.04	9.31	11.42
<b>S<sub>2</sub>: 60 X 30 cm</b>	4.61	8.90	11.24
<b>F test</b>	<b>*</b>	<b>*</b>	<b>NS</b>
<b>S.Em ±</b>	<b>0.09</b>	<b>0.143</b>	<b>-</b>
<b>CD @ 5%</b>	<b>0.25</b>	<b>0.410</b>	<b>-</b>

Significant differences were noticed in the number of leaves per plant at 60 DAS in both the spacing's, S<sub>1</sub> has recorded number of leaves per plant of 9.31 compare to S<sub>2</sub> with 8.90.

Non significant results were recorded for number of leaves per plant in female parent (SKV-50) due to spacing at 90 DAS. Whereas, S<sub>1</sub> has recorded number of leaves per plant of 11.42 compared to S<sub>2</sub> with 11.24.

**c) Fertilizer levels x spacing:** There was no significant differences in number of leaves per plant due to interaction of T X S at 30, 60 and 90 DAS in female (SKV-50) parent are presented in Table 4.6.

#### **4.1.1.2.2 Number of leaves per plant at 30, 60 and 90 DAS on male parent (MAI-105)**

**a) Fertilizer levels:** Non significant results were observed with number of leaves per plant in male parent (MAI-105) parent due to application of fertilizers at 30 DAS (Table 4.7). However, T<sub>9</sub> recorded higher number of leaves per plant in female parent (5.37) and T<sub>1</sub> has recorded lower number of leaves per plant in female parent (4.77).

Significant difference were noticed in the number of leaves per plant at 60 DAS among the fertilizer levels, T<sub>9</sub> recorded higher number of leaves per plant 11.73 followed by T<sub>8</sub> (11.57), T<sub>7</sub> (11.20), T<sub>6</sub> (11.13), T<sub>5</sub> (11.13), T<sub>4</sub> (10.77), T<sub>3</sub> (10.63), T<sub>2</sub> (10.30), and T<sub>1</sub> (9.30).

Significant difference were recorded in the number of leaves per plant at 90 DAS among the fertilizer levels, T<sub>9</sub> recorded higher number of leaves per plant 12.85 followed by T<sub>8</sub> (12.70), T<sub>6</sub> (12.53), T<sub>5</sub> (12.47), T<sub>7</sub> (12.13), T<sub>3</sub> (11.90), T<sub>4</sub> (11.37), T<sub>2</sub> (11.33), and T<sub>1</sub> (10.23).

**Table 4.6: Number of leaves per plant of female parent (SKV-50) as influenced by the interaction of fertilizer levels and spacings at 30, 60 and 90 DAS on hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Number of leaves per plant					
	30 DAS		60 DAS		90 DAS	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	4.53	4.33	8.33	8.00	10.93	10.60
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	5.07	4.33	8.93	8.10	11.10	10.67
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	5.07	4.53	8.93	8.47	11.20	11.00
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	5.07	4.47	9.13	8.80	11.33	11.27
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub>@ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	5.07	4.93	9.40	9.07	11.43	11.20
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	4.40	4.67	9.53	9.33	11.47	11.33
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	4.87	5.00	9.67	9.00	11.63	11.53
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	5.80	4.40	9.67	9.40	11.67	11.60
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	5.53	4.87	10.20	9.93	12.00	11.97
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>S.Em±</b>	-	-	-	-	-	-
<b>CD @ 5%</b>	-	-	-	-	-	-

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

**Table 4.7: Effect of fertilizer levels and spacings on number of leaves per plant at 30, 60 and 90 days after sowing in male parent (MAI-105) of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Number of leaves per plant		
	30 DAS	60 DAS	90 DAS
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	4.77	9.30	10.23
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	4.97	10.30	11.33
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	4.87	10.63	11.90
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	4.93	10.77	11.37
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub>@ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	5.27	11.13	12.47
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	5.03	11.13	12.53
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	5.13	11.20	12.13
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	5.18	11.57	12.70
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	5.37	11.73	12.85
<b>F test</b>	<b>NS</b>	<b>*</b>	<b>*</b>
<b>S.Em ±</b>	-	<b>0.328</b>	<b>0.322</b>
<b>CD @ 5%</b>	-	<b>0.943</b>	<b>0.924</b>
<b>Spacing (S)</b>			
<b>S<sub>1</sub>: 75 X 30 cm</b>	5.12	11.08	12.25
<b>S<sub>2</sub>: 60 X 30 cm</b>	5.00	10.64	11.67
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>*</b>
<b>S.Em ±</b>	-	-	<b>0.152</b>
<b>CD @ 5%</b>	-	-	<b>0.436</b>

**b) Spacing:** Non significant results were observed on number of leaves per plant in male parent (MAI-105) due to spacing at 30 DAS. Whereas, S<sub>1</sub> has recorded number of leaves per plant of 5.12 compare to S<sub>2</sub> with 5.00 are presented in Table 4.7.

Non significant results were recorded for number of leaves per plant in male parent (MAI-105) due to spacing at 60 DAS. Whereas, S<sub>1</sub> has recorded number of leaves per plant of 11.08 compare to S<sub>2</sub> with 10.64.

Significant differences were noticed in the number of leaves per plant at 90 DAS in both the spacing's, S<sub>1</sub> has recorded number of leaves per plant of 12.25 compare to S<sub>2</sub> with 11.67.

**c) Fertilizer levels X Spacing:** Number of leaves did not differed significantly due to interaction of T X S in male (MAI-105) parent at 30 and 60 DAS. Whereas, in Male (MAI-105) parent at 90 DAS number of leaves per plant differed significantly due to interaction of T X S, T<sub>9</sub>S<sub>1</sub> has recorded 13.30, T<sub>8</sub>S<sub>1</sub> (13.20), T<sub>7</sub>S<sub>1</sub> (12.73), T<sub>5</sub>S<sub>1</sub> (12.53), T<sub>6</sub>S<sub>1</sub> (12.40) and T<sub>4</sub>S<sub>1</sub> (12.33) followed by lowest with T<sub>2</sub>S<sub>1</sub> (11.73), T<sub>3</sub>S<sub>1</sub> (11.07) and T<sub>1</sub>S<sub>1</sub> (10.93). Similarly S<sub>2</sub> also noticed T<sub>9</sub>S<sub>2</sub> (12.40), T<sub>5</sub>S<sub>2</sub> (12.40) T<sub>3</sub>S<sub>2</sub> (12.73), T<sub>6</sub>S<sub>2</sub> (12.67) and T<sub>8</sub>S<sub>2</sub> (12.20) followed by the lowest with T<sub>7</sub>S<sub>2</sub> (11.53), T<sub>2</sub>S<sub>2</sub> (10.93), T<sub>4</sub>S<sub>2</sub> (10.40) and T<sub>1</sub>S<sub>2</sub> (9.53). The results are presented in Table 4.8.

#### **4.1.1.3 Number of days taken to 50 per cent tasseling in pollen parent (MAI-105)**

**a) Fertilizer levels:** Significant differences were observed in the number of days taken for 50 per cent tasseling in male (MAI-105) parent among the fertilizer levels (Table 4.9). T<sub>9</sub> tasselled early with 46.83 days followed by T<sub>8</sub> (48.50 days), T<sub>3</sub> (48.67 days), T<sub>6</sub> (49.17 days), T<sub>7</sub> (51.33

**Table 4.8: Number of leaves per plant of male parent (MAI-105) as influenced by the interaction of fertilizer levels and spacings at 30, 60 and 90 days after sowing on hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Number of leaves per plant					
	30 DAS		60 DAS		90 DAS	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	4.87	4.67	9.47	9.13	10.93	9.53
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	4.73	5.20	10.40	10.20	11.73	10.93
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	4.87	4.87	10.73	10.53	11.07	12.73
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	5.07	4.80	11.33	10.20	12.33	10.40
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub>@ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	5.27	5.27	11.27	11.00	12.53	12.40
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	5.07	5.00	11.40	10.87	12.40	12.67
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	5.27	5.00	11.60	10.80	12.73	11.53
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	5.40	4.97	11.67	11.47	13.20	12.20
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	5.53	5.20	11.87	11.60	13.30	12.40
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>*</b>	<b>*</b>
<b>S.Em±</b>	-	-	-	-	<b>0.455</b>	<b>0.455</b>
<b>CD 5%</b>	-	-	-	-	<b>1.307</b>	<b>1.307</b>

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

days), T<sub>5</sub> (52.33 days), T<sub>4</sub> (53.83 days), T<sub>2</sub> (53.83 days) and T<sub>1</sub> (56.50 days).

**b) Spacing:** Significant differences were observed in the number of days taken for 50 per cent tasseling in male (MAI-105) parent in both the spacing's. S<sub>1</sub> flowered earlier (50.74 days) than S<sub>2</sub> (51.70 days).

**c) Fertilizer levels X Spacing:** T X S interaction was significantly differed in number of days taken to 50 per cent tasseling in pollen parent (MAI-105). T<sub>9</sub>S<sub>1</sub> has recorded early flowering with 45.33 days, T<sub>6</sub>S<sub>1</sub> (47.67 days), T<sub>3</sub>S<sub>1</sub> (48.00 days), T<sub>8</sub>S<sub>1</sub> (49.00 days) and T<sub>7</sub> S<sub>1</sub> (50.67 days) followed by highest with T<sub>5</sub>S<sub>1</sub> (52 days), T<sub>4</sub>S<sub>1</sub> (53.33 days), T<sub>2</sub> S<sub>1</sub> (53.67 days) and T<sub>1</sub>S<sub>1</sub> (57 days). Similarly, S<sub>2</sub> also noticed T<sub>8</sub>S<sub>2</sub> (48 days), T<sub>9</sub>S<sub>2</sub> (48.33 days), T<sub>3</sub>S<sub>2</sub> (49.33 days), T<sub>6</sub>S<sub>2</sub> (50.67 days), T<sub>7</sub>S<sub>2</sub> (52 days) and T<sub>5</sub>S<sub>2</sub> (52.67 days) followed by the highest with T<sub>2</sub>S<sub>2</sub> (54 days), T<sub>4</sub>S<sub>2</sub> (54.33) and T<sub>1</sub>S<sub>2</sub> (56 days). The results are presented in Table 4.10.

#### **4.1.1.4 Number of days taken to 50 per cent silking in seed parent (SKV-50)**

**a) Fertilizer levels:** Significant differences were observed in the number of days taken for 50 per cent silking in female (MAI-105) parent (Table 4.9), among the fertilizer levels. T<sub>9</sub> silking early with 51.00 days followed by T<sub>8</sub> (55 days), T<sub>3</sub> (57.50 days), T<sub>6</sub> (58 days), T<sub>7</sub> (58.50 days), T<sub>5</sub> (63 days), T<sub>2</sub> (63.67 days), T<sub>4</sub> (64.17 days) and T<sub>1</sub> (68 days).

**b) Spacing:** Significant differences were observed in the number of days taken for 50 per cent silking in female (MAI-105) parent in both the spacing's. S<sub>1</sub> flowered earlier (55.15 days) than S<sub>2</sub> (64.59 days).

**Table 4.9: Effect of fertilizer levels and spacings on days to 50 per cent tasseling in male parent (MAI-105) and days to 50 per cent silking in female parent (SKV-50) in hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Days to 50% tasseling (MAI-105)</b>	<b>Days to 50% silking (SKV-50)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	56.50	68.00
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	53.83	63.67
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	48.67	57.50
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	53.83	64.17
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	52.33	63.00
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	49.17	58.00
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	51.33	58.50
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	48.50	55.00
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	46.83	51.00
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.466</b>	<b>1.019</b>
<b>CD @ 5%</b>	<b>1.338</b>	<b>2.928</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	50.74	55.15
<b>S<sub>2</sub>: 60 X 30 cm</b>	51.70	64.59
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.219</b>	<b>0.480</b>
<b>CD @ 5%</b>	<b>0.631</b>	<b>1.380</b>

**Table 4.10: Days to 50 per cent tasseling in male parent (MAI-105) and Days to 50 per cent silking in female parent (SKV-50) as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Days to 50% tasseling (MAI-105)		Days to 50% silking (SKV-50)	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
	<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	57.00	56.00	67.67
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	53.67	54.00	60.00	67.33
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	48.00	49.33	50.00	65.00
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	53.33	54.33	60.67	67.67
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	52.00	52.67	59.67	66.33
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	47.67	50.67	50.00	66.00
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	50.67	52.00	53.00	64.00
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	49.00	48.00	48.67	61.33
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	45.33	48.33	46.67	55.33
<b>F test</b>	*	*	*	*
<b>S.Em ±</b>	<b>0.658</b>	<b>0.658</b>	<b>1.441</b>	<b>1.441</b>
<b>CD @ 5%</b>	<b>1.892</b>	<b>1.892</b>	<b>4.140</b>	<b>4.140</b>

S = Spacing

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

**c) Fertilizer levels X Spacing:** T X S interaction was significant in number of days to 50 per cent silking in seed parent (SKV-50). T<sub>9</sub>S<sub>1</sub> has recorded early flowering with 46.67 days, T<sub>8</sub>S<sub>1</sub> (48.67 days) T<sub>6</sub>S<sub>1</sub> (50 days), T<sub>3</sub>S<sub>1</sub> (50 days), and T<sub>7</sub>S<sub>1</sub> (53 days) followed by highest with T<sub>5</sub>S<sub>1</sub> (59.67 days), T<sub>2</sub>S<sub>1</sub> (60 days), T<sub>4</sub>S<sub>1</sub> (60.67 days) and T<sub>1</sub>S<sub>1</sub> (67.67 days). Similarly S<sub>2</sub> also noticed early flowering with T<sub>9</sub>S<sub>2</sub> (55.33 days), T<sub>8</sub>S<sub>2</sub> (61.33 days), T<sub>7</sub>S<sub>2</sub> (64 days), T<sub>3</sub>S<sub>2</sub> (65 days), T<sub>6</sub>S<sub>2</sub> (66 days), and T<sub>5</sub>S<sub>2</sub> (66.33 days) followed by the highest with T<sub>2</sub>S<sub>2</sub> (67.33 days), T<sub>4</sub>S<sub>2</sub> (67.67) and T<sub>1</sub>S<sub>2</sub> (68.33 days). The results are presented in Table 4.10.

#### 4.1.2 Yield parameters

##### 4.1.2.1 Number of cobs per plant

**a) Fertilizer levels:** significant differences were observed in the number of cobs per plant (Table 4.11). Among the fertilizer levels, T<sub>9</sub> recorded higher number of cobs per plant with 2.10 followed by T<sub>8</sub> (2.00), T<sub>6</sub> (1.53), T<sub>7</sub> (1.43), T<sub>5</sub> (1.30), T<sub>3</sub> (1.27), T<sub>4</sub> (1.13), T<sub>2</sub> (1.17) and T<sub>1</sub> (1.03).

**b) Spacing:** Non significant results were recorded for number of cobs per plant due to spacing. Whereas, S<sub>1</sub> has recorded number of cobs per plant of 1.51 compare to S<sub>2</sub> with 1.37.

**c) Fertilizer levels X Spacing:** number of cobs per plant differed non-significantly due to interaction of T X S. The results are presented in Table 4.12.

##### 4.1.2.2 Cob length (cm)

**a) Fertilizer levels:** significant differences were observed in the Cob length (cm) among the fertilizer levels (Table 4.13). T<sub>9</sub> recorded higher Cob length with 14.74 cm followed by T<sub>8</sub> (14.66 cm), T<sub>3</sub> (13.15 cm), T<sub>7</sub> (13.13 cm), T<sub>4</sub> (12.94 cm), T<sub>6</sub> (12.90 cm), T<sub>5</sub> (12.79 cm), T<sub>2</sub> (11.68 cm), and T<sub>1</sub> (10.95 cm).

**Table 4.11: Effect of fertilizer levels and spacings on number of cobs plant<sup>-1</sup> of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Number of cobs plant<sup>-1</sup></b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	1.03
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	1.17
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	1.27
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	1.13
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> . spray (2%) + Boron spray (1%)</b>	1.30
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	1.53
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	1.43
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	2.00
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	2.10
<b>F test</b>	*
<b>S.Em ±</b>	<b>0.154</b>
<b>CD @ 5%</b>	<b>0.441</b>
<b>Spacing (S)</b>	
<b>S<sub>1</sub>: 75 X 30 cm</b>	1.51
<b>S<sub>2</sub>: 60 X 30 cm</b>	1.37
<b>F test</b>	NS
<b>S.Em ±</b>	-
<b>CD @ 5%</b>	-

**Table 4.12: Number of cobs plant<sup>-1</sup> as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Number of cobs plant <sup>-1</sup>	
	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	1.07	1.00
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	1.27	1.07
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	1.33	1.20
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	1.07	1.20
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> . spray (2%) + Boron spray (1%)</b>	1.33	1.27
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	1.73	1.33
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	1.53	1.33
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	2.07	1.93
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	2.20	2.00
<b>F test</b>	<b>NS</b>	<b>NS</b>
<b>S.Em ±</b>	-	-
<b>CD @ 5%</b>	-	-

S = Spacing    S<sub>1</sub>=75 X 30 cm    S<sub>2</sub>= 60 X 30 cm

**b) Spacing:** Significant differences were observed in Cob length (cm) in both the spacing's. S<sub>1</sub> noticed higher Cob length (14.12 cm) than S<sub>2</sub> (11.87 cm).

**c) Fertilizer levels X Spacing:** Cob length differed non-significantly due to interaction of T X S presented in Table 4.14.

#### 4.1.2.3 Cob diameter (cm)

**a) Fertilizer levels:** significant differences were observed in the Cob diameter (cm) among the fertilizer levels (Table 4.13), T<sub>9</sub> recorded higher Cob diameter with 12.16 cm followed by T<sub>6</sub> (11.84 cm), T<sub>8</sub> (11.56 cm), T<sub>5</sub> (11.37 cm), T<sub>3</sub> (11.22 cm), T<sub>7</sub> (10.95 cm), T<sub>4</sub> (10.94 cm), T<sub>2</sub> (10.81 cm) and T<sub>1</sub> (9.70 cm),

**b) Spacing:** Significant differences were observed in Cob diameter (cm) in both the spacing's. S<sub>1</sub> noticed higher Cob diameter (11.68 cm) than S<sub>2</sub> (10.670 cm).

**c) Fertilizer levels X Spacing:** Cob diameter (cm) differed non-significantly due to interaction of T X S. The results are presented in Table 4.14.

#### 4.1.2.4 Cob weight (g)

**a) Fertilizer levels:** significant differences were observed in the Cob weight (g) among the fertilizer levels (Table 4.15). T<sub>9</sub> recorded higher cob weight 135.40 g followed by T<sub>8</sub> (129.35 g), T<sub>6</sub> (125.60 g), T<sub>3</sub> (124.50 g), T<sub>7</sub> (119.63 g), T<sub>4</sub> (115.70 g), T<sub>5</sub> (115.47 g), T<sub>2</sub> (109.77 g) and T<sub>1</sub> (101.50 g).

**b) Spacing:** Significant differences were observed in Cob weight (g) in both the spacing's. S<sub>1</sub> noticed higher Cob weight (124.44 g) than S<sub>2</sub> (114.87 g).

**Table 4.13: Effect of fertilizer levels and spacings on Cob length (cm) and Cob diameter (cm) of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Cob length (cm)</b>	<b>Cob diameter (cm)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	10.95	9.70
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	11.68	10.81
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	13.15	11.22
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	12.94	10.94
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	12.79	11.37
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	12.90	11.84
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	13.13	10.95
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	14.66	11.56
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	14.74	12.16
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.391</b>	<b>0.338</b>
<b>CD @ 5%</b>	<b>1.124</b>	<b>0.971</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	14.12	11.68
<b>S<sub>2</sub>: 60 X 30 cm</b>	11.87	10.67
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.184</b>	<b>0.159</b>
<b>CD @ 5%</b>	<b>0.530</b>	<b>0.458</b>

**Table 4.14: Cob length (cm) and cob diameter (cm) as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Cob length (cm)		Cob diameter (cm)	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	11.73	10.17	10.03	9.37
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	13.20	10.17	11.75	9.87
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	14.23	11.70	12.15	10.30
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>spray (2%)</b>	14.70	11.19	11.14	10.74
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	13.57	12.02	12.16	10.59
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	14.55	11.26	12.22	11.47
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	14.57	12.06	11.13	10.78
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	14.87	13.81	12.31	10.82
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	15.67	14.45	12.24	12.08
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>S.Em ±</b>	-	-	-	-
<b>CD @ 5%</b>	-	-	-	-
S = Spacing      S <sub>1</sub> =75 X 30 cm      S <sub>2</sub> = 60 X 30 cm				

**c) Fertilizer levels X Spacing:** Cob weight (g) differed non-significantly due to interaction of T X S. The results are presented in Table 4.16.

#### 4.1.2.5 Pith weight (g)

**a) Fertilizer levels:** significant differences were observed in the Cob weight (g) among the fertilizer levels (Table 4.15). T<sub>9</sub> recorded higher pith weight 32.33 g followed by T<sub>3</sub> (30.33 g), T<sub>8</sub> (28.43 g), T<sub>5</sub> (28.37 g), T<sub>7</sub> (28.00 g), T<sub>4</sub> (26.47 g), T<sub>6</sub> (25.77 g), T<sub>2</sub> (26.60 g) and T<sub>1</sub> (22.53 g).

**b) Spacing:** Significant differences were observed in Pith weight (g) in both the spacing's. S<sub>1</sub> noticed higher Pith weight (28.64 g) than S<sub>2</sub> (26.66 g).

**c) Fertilizer levels X Spacing:** T X S interaction was significantly differed with pith weight (g). T<sub>9</sub>S<sub>1</sub> has recorded with 34.27 (g), T<sub>3</sub>S<sub>1</sub> (32.33 g), T<sub>7</sub>S<sub>1</sub> (30.67 g), S<sub>1</sub>T<sub>2</sub> (29.40 g), S<sub>1</sub>T<sub>4</sub> (28.07 g) and S<sub>1</sub>T<sub>5</sub> (27.93 g), followed by lowest with S<sub>1</sub>T<sub>8</sub> (26.67 g), S<sub>1</sub>T<sub>6</sub> (25.27 g) and S<sub>1</sub>T<sub>1</sub> (23.13 g). Similarly S<sub>2</sub> also pith weight (g) with S<sub>2</sub>T<sub>9</sub> (30.40 g), S<sub>2</sub>T<sub>8</sub> (30.20 g), S<sub>2</sub>T<sub>5</sub> (28.80 g), S<sub>2</sub>T<sub>3</sub> (28.33 g) and S<sub>2</sub>T<sub>6</sub> (26.27 g) followed by the lowest with S<sub>2</sub>T<sub>7</sub> (25.33 g), S<sub>2</sub>T<sub>4</sub> (24.87 g), S<sub>2</sub>T<sub>2</sub> (23.80 g) and S<sub>2</sub>T<sub>1</sub> (21.93 g) the results are presented in Table 4.16.

#### 4.1.2.6 Number of rows per cob

**a) Fertilizer levels:** Non significant results were recorded with number of Rows per cob due to application of different fertilizers levels (Table 4.17). However, T<sub>9</sub> recorded higher number of rows per cob 10.60 and T<sub>1</sub> has recorded lower number of Rows per cob (10.13).

**b) Spacing:** Non significant results were recorded for number of rows per cob due to spacing's. Whereas, S<sub>1</sub> has recorded number of rows per cob of 10.40 compare to S<sub>2</sub> with 10.31.

**Table 4.15: Effect of fertilizer levels and spacings on Cob weight (g) and pith weight (g) of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Cob weight (g)</b>	<b>Pith weight (g)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	101.50	22.53
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	109.77	26.60
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	124.50	30.33
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	115.70	26.47
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	115.47	28.37
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	125.60	25.77
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	119.63	28.00
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	129.35	28.43
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	135.40	32.33
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>2.960</b>	<b>0.937</b>
<b>CD @ 5%</b>	<b>8.505</b>	<b>2.693</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	124.44	28.64
<b>S<sub>2</sub>: 60 X 30 cm</b>	114.87	26.66
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>1.395</b>	<b>0.442</b>
<b>CD @ 5%</b>	<b>4.009</b>	<b>1.269</b>

**Table 4.16: Cob weight (g) and pith weight (g) as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Cob weight (g)		Pith weight (g)	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	104.67	98.33	23.13	21.93
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	118.53	101.00	29.40	23.80
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	127.57	121.43	32.33	28.33
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	121.07	110.33	28.07	24.87
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	119.27	111.67	27.93	28.80
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	128.47	122.73	25.27	26.27
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	126.93	112.33	30.67	25.33
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	134.93	123.77	26.67	30.20
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	138.53	132.27	34.27	30.40
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>*</b>	<b>*</b>
<b>S.Em ±</b>	-	-	<b>1.32</b>	<b>1.32</b>
<b>CD @ 5%</b>	-	-	<b>3.80</b>	<b>3.80</b>

S = Spacing    S<sub>1</sub>=75 X 30 cm        S<sub>2</sub>= 60 X 30 cm

**c) Fertilizer levels X Spacing:** Number of rows per cob differed non-significantly due to interaction of T X S. The results are presented in Table 4.18.

#### 4.1.2.7 Number of seeds per row

**a) Fertilizer levels:** significant differences were observed in the number of seeds per row among the fertilizer levels (Table 4.17). T<sub>9</sub> recorded higher seeds per row 26.97 followed by the T<sub>4</sub> (26.40), T<sub>3</sub> (26.03), T<sub>2</sub> (25.67), T<sub>6</sub> (25.30), T<sub>8</sub> (25.07), T<sub>5</sub> (24.93), T<sub>7</sub> (24.50), and T<sub>1</sub> (21.47),

**b) Spacing:** Significant differences were observed in number of seeds per row in both the spacing's. S<sub>1</sub> noticed highest seeds per row (25.99) than S<sub>2</sub> (24.31).

**c) Fertilizer levels X Spacing:** T X S interaction was significant in number of seeds per row, T<sub>6</sub>S<sub>1</sub> has recorded with 26.53, T<sub>9</sub>S<sub>1</sub> (26.40), T<sub>8</sub>S<sub>1</sub> (26.40), T<sub>2</sub>S<sub>1</sub> (26.20), T<sub>5</sub>S<sub>1</sub> (26.13) and T<sub>4</sub>S<sub>1</sub> (26.00) and followed by lowest with T<sub>3</sub>S<sub>1</sub> (25.93), T<sub>7</sub>S<sub>1</sub> (25.33), and T<sub>1</sub>S<sub>1</sub> (24.93). Similarly S<sub>2</sub> also number of seeds per row with T<sub>9</sub>S<sub>2</sub> (27.53), T<sub>4</sub>S<sub>2</sub> (26.80), T<sub>3</sub>S<sub>2</sub> (26.13), T<sub>2</sub>S<sub>2</sub> (25.13) and T<sub>6</sub>S<sub>2</sub> (24.07) followed by the lowest with T<sub>5</sub>S<sub>2</sub> (23.73), T<sub>8</sub>S<sub>2</sub> (23.73), T<sub>7</sub>S<sub>2</sub> (23.67) and T<sub>1</sub>S<sub>2</sub> (18.00) and the results are presented in Table 4.18.

#### 4.1.2.8 Seed yield plant<sup>-1</sup> (g)

**a) Fertilizer levels:** significant differences were observed in the Seed yield plant<sup>-1</sup> (g) (Table 4.19), among the fertilizer levels T<sub>9</sub> recorded highest seed yield per plant 114.20 g followed by the T<sub>8</sub> (111.50 g), T<sub>7</sub> (110.30 g), T<sub>6</sub> (107.83 g), T<sub>5</sub> (105.23 g), T<sub>4</sub> (103.17 g), T<sub>3</sub> (101.47 g), T<sub>2</sub> (99.73 g) and T<sub>1</sub> (92.30 g).

**Table 4.17: Effect of fertilizer levels and spacings on Rows per cob and Seeds per row of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Rows per cob</b>	<b>Seeds per row</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	10.13	21.47
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	10.27	25.67
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	10.27	26.03
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	10.33	26.40
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	10.33	24.93
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	10.27	25.30
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	10.47	24.50
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	10.53	25.07
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	10.60	26.97
<b>F test</b>	<b>NS</b>	<b>*</b>
<b>S.Em ±</b>	<b>-</b>	<b>0.590</b>
<b>CD @ 5%</b>	<b>-</b>	<b>1.694</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	10.40	25.99
<b>S<sub>2</sub>: 60 X 30 cm</b>	10.31	24.31
<b>F test</b>	<b>NS</b>	<b>*</b>
<b>S.Em ±</b>	<b>-</b>	<b>0.278</b>
<b>CD @ 5%</b>	<b>-</b>	<b>0.799</b>

**Table 4.18: Rows per cob and Seeds per row as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Rows per cob		Seeds per row	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	10.13	10.00	24.93	18.00
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> + Boron spray (1%)</b>	10.40	10.13	26.20	25.13
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> + Boron spray (1%)</b>	10.27	10.13	25.93	26.13
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	10.40	10.27	26.00	26.80
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	10.13	10.53	26.13	23.73
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	10.40	10.13	26.53	24.07
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	10.53	10.40	25.33	23.67
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	10.53	10.53	26.40	23.73
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	10.53	10.67	26.40	27.53
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>*</b>	<b>*</b>
<b>S.Em ±</b>	-	-	<b>0.834</b>	<b>0.834</b>
<b>CD @ 5%</b>	-	-	<b>2.396</b>	<b>2.396</b>

S = Spacings      S<sub>1</sub>=75 X 30 cm      S<sub>2</sub>= 60 X 30 cm

**b) Spacing:** Significant differences were observed in Seed yield plant<sup>-1</sup> (g) in both the spacing's. S<sub>1</sub> noticed higher Seed yield plant<sup>-1</sup> (107.26 g) than S<sub>2</sub> (102.90 g).

**c) Fertilizer levels X Spacing:** Seed yield plant<sup>-1</sup> (g) differed non-significantly due to interaction of T X S and results are presented in Table 4.20.

#### 4.1.2.9 100 seed weight (g)

**a) Fertilizer levels:** Significant differences were noticed in the 100 seed weight (g) among the fertilizer levels (Table 4.19), T<sub>9</sub> recorded higher Test weight 35.18 g followed by T<sub>6</sub> (33.56 g), T<sub>3</sub> (33.34 g), T<sub>8</sub> (32.98 g), T<sub>5</sub> (32.54 g), T<sub>7</sub> (32.53 g), T<sub>4</sub> (33.12 g), T<sub>2</sub> (32.06 g), and T<sub>1</sub> (30.77 g).

**b) Spacing:** Significant differences were observed in 100 seed weight (g) in both the spacing's. S<sub>1</sub> noticed higher Test weight (34.32 g) than S<sub>2</sub> (31.48 g).

**c) Fertilizer levels X Spacing:** T X S interaction was significant in 100 seed weight (g), T<sub>9</sub>S<sub>1</sub> has recorded with 35.61 g, T<sub>6</sub>S<sub>1</sub> (35.02 g), T<sub>5</sub>S<sub>1</sub> (34.81 g), T<sub>3</sub>S<sub>1</sub> (34.78 g), T<sub>4</sub>S<sub>1</sub> (34.53 g), and T<sub>8</sub>S<sub>1</sub> (34.15 g) and followed by lowest with T<sub>2</sub>S<sub>1</sub> (33.94 g), T<sub>7</sub>S<sub>1</sub> (33.37 g) and T<sub>1</sub>S<sub>1</sub> (32.64 g). Similarly S<sub>2</sub> also test weight (g) with T<sub>9</sub>S<sub>2</sub> (34.76 g), T<sub>6</sub>S<sub>2</sub> (32.09 g), T<sub>3</sub>S<sub>2</sub> (31.90 g), T<sub>8</sub>S<sub>2</sub> (31.81 g), and T<sub>4</sub>S<sub>2</sub> (31.72 g) followed by the lowest with T<sub>7</sub>S<sub>2</sub> (31.69 g), T<sub>5</sub>S<sub>2</sub> (30.27 g), T<sub>2</sub>S<sub>2</sub> (30.17 g), and T<sub>1</sub>S<sub>2</sub> (28.89 g) and the results are presented in Table 4.20.

#### 4.1.2.10 Hybrid seed yield (kg plot<sup>-1</sup>)

**a) Fertilizer levels:** Significant difference were noticed in the Hybrid seed yield (kg plot<sup>-1</sup>) among the fertilizer levels (Table 4.21), T<sub>9</sub> recorded higher seed yield plot<sup>-1</sup> 2.33 kg followed by T<sub>8</sub> (2.30 kg), T<sub>6</sub> (2.27 kg), T<sub>3</sub>

**Table 4.19: Effect of fertilizer levels and spacings on seed yield plant<sup>-1</sup> (g) and 100 seed weight (g) of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Seed yield plant<sup>-1</sup> (g)</b>	<b>100 seed weight (g)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	92.30	30.77
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	99.73	32.06
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	101.47	33.34
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	103.17	33.12
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	105.23	32.54
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	107.83	33.56
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	110.30	32.53
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	111.50	32.98
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	114.20	35.18
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>2.821</b>	<b>0.327</b>
<b>CD @ 5%</b>	<b>8.105</b>	<b>0.928</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	107.26	34.32
<b>S<sub>2</sub>: 60 X 30 cm</b>	102.90	31.48
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>1.330</b>	<b>0.154</b>
<b>CD @ 5%</b>	<b>3.821</b>	<b>0.438</b>

**Table 4.20: Seed yield plant<sup>-1</sup> (g) and 100 seed weight (g) as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Seed yield plant <sup>-1</sup> (g)		100 seed weight (g)	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	95.00	89.60	32.64	28.89
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	100.60	98.87	33.94	30.17
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	100.73	102.20	34.78	31.90
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	102.27	104.07	34.53	31.72
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	104.80	105.67	34.81	30.27
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	111.40	104.27	35.02	32.09
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	114.33	106.27	33.37	31.69
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	117.73	105.27	34.15	31.81
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	118.47	109.93	35.61	34.76
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>*</b>	<b>*</b>
<b>S.Em ±</b>	-	-	<b>0.46</b>	<b>0.46</b>
<b>CD @ 5%</b>	-	-	<b>1.31</b>	<b>1.31</b>
S = Spacings	S <sub>1</sub> =75 X 30 cm	S <sub>2</sub> = 60 X 30 cm		

(2.10 kg), T<sub>7</sub> (1.98 kg), T<sub>5</sub> (1.95 kg) T<sub>4</sub> (1.84 kg), T<sub>2</sub> (1.75 kg), and T<sub>1</sub> (1.62 kg).

**b) Spacing:** Non significant results were recorded for number of Hybrid seed yield (kg plot<sup>-1</sup>) due to spacing. Whereas, S<sub>2</sub> has recorded higher seed yield plot<sup>-1</sup> of 2.04 kg compare to S<sub>1</sub> with 1.99 kg.

**c) Fertilizer levels X Spacing:** Hybrid seed yield (kg plot<sup>-1</sup>) differed non-significantly due to interaction of T X S and results are presented in Table 4.22.

#### 4.1.2.11 Male seed yield (kg plot<sup>-1</sup>)

**a) Fertilizer levels:** Significant difference were noticed in the male seed yield (kg plot<sup>-1</sup>) among the fertilizer levels (Table 4.21), T<sub>9</sub> recorded higher male seed yield plot<sup>-1</sup> 0.56 kg followed by T<sub>6</sub> (0.52 kg), T<sub>3</sub> (0.52 kg), T<sub>5</sub> (0.51 kg), T<sub>8</sub> (0.50 kg), T<sub>4</sub> (0.48 kg), T<sub>7</sub> (0.46 kg), T<sub>2</sub> (0.43 kg), and T<sub>1</sub> (0.40 kg).

**b) Spacing:** significant results were recorded for number of male seed yield (kg plot<sup>-1</sup>) due to spacing's. Whereas, S<sub>1</sub> has recorded higher seed yield plot<sup>-1</sup> of 0.51 kg compare to S<sub>2</sub> with 0.46 kg.

**c) Fertilizer levels X Spacing:** Male parent seed yield (kg plot<sup>-1</sup>) differed non-significantly due to interaction of T X S presented in Table 4.22.

#### 4.1.2.12 Hybrid seed yield (kg ha<sup>-1</sup>)

**a) Fertilizer levels:** Significant difference were noticed in the hybrid seed yield (kg ha<sup>-1</sup>) among the fertilizer levels (Table 4.23), T<sub>9</sub> recorded higher seed yield 3237.65 kg followed by T<sub>8</sub> (3200.62 kg), T<sub>6</sub> (3154.01 kg), T<sub>3</sub> (2918.21 kg), T<sub>7</sub> (2748.46 kg), T<sub>5</sub> (2711.11 kg) T<sub>4</sub> (2561.73 kg), T<sub>2</sub> (2424.07 kg), and T<sub>1</sub> (2253.09 kg).

**Table 4.21: Effect of fertilizer levels and spacings on hybrid seed yield (kg plot<sup>-1</sup>) and male parent seed yield (kg plot<sup>-1</sup>) of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Hybrid seed yield (kg plot<sup>-1</sup>)</b>	<b>Male parent seed yield (kg plot<sup>-1</sup>)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	1.62	0.40
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	1.75	0.43
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2.10	0.52
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	1.84	0.48
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	1.95	0.51
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	2.27	0.52
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	1.98	0.46
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	2.30	0.50
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	2.33	0.56
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.120</b>	<b>0.017</b>
<b>CD @ 5%</b>	<b>0.346</b>	<b>0.049</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	2.04	0.51
<b>S<sub>2</sub>: 60 X 30 cm</b>	1.99	0.46
<b>F test</b>	<b>NS</b>	*
<b>S.Em ±</b>	-	<b>0.008</b>
<b>CD @ 5%</b>	-	<b>0.023</b>

**b) Spacing:** Non-significant results were recorded for number of hybrid seed yield ( $\text{kg ha}^{-1}$ ) due to spacing. Whereas,  $S_1$  has recorded higher seed yield of 2836.90 kg compare to  $S_2$  with 2765.09 kg.

**c) Fertilizer levels X Spacing:** Hybrid seed yield ( $\text{kg ha}^{-1}$ ) differed non-significantly due to interaction of T X S presented in Table 4.24.

#### **4.1.2.13 Male parent seed yield ( $\text{kg ha}^{-1}$ )**

**a) Fertilizer levels:** Significant difference were noticed in the male seed yield ( $\text{kg ha}^{-1}$ ) among the fertilizer levels (Table 4.23),  $T_9$  recorded higher seed yield 782.40 kg followed by  $T_6$  (725.47 kg),  $T_4$  (718.40 kg),  $T_5$  (702.40 kg),  $T_8$  (689.60 kg),  $T_3$  (670.40 kg),  $T_7$  (640 kg),  $T_2$  (602.80 kg), and  $T_1$  (555.17 kg).

**b) Spacing:** Non-significant results were recorded for number of male seed yield ( $\text{kg ha}^{-1}$ ) due to spacing. Whereas,  $S_1$  has recorded higher seed yield of 708.62 kg compare to  $S_2$  with 643.96 kg.

**c) Fertilizer levels X Spacing:** male seed yield ( $\text{kg ha}^{-1}$ ) differed non-significantly due to interaction of T X S presented in Table 4.24.

#### **4.1.3 Seed quality parameters**

##### **4.1.3.1 Germination (%)**

**a) Fertilizer levels:** Significant differences were noticed in germination per cent among the fertilizer levels (Table 4.25),  $T_9$  recorded higher germination per cent 98% followed by  $T_8$  (97 %),  $T_6$  (97 %),  $T_7$  (96 %),  $T_3$  (96 %),  $T_4$  (96 %),  $T_5$  (96 %),  $T_2$  (95 %), and  $T_1$  (94 %).

**b) Spacing:** Significant differences were observed in germination per cent in both the spacing's.  $S_1$  noticed higher Germination per cent (98 %) than  $S_2$  (94 %).

**Table 4.23: Effect of fertilizer levels and spacings on hybrid seed yield (kg ha<sup>-1</sup>) and male parent seed yield (kg ha<sup>-1</sup>) of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Hybrid seed yield (kg ha<sup>-1</sup>)</b>	<b>Male parent seed yield (kg ha<sup>-1</sup>)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	2253.09	555.17
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2424.07	602.80
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2918.21	670.40
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	2561.73	718.40
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	2711.11	702.40
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	3154.01	725.47
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	2748.46	640.00
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	3200.62	689.60
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	3237.65	782.40
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>167.20</b>	<b>23.57</b>
<b>CD @ 5%</b>	<b>480.46</b>	<b>67.73</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	2836.90	708.62
<b>S<sub>2</sub>: 60 X 30 cm</b>	2765.09	643.96
<b>F test</b>	NS	*
<b>S.Em ±</b>	-	<b>11.11</b>
<b>CD @ 5%</b>	-	<b>31.93</b>

**Table 4.24: Hybrid seed yield (kg ha<sup>-1</sup>) and male parent seed yield (kg ha<sup>-1</sup>) as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Hybrid seed yield (kg ha <sup>-1</sup> )		Male parent seed yield (kg ha <sup>-1</sup> )	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	2345.68	2160.49	598.40	511.93
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2379.01	2469.14	659.20	546.40
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2993.83	2842.59	710.40	630.40
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	2561.73	2561.73	761.60	675.20
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	2811.11	2611.11	720.00	684.80
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	3122.84	3185.19	729.60	721.33
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	2842.59	2654.32	684.80	595.20
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	3209.88	3191.36	710.40	668.80
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	3265.43	3209.88	803.20	761.60
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>S.Em ±</b>	-	-	-	-
<b>CD @ 5%</b>	-	-	-	-

S = Spacings S<sub>1</sub>=75 X 30 cm S<sub>2</sub>= 60 X 30 cm

**c) Fertilizer levels X Spacing:** Germination per cent differed non-significantly due to interaction of T X S and presented in Table 4.26.

#### **4.1.3.2 Mean seedling dry weight (mg)**

**a) Fertilizer levels:** Significant differences were noticed in the mean seedling dry weight (mg) among the fertilizer levels (Table 4.25), T<sub>9</sub> recorded higher seedling dry weight 87.45 mg followed by T<sub>8</sub> (85.23 mg), T<sub>7</sub> (81.08 mg), T<sub>6</sub> (80.62 mg), T<sub>3</sub> (78.98 mg), T<sub>4</sub> (77.13 mg), T<sub>5</sub> (75.92 mg), T<sub>2</sub> (72.68 mg), and T<sub>1</sub> (65.22 mg).

**b) Spacing:** Significant differences were observed in mean seedling dry weight (mg) in both the spacing's. S<sub>1</sub> noticed higher seedling dry weight (82.09 mg) than S<sub>2</sub> (74.43 mg).

**c) Fertilizer levels X Spacing:** T X S interaction was significant in mean seedling dry weight (mg), T<sub>9</sub>S<sub>1</sub> has recorded with 90.57 mg, T<sub>7</sub>S<sub>1</sub> (88.90 mg), T<sub>8</sub>S<sub>1</sub> (88.33 mg), T<sub>6</sub>S<sub>1</sub> (84.57 mg), T<sub>3</sub>S<sub>1</sub> (83.17 mg) and T<sub>4</sub>S<sub>1</sub> (80.60 mg) followed by lowest with T<sub>5</sub>S<sub>1</sub> (79.47 mg), T<sub>2</sub>S<sub>1</sub> (78.40 mg) and T<sub>1</sub>S<sub>1</sub> (64.77 mg). Similarly S<sub>2</sub> also mean seedling dry weight (mg) with T<sub>9</sub>S<sub>2</sub> (84.33 mg), T<sub>8</sub>S<sub>2</sub> (82.13 mg), T<sub>6</sub>S<sub>2</sub> (76.67 mg), T<sub>3</sub>S<sub>2</sub> (74.80 mg), and T<sub>4</sub>S<sub>2</sub> (73.67 mg) followed by the lowest with T<sub>7</sub>S<sub>2</sub> (73.27 mg), T<sub>5</sub>S<sub>2</sub> (72.37 mg), T<sub>2</sub>S<sub>2</sub> (66.77 mg) and T<sub>1</sub>S<sub>2</sub> (65.67 mg) and the results are presented in Table 4.26.

#### **4.1.3.3 Shoot length (cm)**

**a) Fertilizer levels:** Significant differences were noticed in shoot length (cm) among the fertilizer levels (Table 4.27), T<sub>9</sub> recorded higher shoot length 14.10 cm followed by T<sub>8</sub> (11.35 cm), T<sub>7</sub> (10.66 cm), T<sub>3</sub> (10.32 cm), T<sub>6</sub> (10.21 cm), T<sub>5</sub> (10.15 cm), T<sub>4</sub> (9.94 cm), T<sub>2</sub> (8.91 cm), and T<sub>1</sub> (8.84 cm).

**Table 4.25: Effect of fertilizer levels and spacings on germination (%) and seedling dry weight (mg) of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Germination (%)</b>	<b>Seedling dry weight (mg)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	94 (76)	65.22
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	95 (77)	72.68
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	96 (78)	78.98
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	96 (78)	77.13
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	96 (78)	75.92
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	97 (80)	80.62
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	96 (78)	81.08
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	97 (80)	85.23
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	98 (81)	87.45
<b>F test</b>	*	*
<b>S.Em ±</b>	0.506	1.00
<b>CD @ 5%</b>	1.455	2.86
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	98 (81)	82.09
<b>S<sub>2</sub>: 60 X 30 cm</b>	94 (76)	74.43
<b>F test</b>	*	*
<b>S.Em ±</b>	0.239	0.47
<b>CD @ 5%</b>	0.686	1.35

**Note:** Figure in parentheses is *arc sine* transformed values.

**Table 4.26: Germination (%) and Seedling dry weight (mg) as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Germination (%)		Seedling dry weight (mg)	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	96 (78)	93 (75)	64.77	65.67
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	97(80)	93 (75)	78.40	66.97
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	98 (81)	95 (77)	83.17	74.80
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	98 (81)	94 (76)	80.60	73.67
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	97(80)	95 (77)	79.47	72.37
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	98 (81)	95 (77)	84.57	76.67
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	98 (81)	94 (76)	88.90	73.27
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	99 (86)	96 (78)	88.33	82.13
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	99 (86)	96 (78)	90.57	84.33
<b>F test</b>	NS	NS	*	*
<b>S.Em ±</b>	-	-	<b>1.41</b>	<b>1.41</b>
<b>CD @ 5%</b>	-	-	<b>4.05</b>	<b>4.05</b>

**Note:** Figure in parentheses is *arc sine* transformed values.

S = Spacings    S<sub>1</sub>=75 X 30 cm    S<sub>2</sub>= 60 X 30 cm

**b) Spacing:** Significant differences were observed in shoot length (cm) in both the spacing's. S<sub>1</sub> noticed higher shoot length (11.09 cm) than S<sub>2</sub> (9.90 cm).

**c) Fertilizer levels X Spacing:** T X S interaction was significant in shoot length (cm), T<sub>9</sub>S<sub>1</sub> has recorded with 15.79 cm, T<sub>8</sub>S<sub>1</sub> (11.82 cm), T<sub>3</sub>S<sub>1</sub> (10.83 cm), T<sub>7</sub>S<sub>1</sub> (10.68 cm), T<sub>6</sub>S<sub>1</sub> (10.57 cm) and T<sub>5</sub>S<sub>1</sub> (10.57 cm) followed by lowest with T<sub>4</sub>S<sub>1</sub> (10.47 cm), T<sub>2</sub>S<sub>1</sub> (9.58 cm) and T<sub>1</sub>S<sub>1</sub> (9.53 cm). Similarly S<sub>2</sub> also shoot length (cm) with T<sub>9</sub>S<sub>2</sub> (12.40 cm), T<sub>8</sub>S<sub>2</sub> (10.89 cm), T<sub>7</sub>S<sub>2</sub> (10.64 cm), T<sub>6</sub>S<sub>2</sub> (9.86 cm), T<sub>3</sub>S<sub>2</sub> (9.80 cm), T<sub>5</sub>S<sub>2</sub> (9.73 cm) and T<sub>4</sub>S<sub>2</sub> (9.40 cm) followed by the lowest with T<sub>2</sub>S<sub>2</sub> (8.23 cm) and T<sub>1</sub>S<sub>2</sub> (8.15 cm) and the results are presented in Table 4.28.

#### 4.1.3.4 Root length (cm)

**a) Fertilizer levels:** Significant differences were noticed in root length (cm) among the fertilizer levels (Table 4.27), T<sub>9</sub> recorded higher root length 19.03 cm followed by T<sub>8</sub> (15.67 cm), T<sub>5</sub> (14.71 cm), T<sub>7</sub> (14.11 cm), T<sub>6</sub> (14.36 cm), T<sub>3</sub> (14.01 cm), T<sub>4</sub> (13.06 cm), T<sub>2</sub> (12.51 cm), and T<sub>1</sub> (10.75 cm).

**b) Spacing:** Significant differences were observed in root length (cm) in both the spacing's. S<sub>1</sub> noticed higher root length (15.01 cm) than S<sub>2</sub> (13.48 cm).

**c) Fertilizer levels X Spacing:** T X S interaction was significant in root length (cm), T<sub>9</sub>S<sub>1</sub> has recorded with 20.46 cm, T<sub>8</sub>S<sub>1</sub> (18.77 cm), T<sub>6</sub>S<sub>1</sub> (16.07 cm), T<sub>7</sub>S<sub>1</sub> (15.10 cm), T<sub>3</sub>S<sub>1</sub> (14.37 cm), and T<sub>5</sub>S<sub>1</sub> (13.80 cm) followed by lowest with T<sub>4</sub>S<sub>1</sub> (13.48 cm), T<sub>2</sub>S<sub>1</sub> (12.70 cm) and T<sub>1</sub>S<sub>1</sub> (10.37 cm). Similarly S<sub>2</sub> also root length (cm) with T<sub>9</sub>S<sub>2</sub> (17.60 cm), T<sub>5</sub>S<sub>2</sub> (15.62 cm), T<sub>3</sub>S<sub>2</sub> (13.65 cm), T<sub>7</sub>S<sub>2</sub> (13.12 cm), T<sub>6</sub>S<sub>2</sub> (12.65 cm), T<sub>4</sub>S<sub>2</sub> (12.64 cm) and T<sub>8</sub>S<sub>2</sub> (12.57 cm) followed by the lowest with T<sub>2</sub>S<sub>2</sub> (12.32 cm) and T<sub>1</sub>S<sub>2</sub> (11.13 cm) and the results are presented in Table 4.28.

**Table 4.27: Effect of fertilizer levels and spacings on shoot and root length (cm) hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>Shoot length (cm)</b>	<b>Root length (cm)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	8.84	10.75
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	8.91	12.51
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	10.32	14.01
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	9.94	13.06
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	10.15	14.71
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	10.21	14.36
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	10.66	14.11
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	11.35	15.67
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	14.10	19.03
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.195</b>	<b>0.160</b>
<b>CD @ 5%</b>	<b>0.561</b>	<b>0.460</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	11.09	15.01
<b>S<sub>2</sub>: 60 X 30 cm</b>	9.90	13.48
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.092</b>	<b>0.075</b>
<b>CD @ 5%</b>	<b>0.265</b>	<b>0.217</b>

**Table 4.28: Shoot and root length (cm) as influenced by the interaction of fertilizer levels and Spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Shoot length (cm)		Root length (cm)	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	9.53	8.15	10.37	11.13
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	9.58	8.23	12.70	12.32
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	10.83	9.80	14.37	13.65
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub>spray (2%)</b>	10.47	9.40	13.48	12.64
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	10.57	9.73	13.80	15.62
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	10.57	9.86	16.07	12.65
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	10.68	10.64	15.10	13.12
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	11.82	10.89	18.77	12.57
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	15.79	12.40	20.46	17.60
<b>F test</b>	*	*	*	*
<b>S.Em ±</b>	<b>0.276</b>	<b>0.276</b>	<b>0.226</b>	<b>0.226</b>
<b>CD @ 5%</b>	<b>0.794</b>	<b>0.794</b>	<b>0.651</b>	<b>0.651</b>

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

#### 4.1.3.5 Seedling vigour index I

a) **Fertilizer levels:** Significant differences were noticed in seedling vigour index I among the fertilizer levels (Table 4.29), T<sub>9</sub> recorded higher 3240 followed by T<sub>8</sub> (2636), T<sub>5</sub> (2386), T<sub>7</sub> (2379), T<sub>6</sub> (2373), T<sub>3</sub> (2340), T<sub>4</sub> (2209), T<sub>2</sub> (2029), and T<sub>1</sub> (1845).

b) **Spacing:** Significant differences were observed in seedling vigour index I in both the spacing's. S<sub>1</sub> noticed higher (2553) than S<sub>2</sub> (2211).

c) **Fertilizer levels X Spacing:** T X S interaction was significant in seedling vigour index I, T<sub>9</sub>S<sub>1</sub> has recorded with 3290, T<sub>8</sub>S<sub>1</sub> (2936), T<sub>3</sub>S<sub>1</sub> (2601), T<sub>7</sub>S<sub>1</sub> (2510), T<sub>6</sub>S<sub>1</sub> (2435), and T<sub>4</sub>S<sub>1</sub> (2370), followed by lowest with T<sub>5</sub>S<sub>1</sub> (2252), T<sub>2</sub>S<sub>1</sub> (2153) and T<sub>1</sub>S<sub>1</sub> (1904). Similarly S<sub>2</sub> also with T<sub>9</sub>S<sub>2</sub> (2702), T<sub>5</sub>S<sub>2</sub> (2001), T<sub>8</sub>S<sub>2</sub> (2233), T<sub>7</sub>S<sub>2</sub> (2212), T<sub>3</sub>S<sub>2</sub> (2368), T<sub>6</sub>S<sub>2</sub> (2071) and T<sub>4</sub>S<sub>2</sub> (2013) followed by the lowest with T<sub>2</sub>S<sub>2</sub> (1905) and T<sub>1</sub>S<sub>2</sub> (1787) and the results are presented in Table 4.30.

#### 4.1.3.6 Seedling vigour index II

a) **Fertilizer levels:** Significant differences were noticed in seedling vigour index II among the fertilizer levels (Table 4.29), T<sub>9</sub> recorded higher 8547 followed by T<sub>8</sub> (8301), T<sub>7</sub> (7797), T<sub>6</sub> (7785), T<sub>3</sub> (7600), T<sub>4</sub> (7410), T<sub>5</sub> (7292), T<sub>2</sub> (6892), and T<sub>1</sub> (6140).

b) **Spacing:** Significant differences were observed in seedling vigour index II in both the spacing's. S<sub>1</sub> noticed higher (8021) than S<sub>2</sub> (7038).

c) **Fertilizer levels X Spacing:** T X S interaction was significant in seedling vigour index II, T<sub>9</sub>S<sub>1</sub> has recorded with 8996, T<sub>8</sub>S<sub>1</sub> (8745), T<sub>7</sub>S<sub>1</sub> (8683), T<sub>6</sub>S<sub>1</sub> (8260), T<sub>3</sub>S<sub>1</sub> (8119) and T<sub>4</sub>S<sub>1</sub> (7872) followed by lowest with T<sub>5</sub>S<sub>1</sub> (7736), T<sub>2</sub>S<sub>1</sub> (7578) and T<sub>1</sub>S<sub>1</sub> (6197). Similarly S<sub>2</sub> also vigour index II with T<sub>9</sub>S<sub>2</sub> (8098), T<sub>8</sub>S<sub>2</sub> (7857), T<sub>6</sub>S<sub>2</sub> (7309), T<sub>3</sub>S<sub>2</sub> (7081), T<sub>4</sub>S<sub>2</sub> (6949),

**Table 4.29 :** Effect of fertilizer levels and spacings on seedling vigour index I and seedling vigour index II on hybrid maize NAH-2049 (Nithyashree)

<b>Fertilizer levels</b>	<b>Seedling vigour index I</b>	<b>Seedling vigour index II</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	1845	6140
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2029	6892
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2340	7600
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	2209	7410
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	2386	7292
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	2373	7785
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	2379	7797
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	2636	8301
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	3240	8547
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>22.03</b>	<b>102.84</b>
<b>CD @ 5%</b>	<b>63.30</b>	<b>295.52</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	2553	8021
<b>S<sub>2</sub>: 60 X 30 cm</b>	2211	7038
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>10.38</b>	<b>48.48</b>
<b>CD @ 5%</b>	<b>29.84</b>	<b>139.32</b>

**Table 4.30: Seedling vigour index I and seedling vigour index II as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Seedling vigour index I		Seedling vigour index II	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	1904	1787	6197	6084
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2153	1905	7578	6206
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2601	2368	8119	7081
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	2370	2013	7872	6949
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	2252	2001	7736	6849
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	2435	2071	8260	7309
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	2510	2212	8683	6910
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	2936	2233	8745	7857
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	3290	2702	8996	8098
<b>F test</b>	*	*	*	*
<b>S.Em ±</b>	<b>31.15</b>	<b>31.15</b>	<b>145.44</b>	<b>145.44</b>
<b>CD @ 5%</b>	<b>89.52</b>	<b>89.52</b>	<b>417.92</b>	<b>417.92</b>

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

T<sub>7</sub>S<sub>2</sub> (6910), and T<sub>5</sub>S<sub>2</sub> (6849) followed by the lowest with T<sub>2</sub>S<sub>2</sub> (6206) and T<sub>1</sub>S<sub>2</sub> (6084) and the results are presented in Table 4.30.

#### 4.1.3.7 Electrical Conductivity (dSm<sup>-1</sup>)

- a) Fertilizer levels:** Non significant results were recorded with electrical conductivity of the seeds due to application of different fertilizers levels (Table 4.31). However, T<sub>9</sub> recorded lower electrical conductivity 0.02 dSm<sup>-1</sup> and T<sub>1</sub> has recorded higher electrical conductivity (0.053 dSm<sup>-1</sup>).
- b) Spacing:** Significant differences were observed in electrical conductivity of the seeds in both the spacing's. S<sub>1</sub> noticed lower electrical conductivity (0.022 dSm<sup>-1</sup>) than S<sub>2</sub> (0.049 dSm<sup>-1</sup>).
- c) Fertilizer levels X Spacing:** Electrical Conductivity of the seeds showed non-significant results due to interaction of T X S and presented in Table 4.32.

#### 4.1.3.8 Total dehydrogenase activity (OD Value) @ 480nm

- a) Fertilizer levels:** Significant differences were noticed in TDH activity (OD Value) at 480 nm among the fertilizer levels (Table 4.31), T<sub>9</sub> recorded higher 1.45 followed by T<sub>8</sub> (1.25), T<sub>6</sub> (1.23), T<sub>7</sub> (1.22), T<sub>3</sub> (1.17), T<sub>5</sub> (1.13), T<sub>4</sub> (1.04), T<sub>2</sub> (1.02), and T<sub>1</sub> (0.92).
- b) Spacing:** Significant differences were observed in TDH activity (OD Value) at 480 nm in both the spacing's. S<sub>1</sub> noticed higher (1.39) than S<sub>2</sub> (0.93).
- c) Fertilizer levels X Spacing:** T X S interaction was significant in TDH activity (OD Value) at 480 nm, T<sub>9</sub>S<sub>1</sub> has recorded with 1.75, T<sub>7</sub>S<sub>1</sub> (1.58), T<sub>8</sub>S<sub>1</sub> (1.53), T<sub>6</sub>S<sub>1</sub> (1.47), T<sub>3</sub>S<sub>1</sub> (1.38) and T<sub>5</sub>S<sub>1</sub> (1.33) followed by lowest with T<sub>2</sub>S<sub>1</sub> (1.25), T<sub>4</sub>S<sub>1</sub> (1.14) and T<sub>1</sub>S<sub>1</sub> (1.09). Similarly S<sub>2</sub> also TDH activity (OD Value) at 480 nm with T<sub>9</sub>S<sub>2</sub> (1.16), T<sub>6</sub>S<sub>2</sub> (0.99), T<sub>8</sub>S<sub>2</sub> (0.97),

**Table 4.31: Effect of fertilizer levels and spacings on electrical conductivity (dSm<sup>-1</sup>) and total dehydrogenase activity @ 480nm of hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer levels</b>	<b>EC (dSm<sup>-1</sup>)</b>	<b>TDH (OD value)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	0.053	0.92
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	0.052	1.02
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	0.025	1.17
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	0.046	1.04
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	0.038	1.13
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	0.028	1.23
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	0.033	1.22
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	0.024	1.25
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	0.020	1.45
<b>F test</b>	NS	*
<b>S.Em ±</b>	-	<b>0.011</b>
<b>CD @ 5%</b>	-	<b>0.032</b>
<b>Spacing (S)</b>		
<b>S<sub>1</sub>: 75 X 30 cm</b>	0.022	1.39
<b>S<sub>2</sub>: 60 X 30 cm</b>	0.049	0.93
<b>F test</b>	*	*
<b>S.Em ±</b>	<b>0.004</b>	<b>0.005</b>
<b>CD @ 5%</b>	<b>0.012</b>	<b>0.015</b>

**Table 4.32: Electrical conductivity (dSm<sup>-1</sup>) and total dehydrogenase activity @ 480 nm as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	EC (dSm <sup>-1</sup> )		TDH (OD value)	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	0.026	0.081	1.09	0.76
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	0.025	0.080	1.25	0.79
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	0.019	0.030	1.38	0.95
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	0.020	0.071	1.14	0.94
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	0.020	0.055	1.33	0.94
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	0.023	0.033	1.47	0.99
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	0.025	0.041	1.58	0.86
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	0.019	0.029	1.53	0.97
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	0.017	0.022	1.75	1.16
<b>F test</b>	NS	NS	*	*
<b>S.Em ±</b>	-	-	<b>0.016</b>	<b>0.016</b>
<b>CD @ 5%</b>	-	-	<b>0.045</b>	<b>0.045</b>

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

T<sub>3</sub>S<sub>2</sub> (0.95), T<sub>5</sub>S<sub>2</sub> (0.94) T<sub>4</sub>S<sub>2</sub> (0.94) and T<sub>7</sub>S<sub>2</sub> (0.86) followed by the lowest with T<sub>2</sub>S<sub>2</sub> (0.79) and T<sub>1</sub>S<sub>2</sub> (0.76) and the results are presented in Table 4.32.

#### **4.1.3.9 Field emergence (%)**

**a) Fertilizer levels:** Significant differences were noticed in field emergence per cent among the fertilizer levels (Table 4.33), T<sub>9</sub> recorded higher 96 per cent followed by T<sub>8</sub> (96 %), T<sub>6</sub> (95 %), T<sub>7</sub> (94 %), T<sub>3</sub> (94 %), T<sub>5</sub> (93 %), T<sub>4</sub> (93 %), T<sub>2</sub> (92 %), and T<sub>1</sub> (91 %).

**b) Spacing:** Significant differences were observed in field emergence per cent in both the spacing's. S<sub>1</sub> noticed higher (95 %) than S<sub>2</sub> (92 %).

**c) Fertilizer levels X Spacing:** Field emergence per cent showed non-significant results due to interaction of T X S and presented in Table 4.34.

#### **4.2 Influence of fertilizer treatments on pollen viability percentage of pollen parent (MAI-105) of hybrid maize NAH-2049 (Nithyashree)**

The data on Pollen viability per cent as influenced by fertilizer treatments in the pollen parent of hybrid maize NAH-2049 (Nithyashree) are presented (Table 4.35). Significant differences were recorded in pollen viability per cent among the fertilizer treatments, T<sub>5</sub> observed higher pollen viability per cent 89.89 per cent followed by T<sub>4</sub> (80.27 %), T<sub>3</sub> (79.68 %), T<sub>2</sub> (79.29 %) and T<sub>1</sub> (70.46 %).

**Table 4.33: Effect of fertilizer levels and spacings on field emergence (%) of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Field emergence (%)
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	91 (72)
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	92 (73)
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	94 (76)
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	93 (75)
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> . spray (2%) + Boron spray (1%)</b>	93 (75)
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	95 (77)
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	94 (76)
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	96 (78)
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	96 (78)
<b>F test</b>	*
<b>S.Em ±</b>	<b>0.471</b>
<b>CD @ 5%</b>	<b>1.354</b>
<b>Spacing (S)</b>	
<b>S<sub>1</sub>: 75 X 30 cm</b>	95 (77)
<b>S<sub>2</sub>: 60 X 30 cm</b>	92 (73)
<b>F test</b>	*
<b>S.Em ±</b>	<b>0.222</b>
<b>CD @ 5%</b>	<b>0.638</b>

**Note:** Figure in parentheses is *arc sine* transformed values.

**Table 4.34: Field emergence (%) as influenced by the interaction of fertilizer levels and spacing of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Field emergence (%)	
	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	91 (72)	90 (70)
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	93 (75)	90 (70)
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	94 (76)	93 (75)
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	95 (77)	91 (72)
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> . spray (2%) + Boron spray (1%)</b>	95 (77)	92 (73)
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	96 (78)	94 (76)
<b>T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)</b>	95 (77)	92 (73)
<b>T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM</b>	96 (78)	95 (77)
<b>T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM</b>	98 (78)	95 (77)
<b>F test</b>	<b>NS</b>	<b>NS</b>
<b>S.Em ±</b>	-	-
<b>CD @ 5%</b>	-	-

**Note:** Figure in parentheses is *arc sine* transformed values.

S = Spacings S<sub>1</sub>=75 X 30 cm S<sub>2</sub>= 60 X 30 cm

**Table 4.35 : Influence of fertilizer treatments on pollen viability percentage of Pollen parent (MAI-105) in hybrid maize NAH-2049 (Nithyashree)**

<b>Fertilizer Treatments</b>	<b>Pollen viability (%)</b>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>)</b>	70.46 (57.05)
<b>T<sub>2</sub>: RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	79.29 (62.90)
<b>T<sub>3</sub>: RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> spray (2%)</b>	79.68 (63.18)
<b>T<sub>4</sub>: RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup> + Boron spray (1%)</b>	80.27 (63.61)
<b>T<sub>5</sub>: RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	89.89 (71.43)
<b>F test</b>	*
<b>S.Em ±</b>	<b>0.707</b>
<b>CD @ 5%</b>	<b>2.177</b>

**Note:** Figure in parentheses are *arc sine* transformed values.

### **4.3 Study the seed ageing on seed quality of F<sub>1</sub> seeds on maize hybrid NAH- 2049 (Nithyashree)**

#### **4.3.1 Germination (%)**

The data on seed germination percentage during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods are depicted in (Table 4.36). The results revealed that the significant difference in seed germination quality observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly higher (96 %) germination, which was on par with treatments of T<sub>8</sub>S<sub>1</sub> (95 %), T<sub>7</sub>S<sub>1</sub> (95 %) and T<sub>3</sub>S<sub>1</sub> (95 %). While, T<sub>1</sub>S<sub>2</sub> and T<sub>2</sub>S<sub>2</sub> has recorded lower germination per cent (90 %). The other treatments were in between.

Accelerated ageing (AA) periods showed significant difference for germination percentage. Among the accelerated aged seeds, the non-aged seeds (A<sub>0</sub>) recorded the highest (96 %) germination and it was lowest (87 %) with the seed subjected to accelerated ageing for 6 days (A<sub>6</sub>). The results also revealed that the increase in the accelerated ageing period declined the germination percentage.

Seed subjected to accelerated ageing maintained a minimum of 90 per cent germination up to four days of ageing, then after it declined below the minimum seed certification standards for germination.

Interaction effects due to treatment application and ageing periods on during accelerated aged seeds did not show any significant difference in seed germination percentage.

#### **4.3.2 Mean seedling dry weight (mg)**

The data on seedling dry weight during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods are depicted in (Table 4.36). The results noticed that the

**Table 4.36 : Germination (%) and seedling dry weight (mg) as influenced by plant density and plant nutrition on hybrid maize NAH-2049 (Nithyashree) subjected for accelerated ageing test**

Treatments	Germination (%)					Seedling dry weight (mg)					a. Fertilizer levels (T) T <sub>1</sub> : (150:75:40NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> T <sub>2</sub> :(187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>3</sub> :(225:112.5:60 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>4</sub> :(150:75:40NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%) T <sub>5</sub> : (187.5:93.5: 50 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%)+Boron spray 1%) T <sub>6</sub> :( 225:112.5:60 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%)+ Boron spray(1%) T <sub>7</sub> : T <sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%) T <sub>8</sub> : T <sub>2</sub> + <i>Azotobacter</i> +PSB+VAM T <sub>9</sub> : T <sub>3</sub> + <i>Azotobacter</i> +PSB+VAM
	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	
T <sub>1</sub> S <sub>1</sub>	96(78)	95(77)	94(75)	87(69)	<b>93(75)</b>	64.77	60.87	53.47	45.67	<b>56.19</b>	
T <sub>2</sub> S <sub>1</sub>	97(80)	96(78)	94(75)	88(70)	<b>94(76)</b>	78.40	64.50	54.60	49.10	<b>61.65</b>	
T <sub>3</sub> S <sub>1</sub>	98(81)	97(80)	95(77)	90(71)	<b>95(77)</b>	83.17	81.70	61.63	52.53	<b>69.76</b>	
T <sub>4</sub> S <sub>1</sub>	98(81)	96(78)	94(75)	88(70)	<b>94(76)</b>	80.60	65.33	57.23	52.30	<b>63.87</b>	
T <sub>5</sub> S <sub>1</sub>	97(80)	96(78)	94(75)	86(68)	<b>93(75)</b>	79.47	69.67	59.67	52.20	<b>65.25</b>	
T <sub>6</sub> S <sub>1</sub>	98(81)	96(78)	95(77)	87(69)	<b>94(76)</b>	84.57	72.03	68.20	55.17	<b>69.99</b>	
T <sub>7</sub> S <sub>1</sub>	98(81)	97(80)	96(78)	90(71)	<b>95(77)</b>	88.90	67.83	60.57	56.53	<b>68.46</b>	
T <sub>8</sub> S <sub>1</sub>	99(86)	97(80)	95(77)	88(70)	<b>95(77)</b>	88.33	73.33	70.10	58.97	<b>72.68</b>	
T <sub>9</sub> S <sub>1</sub>	99(86)	99(86)	95(77)	90(71)	<b>96(78)</b>	90.57	80.33	72.87	62.90	<b>76.67</b>	
T <sub>1</sub> S <sub>2</sub>	93(75)	92(73)	90(71)	85(67)	<b>90(71)</b>	65.67	64.00	47.20	43.70	<b>55.14</b>	
T <sub>2</sub> S <sub>2</sub>	93(75)	92(73)	91(72)	85(67)	<b>90(71)</b>	66.97	64.47	47.90	44.00	<b>55.83</b>	
T <sub>3</sub> S <sub>2</sub>	95(77)	94(76)	92(73)	87(69)	<b>92(73)</b>	74.80	65.67	57.73	45.93	<b>61.03</b>	
T <sub>4</sub> S <sub>2</sub>	94(76)	94(76)	92(73)	86(68)	<b>92(73)</b>	73.67	71.80	48.97	44.37	<b>59.70</b>	
T <sub>5</sub> S <sub>2</sub>	95(77)	95(77)	93(75)	88(70)	<b>92(73)</b>	72.37	70.67	53.33	46.00	<b>60.59</b>	
T <sub>6</sub> S <sub>2</sub>	95(77)	94(76)	93(75)	87(69)	<b>92(73)</b>	76.67	72.00	54.40	48.13	<b>62.80</b>	
T <sub>7</sub> S <sub>2</sub>	94(76)	94(76)	92(73)	87(69)	<b>92(73)</b>	73.27	73.00	57.57	44.17	<b>62.00</b>	
T <sub>8</sub> S <sub>2</sub>	96(78)	95(77)	93(75)	87(69)	<b>93(75)</b>	82.13	76.00	60.10	45.47	<b>65.93</b>	
T <sub>9</sub> S <sub>2</sub>	96(78)	95(77)	94(76)	88(70)	<b>93(75)</b>	84.33	81.73	61.40	54.27	<b>70.43</b>	
<b>Ageing (A)</b>	<b>96(78)</b>	<b>95(77)</b>	<b>93(75)</b>	<b>87(69)</b>	<b>93(75)</b>	<b>78.26</b>	<b>70.83</b>	<b>58.16</b>	<b>50.08</b>	<b>64.33</b>	
	<b>F test</b>	<b>S.Em±</b>	<b>CD 5 %</b>	<b>CD 1%</b>		<b>F test</b>	<b>S.Em±</b>	<b>CD 5%</b>	<b>CD 1%</b>		
<b>T</b>	*	<b>0.38</b>	<b>1.06</b>	<b>1.39</b>		<b>T</b>	*	<b>1.58</b>	<b>4.42</b>	<b>5.83</b>	
<b>A</b>	*	<b>0.19</b>	<b>0.50</b>	<b>0.66</b>		<b>A</b>	*	<b>0.74</b>	<b>2.08</b>	<b>2.75</b>	
<b>T X A</b>	NS	-	-	-		<b>T X A</b>	NS	-	-	-	

**b. Spacing (S):** S<sub>1</sub>=75 X 30 cm  
S<sub>2</sub>= 60 X 30 cm

**c. Ageing period (A):** A<sub>0</sub> = Non aged seeds  
A<sub>2</sub> = 2 days  
A<sub>4</sub> = 4 days  
A<sub>6</sub> = 6 days

significant difference in seedling dry weight observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly higher (76.67 mg) seedling dry weight, which was on par with treatments of T<sub>8</sub>S<sub>1</sub> (72.68 mg). The lowest seedling dry weight was recorded in the treatment T<sub>1</sub>S<sub>2</sub> (55.14 mg). The other treatments were inbetween.

Accelerated ageing (AA) periods showed significant difference for seedling dry weight (mg). Among the accelerated aged seeds, the non aged seeds (A<sub>0</sub>) recorded the highest (78.26 mg) seedling dry weight and it was lowest (50.08 mg) with the seed subjected to accelerated ageing for 6 days (A<sub>6</sub>). The seedling dry weight (mg) decreased linearly with increase in ageing period upto six days of AA. Seedling dry weight (mg), there was no significant difference noticed in interaction effects due to treatments and ageing period during accelerated aged hybrid seeds.

#### **4.3.3 Shoot length (cm)**

The data on shoot length during Accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.37). The results showed that the significant difference in shoot length was observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly higher (12.11cm) shoot length, while lower shoot length recorded in treatment T<sub>1</sub>S<sub>2</sub> of (7.63 cm).

Accelerated ageing (AA) period showed significant difference for shoot length. Among the accelerated aged seeds, the non aged seeds (A<sub>0</sub>) recorded the highest (10.52 cm) shoot length and it was lowest (8.38 cm) with the seed subjected to accelerated ageing for 6 days (A<sub>6</sub>). The results also revealed that the increase in the accelerated ageing period declined the shoot length.

Interaction effect due to treatments and ageing period during accelerated ageing in (Table 4.37), showed significant difference in shoot

**Table 4.37 : Shoot and root length (cm) as influenced by plant density and plant nutrition on hybrid maize NAH-2049 (Nithyashree) subjected for accelerated ageing test.**

Treatments	Shoot length (cm)					Root length (cm)					a. Fertilizer levels (T) T <sub>1</sub> : (150:75:40NPK kg ha <sup>-1</sup> ) + ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> T <sub>2</sub> :(187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>3</sub> :(225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>4</sub> :(150:75:40NPK kg ha <sup>-1</sup> ) + ZnSO <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> spray (2%) T <sub>5</sub> : (187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> spray (2%)+Boron spray 1%) T <sub>6</sub> :( 225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> spray (2%)+ Boron spray(1%) T <sub>7</sub> : T <sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%) T <sub>8</sub> : T <sub>2</sub> + <i>Azotobacter</i> +PSB+VAM T <sub>9</sub> : T <sub>3</sub> + <i>Azotobacter</i> +PSB+VAM
	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	
T <sub>1</sub> S <sub>1</sub>	9.53	9.32	8.76	7.46	<b>8.77</b>	10.37	9.73	8.41	7.59	<b>9.02</b>	b. Spacing (S): S <sub>1</sub> =75 X 30 cm S <sub>2</sub> = 60 X 30 cm
T <sub>2</sub> S <sub>1</sub>	9.58	9.33	8.87	8.54	<b>9.08</b>	12.70	9.89	8.69	8.68	<b>9.99</b>	
T <sub>3</sub> S <sub>1</sub>	10.83	10.57	9.07	8.72	<b>9.80</b>	14.37	12.05	9.78	9.20	<b>11.35</b>	
T <sub>4</sub> S <sub>1</sub>	10.47	9.65	8.92	8.41	<b>9.36</b>	13.48	10.12	9.51	9.15	<b>10.57</b>	
T <sub>5</sub> S <sub>1</sub>	10.57	9.78	8.89	8.75	<b>9.50</b>	13.80	10.22	9.57	9.23	<b>10.71</b>	
T <sub>6</sub> S <sub>1</sub>	10.57	10.19	9.57	8.91	<b>9.81</b>	16.07	12.83	10.02	9.50	<b>12.11</b>	
T <sub>7</sub> S <sub>1</sub>	10.68	10.47	9.46	9.37	<b>9.99</b>	15.10	11.16	9.58	9.57	<b>11.35</b>	
T <sub>8</sub> S <sub>1</sub>	11.82	10.70	10.00	9.39	<b>10.48</b>	18.77	14.48	10.39	9.48	<b>13.28</b>	
T <sub>9</sub> S <sub>1</sub>	15.79	12.66	10.27	9.73	<b>12.11</b>	20.46	15.56	12.30	9.88	<b>14.55</b>	
T <sub>1</sub> S <sub>2</sub>	8.15	7.82	7.72	6.82	<b>7.63</b>	11.13	9.14	8.71	6.86	<b>8.96</b>	c. Ageing period (A): A <sub>0</sub> = Non aged seeds A <sub>2</sub> = 2 days A <sub>4</sub> = 4 days A <sub>6</sub> = 6 days
T <sub>2</sub> S <sub>2</sub>	8.23	8.06	8.00	6.89	<b>7.79</b>	12.32	10.70	9.06	7.30	<b>9.84</b>	
T <sub>3</sub> S <sub>2</sub>	9.80	9.15	8.71	8.11	<b>8.94</b>	13.65	11.78	10.05	8.90	<b>11.10</b>	
T <sub>4</sub> S <sub>2</sub>	9.40	8.48	8.63	7.56	<b>8.52</b>	12.64	10.85	9.21	8.71	<b>10.35</b>	
T <sub>5</sub> S <sub>2</sub>	9.73	9.28	8.70	7.75	<b>8.87</b>	15.62	11.01	10.36	8.48	<b>11.37</b>	
T <sub>6</sub> S <sub>2</sub>	9.86	9.34	9.04	8.70	<b>9.23</b>	12.65	12.02	10.46	8.90	<b>11.01</b>	
T <sub>7</sub> S <sub>2</sub>	10.64	9.70	9.22	8.52	<b>9.52</b>	13.12	11.32	10.18	8.90	<b>10.88</b>	
T <sub>8</sub> S <sub>2</sub>	10.89	10.33	9.47	8.54	<b>9.81</b>	12.57	12.57	10.59	9.60	<b>11.33</b>	
T <sub>9</sub> S <sub>2</sub>	12.40	10.55	10.19	8.74	<b>10.47</b>	17.60	13.25	12.93	9.90	<b>13.42</b>	
<b>Ageing (A)</b>	<b>10.50</b>	<b>9.74</b>	<b>9.08</b>	<b>8.38</b>	<b>9.43</b>	<b>14.24</b>	<b>11.59</b>	<b>9.99</b>	<b>8.88</b>	<b>11.18</b>	
	<b>F test</b>	<b>S.Em±</b>	<b>CD 5 %</b>	<b>CD 1%</b>		<b>F test</b>	<b>S.Em±</b>	<b>CD 5%</b>	<b>CD 1%</b>		
<b>T</b>	*	<b>0.16</b>	<b>0.45</b>	<b>0.60</b>		<b>T</b>	*	<b>0.17</b>	<b>0.48</b>	<b>0.64</b>	
<b>A</b>	*	<b>0.08</b>	<b>0.21</b>	<b>0.28</b>		<b>A</b>	*	<b>0.08</b>	<b>0.23</b>	<b>0.30</b>	
<b>T X A</b>	*	<b>0.33</b>	<b>0.91</b>	<b>1.20</b>		<b>T X A</b>	*	<b>0.35</b>	<b>0.96</b>	<b>1.27</b>	

length. The data revealed significant decline in shoot length after two days of ageing compared to fresh seed. Non aged ( $A_0$ ) Nithyashree seeds subjected for accelerated ageing  $T_9S_1$  recorded the highest (15.79 cm) shoot length. While, lower (6.82 cm) observed with  $T_1S_2$  on seeds subjected for six days ( $A_6$ ).

#### **4.3.4 Root length (cm)**

The data on root length during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.37). The results showed that the significant difference in root length was observed among treatments *viz.*,  $T_9S_1$  recorded significantly higher (14.55 cm) root length, while lower root length recorded in treatment  $T_1S_2$  of (8.96 cm).

Accelerated ageing (AA) period showed significant difference for root length. Among the accelerated aged seeds, the non aged seeds ( $A_0$ ) recorded the highest (14.24 cm) root length and it was lowest (8.88 cm) with the seed subjected to accelerated ageing for 6 days ( $A_6$ ). The results also revealed that the increase in the accelerated ageing period declined the shoot length.

Interaction effect due to treatments and ageing period during accelerated ageing in (Table 4.37), showed significant difference in root length. The data revealed significant decline in shoot length after two days of ageing compared to fresh seed. Non aged ( $A_0$ ) Nithyashree seeds subjected for accelerated ageing  $T_9S_1$  recorded the highest (20.46 cm) root length. While, lower (6.86 cm) observed with  $T_1S_2$  on seeds subjected for six days ( $A_6$ ).

#### **4.3.5 Seedling vigour index I**

**Table 4.38 : Seedling vigour index I and II as influenced by plant density and plant nutrition on hybrid maize NAH-2049 (Nithyashree) subjected for accelerated ageing test**

Treatments	Seedling vigour index I					Seedling vigour index II					a). Fertilizer levels (T) T <sub>1</sub> : (150:75:40NPK kg ha <sup>-1</sup> ) + ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> T <sub>2</sub> :(187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>3</sub> :(225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>4</sub> :(150:75:40NPK kg ha <sup>-1</sup> ) + ZnSO <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> spray (2%) T <sub>5</sub> : (187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> spray (2%)+Boron spray 1%) T <sub>6</sub> :( 225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSO <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSO <sub>4</sub> spray (2%)+ Boron spray(1%) T <sub>7</sub> : T <sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%) T <sub>8</sub> : T <sub>2</sub> + <i>Azotobacter</i> +PSB+VAM T <sub>9</sub> : T <sub>3</sub> + <i>Azotobacter</i> +PSB+VAM
	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	
T <sub>1</sub> S <sub>1</sub>	1904	1806	1608	1304	<b>1655</b>	6197	5767	5009	3954	<b>5232</b>	
T <sub>2</sub> S <sub>1</sub>	2153	1847	1653	1524	<b>1794</b>	7578	6189	5139	4348	<b>5814</b>	
T <sub>3</sub> S <sub>1</sub>	2601	2194	1795	1608	<b>2015</b>	8119	7926	5877	4715	<b>6659</b>	
T <sub>4</sub> S <sub>1</sub>	2370	1891	1732	1552	<b>1879</b>	7872	6249	5383	4620	<b>6031</b>	
T <sub>5</sub> S <sub>1</sub>	2252	1920	1738	1553	<b>1896</b>	7736	6691	5620	4438	<b>6121</b>	
T <sub>6</sub> S <sub>1</sub>	2435	2217	1852	1608	<b>2069</b>	8260	6937	6443	4814	<b>6614</b>	
T <sub>7</sub> S <sub>1</sub>	2510	2094	1819	1703	<b>2033</b>	8683	6569	5784	5082	<b>6529</b>	
T <sub>8</sub> S <sub>1</sub>	2936	2442	1944	1667	<b>2270</b>	8745	7115	6682	5209	<b>6938</b>	
T <sub>9</sub> S <sub>1</sub>	3290	2780	2152	1759	<b>2573</b>	8996	7912	6943	5643	<b>7373</b>	
T <sub>1</sub> S <sub>2</sub>	1787	1555	1481	1157	<b>1495</b>	6084	5875	4264	3693	<b>4979</b>	
T <sub>2</sub> S <sub>2</sub>	1905	1729	1547	1207	<b>1597</b>	6206	5938	4342	3744	<b>5058</b>	
T <sub>3</sub> S <sub>2</sub>	2368	1968	1733	1475	<b>1849</b>	7081	6180	5332	3984	<b>5644</b>	
T <sub>4</sub> S <sub>2</sub>	2013	1814	1640	1405	<b>1735</b>	6949	6737	4508	3834	<b>5507</b>	
T <sub>5</sub> S <sub>2</sub>	2001	1924	1763	1424	<b>1878</b>	6849	6700	4929	4040	<b>5630</b>	
T <sub>6</sub> S <sub>2</sub>	2071	2008	1804	1530	<b>1872</b>	7309	6770	5036	4183	<b>5824</b>	
T <sub>7</sub> S <sub>2</sub>	2212	1969	1788	1508	<b>1877</b>	6910	6839	5303	3824	<b>5719</b>	
T <sub>8</sub> S <sub>2</sub>	2233	2174	1872	1576	<b>1967</b>	7857	7219	5617	3951	<b>6161</b>	
T <sub>9</sub> S <sub>2</sub>	2702	2265	2167	1641	<b>2238</b>	8098	7784	5746	4777	<b>6601</b>	
<b>Ageing (A)</b>	<b>2382</b>	<b>2033</b>	<b>1783</b>	<b>1511</b>	<b>1927</b>	<b>7529</b>	<b>6744</b>	<b>5442</b>	<b>4381</b>	<b>6024</b>	
	<b>F test</b>	<b>S.Em±</b>	<b>CD 5 %</b>	<b>CD 1%</b>		<b>F test</b>	<b>S.Em±</b>	<b>CD 5%</b>	<b>CD 1%</b>		
<b>T</b>	*	<b>24.41</b>	<b>68.23</b>	<b>90.11</b>		<b>T</b>	*	<b>150.26</b>	<b>419.96</b>	<b>554.63</b>	
<b>A</b>	*	<b>11.51</b>	<b>32.17</b>	<b>42.48</b>		<b>A</b>	*	<b>70.83</b>	<b>197.98</b>	<b>261.45</b>	
<b>T X A</b>	*	<b>48.82</b>	<b>136.46</b>	<b>180.21</b>		<b>T X A</b>	NS	-	-	-	

b). Spacing (S): S<sub>1</sub>=75 X 30 cm  
S<sub>2</sub>= 60 X 30 cm

c). Ageing period (A): A<sub>0</sub> = Non aged seeds  
A<sub>2</sub> = 2 days  
A<sub>4</sub> = 4 days  
A<sub>6</sub> = 6 days

The data on seedling vigour index I during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.38). The results showed that the significant difference in seedling vigour index I was observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly higher (2573) seedling vigour index I, while lower seedling vigour index I recorded in treatment T<sub>1</sub>S<sub>2</sub> of (1495).

Accelerated ageing (AA) period showed significant difference for seedling vigour index I. Among the accelerated aged seeds, the non aged seeds (A<sub>0</sub>) recorded the highest (2382) seedling vigour index I and it was lowest (1511) with the seed subjected to accelerated ageing for 6 days (A<sub>6</sub>). The results also revealed that the increase in the accelerated ageing period declined the seedling vigour index I.

Interaction effect due to treatments and ageing period during accelerated ageing in (Table 4.38), showed significant difference in seedling vigour index I. The data revealed significant decline in seedling vigour index I after two days of ageing compared to fresh seed. Non aged (A<sub>0</sub>) Nithyashree seeds subjected for accelerated ageing T<sub>9</sub>S<sub>1</sub> recorded the highest (3290) seedling vigour index I. While, lower (1787) observed with T<sub>1</sub>S<sub>2</sub> on seeds subjected for six days (A<sub>6</sub>).

#### **4.3.6 Seedling vigour index II**

The data on seedling vigour index II during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.38). The results showed that the significant difference in seedling vigour index II was observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly higher (7373) seedling vigour index II, while lower seedling vigour index II recorded in treatment T<sub>1</sub>S<sub>2</sub> of (4979).

Accelerated ageing (AA) period showed significant difference for seedling vigour index II. Among the accelerated aged seeds, the non aged

seeds ( $A_0$ ) recorded the highest (7529) seedling vigour index II and it was lowest (4381) with the seed subjected to accelerated ageing for 6 days ( $A_6$ ). The results also revealed that the increase in the accelerated ageing period declined the seedling vigour index II.

Interaction effects due to treatment application during accelerated ageing seeds did not show any significant difference in seedling vigour index II.

#### **4.3.7 Electrical Conductivity ( $\text{dSm}^{-1}$ )**

The data on electrical conductivity during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.39). The results revealed that the non-significant difference in electrical conductivity was observed among treatments *viz.*,  $T_9S_1$  recorded non-significantly lower ( $0.017 \text{ dSm}^{-1}$ ) electrical conductivity, whereas, higher ( $0.081 \text{ dSm}^{-1}$ ) electrical conductance was observed in  $T_1S_2$  treatment.

Accelerated ageing (AA) periods showed significant difference for electrical conductivity. Among the accelerated aged seeds, the non-aged seeds ( $A_0$ ) recorded the lower ( $0.4 \text{ dSm}^{-1}$ ) electrical conductivity and it was higher ( $0.564 \text{ dSm}^{-1}$ ) with the seed subjected to accelerated ageing for 6 days ( $A_6$ ). The results also revealed that the increase in the accelerated ageing period declined the electrical conductivity.

Interaction effects due to treatment application during accelerated ageing seeds did not show any significant difference in electrical conductivity of hybrid seeds.

**Table 4.22: Hybrid seed yield plot<sup>-1</sup> (kg) and male parent seed yield plot<sup>-1</sup> (kg) as influenced by the interaction of fertilizer levels and spacings of hybrid maize NAH-2049 (Nithyashree)**

Fertilizer levels	Hybrid seed yield plot <sup>-1</sup> (kg )		Male parent seed yield plot <sup>-1</sup> (kg )	
	S <sub>1</sub>	S <sub>2</sub>	S <sub>1</sub>	S <sub>2</sub>
<b>T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup></b>	1.69	1.56	0.43	0.37
<b>T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	1.71	1.78	0.47	0.39
<b>T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 10 kg ha<sup>-1</sup>+ Boron spray (1%)</b>	2.16	2.05	0.55	0.49
<b>T<sub>4</sub>: RDF+ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%)</b>	1.84	1.84	0.51	0.45
<b>T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) +ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)</b>	2.02	1.88	0.52	0.49
<b>T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> @ 5 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)</b>	2.25	2.29	0.53	0.52
<b>T<sub>7</sub>: T<sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%)</b>	2.05	1.91	0.49	0.43
<b>T<sub>8</sub>: T<sub>2</sub>+ <i>Azotobacter</i> +PSB+VAM</b>	2.31	2.30	0.51	0.48
<b>T<sub>9</sub>: T<sub>3</sub>+<i>Azotobacter</i> +PSB+VAM</b>	2.35	2.31	0.58	0.55
<b>F test</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>S.Em ±</b>	-	-	-	-
<b>CD @ 5%</b>	-	-	-	-

S = Spacings

S<sub>1</sub>=75 X 30 cm

S<sub>2</sub>= 60 X 30 cm

**Table 4.39 : Electrical conductivity (dSm<sup>-1</sup>) and total dehydrogenase activity (TDH) (OD value) at 480 nm as influenced by plant density and plant nutrition on hybrid maize NAH-2049(Nithyashree) subjected for accelerated ageing test**

Treatments	Electrical conductivity (dSm <sup>-1</sup> )					Total dehydrogenase activity (OD value)					a). Fertilizer levels (T) <b>T<sub>1</sub></b> : (150:75:40NPK kg ha <sup>-1</sup> ) +ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> <b>T<sub>2</sub></b> :(187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) <b>T<sub>3</sub></b> :(225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) <b>T<sub>4</sub></b> :(150:75:40NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%) <b>T<sub>5</sub></b> : (187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%)+Boron spray 1%) <b>T<sub>6</sub></b> :( 225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%)+ Boron spray(1%) <b>T<sub>7</sub></b> : T <sub>1</sub> + <i>Azotobacter</i> +PSB+VAM + Boron spray (1%) <b>T<sub>8</sub></b> : T <sub>2</sub> + <i>Azotobacter</i> +PSB+VAM <b>T<sub>9</sub></b> : T <sub>3</sub> + <i>Azotobacter</i> +PSB+VAM  b). Spacing (S): S <sub>1</sub> =75 X 30 cm S <sub>2</sub> = 60 X 30 cm  c). Ageing period (A): A <sub>0</sub> = Non aged seeds A <sub>2</sub> = 2 days A <sub>4</sub> = 4 days A <sub>6</sub> = 6 days
	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	
<b>T<sub>1</sub>S<sub>1</sub></b>	0.03	0.37	0.54	0.60	0.38	1.09	1.08	0.50	0.30	<b>0.74</b>	
<b>T<sub>2</sub> S<sub>1</sub></b>	0.02	0.35	0.54	0.56	0.37	1.25	1.07	0.53	0.39	<b>0.81</b>	
<b>T<sub>3</sub> S<sub>1</sub></b>	0.02	0.33	0.44	0.46	0.31	1.38	1.15	0.63	0.53	<b>0.92</b>	
<b>T<sub>4</sub> S<sub>1</sub></b>	0.02	0.41	0.45	0.70	0.40	1.14	1.06	0.59	0.39	<b>0.80</b>	
<b>T<sub>5</sub> S<sub>1</sub></b>	0.02	0.26	0.37	0.52	0.29	1.33	1.08	0.59	0.43	<b>0.86</b>	
<b>T<sub>6</sub> S<sub>1</sub></b>	0.02	0.25	0.53	0.55	0.34	1.47	1.09	0.60	0.46	<b>0.91</b>	
<b>T<sub>7</sub> S<sub>1</sub></b>	0.02	0.26	0.52	0.56	0.34	1.58	1.16	0.63	0.59	<b>0.99</b>	
<b>T<sub>8</sub> S<sub>1</sub></b>	0.02	0.25	0.37	0.51	0.29	1.53	1.20	0.73	0.60	<b>1.02</b>	
<b>T<sub>9</sub> S<sub>1</sub></b>	0.02	0.25	0.30	0.58	0.29	1.75	1.40	0.90	0.63	<b>1.17</b>	
<b>T<sub>1</sub>S<sub>2</sub></b>	0.08	0.32	0.48	0.73	0.40	0.94	0.47	0.31	0.28	<b>0.50</b>	
<b>T<sub>2</sub> S<sub>2</sub></b>	0.08	0.29	0.46	0.51	0.34	0.95	0.52	0.36	0.29	<b>0.53</b>	
<b>T<sub>3</sub> S<sub>2</sub></b>	0.03	0.28	0.48	0.51	0.32	0.76	0.83	0.45	0.31	<b>0.59</b>	
<b>T<sub>4</sub> S<sub>2</sub></b>	0.07	0.33	0.47	0.51	0.34	0.94	0.72	0.43	0.32	<b>0.61</b>	
<b>T<sub>5</sub> S<sub>2</sub></b>	0.06	0.28	0.46	0.53	0.33	0.79	0.80	0.38	0.36	<b>0.58</b>	
<b>T<sub>6</sub> S<sub>2</sub></b>	0.03	0.29	0.47	0.55	0.33	0.99	0.80	0.49	0.39	<b>0.67</b>	
<b>T<sub>7</sub> S<sub>2</sub></b>	0.04	0.26	0.47	0.60	0.34	0.86	0.82	0.50	0.46	<b>0.66</b>	
<b>T<sub>8</sub> S<sub>2</sub></b>	0.03	0.25	0.47	0.60	0.34	0.97	0.86	0.52	0.46	<b>0.70</b>	
<b>T<sub>9</sub>S<sub>2</sub></b>	0.02	0.26	0.31	0.57	0.29	1.16	0.86	0.79	0.61	<b>0.85</b>	
<b>Ageing (A)</b>	0.04	0.29	0.45	0.56	0.34	<b>1.16</b>	<b>0.94</b>	<b>0.55</b>	<b>0.43</b>	<b>0.77</b>	
	<b>F test</b>	<b>S.Em±</b>	<b>CD 5 %</b>	<b>CD 1%</b>		<b>F test</b>	<b>S.Em±</b>	<b>CD 5%</b>	<b>CD 1%</b>		
<b>T</b>	NS	-	-	-		<b>T</b>	*	<b>0.08</b>	<b>0.22</b>	<b>0.28</b>	
<b>A</b>	*	<b>0.03</b>	<b>0.07</b>	<b>0.09</b>		<b>A</b>	*	<b>0.04</b>	<b>0.10</b>	<b>0.13</b>	
<b>T X A</b>	NS	-	-	-		<b>T X A</b>	NS	-	-	-	

#### **4.3.8 Total dehydrogenase activity (OD value) @ 480nm**

The data on during Total dehydrogenase activity in accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.39). The results showed that the significant difference in total dehydrogenase activity was observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly higher (1.75 OD value) total dehydrogenase activity, while lower total dehydrogenase activity recorded in treatment T<sub>1</sub>S<sub>2</sub> of (0.76 OD value).

Accelerated ageing (AA) period showed significant difference for total dehydrogenase activity. Among the accelerated aged seeds, the non aged seeds (A<sub>0</sub>) recorded the highest (1.16 OD value) total dehydrogenase activity and it was lowest (0.61 OD value) with the seed subjected to accelerated ageing for 6 days (A<sub>6</sub>). The results also revealed that the increase in the accelerated ageing period declined the total dehydrogenase activity.

Interaction effects due to treatment application during accelerated ageing seeds did not show any significant difference in total dehydrogenase activity.

#### **4.3.9 Seed health percentage**

The data on seed health per cent during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.40). The results showed that the significant difference in seed health per cent was observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly lowest (0.00 %) seed infection or infestation per cent, while higher seed infection or infestation per cent recorded in treatment *viz.*, T<sub>1</sub>S<sub>2</sub>, T<sub>2</sub>S<sub>2</sub> and T<sub>4</sub>S<sub>2</sub> of (20%).

**Table 4.40 : Seed health (%) and field emergence (%) as influenced by plant density and plant nutrition on hybrid maize NAH-2049 (Nithyashree) subjected for accelerated ageing test**

Treatments	Seed health (%)					Field emergence (%)					a). Fertilizer levels (T) T <sub>1</sub> : (150:75:40NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> T <sub>2</sub> :(187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>3</sub> :(225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 10 kg ha <sup>-1</sup> + Boron spray (1%) T <sub>4</sub> :(150:75:40NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%) T <sub>5</sub> : (187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%)+Boron spray 1%) T <sub>6</sub> :( 225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg ha <sup>-1</sup> + ZnSo <sub>4</sub> spray (2%)+ Boron spray(1%) T <sub>7</sub> : T <sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%) T <sub>8</sub> : T <sub>2</sub> + Azotobacter +PSB+VAM T <sub>9</sub> : T <sub>3</sub> +Azotobacter +PSB+VAM
	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	A <sub>0</sub>	A <sub>2</sub>	A <sub>4</sub>	A <sub>6</sub>	MEAN	
T <sub>1</sub> S <sub>1</sub>	-	13.33(21)	18.00(25)	43.00(40)	<b>18.58(21)</b>	91(72)	90(71)	88(70)	79(63)	<b>87(69)</b>	b). Spacing (S): S <sub>1</sub> =75 X 30 cm S <sub>2</sub> = 60 X 30 cm  c). Ageing period (A): A <sub>0</sub> = Non aged seeds A <sub>2</sub> = 2 days A <sub>4</sub> = 4 days A <sub>6</sub> = 6 days
T <sub>2</sub> S <sub>1</sub>	-	9.33(17)	15.67(23)	37.67(37)	<b>15.67(19)</b>	93(75)	90(71)	88(70)	78(62)	<b>88(70)</b>	
T <sub>3</sub> S <sub>1</sub>	-	6.33(14)	12.67(20)	30.33(33)	<b>12.33(17)</b>	94(76)	93(75)	90(71)	84(66)	<b>90(71)</b>	
T <sub>4</sub> S <sub>1</sub>	-	9.67(18)	14.67(22)	39.67(39)	<b>16.00(19)</b>	95(77)	91(72)	88(70)	82(64)	<b>90(71)</b>	
T <sub>5</sub> S <sub>1</sub>	-	9.33(17)	17.00(24)	36.67(37)	<b>15.75(19)</b>	95(77)	91(72)	88(70)	82(62)	<b>90(71)</b>	
T <sub>6</sub> S <sub>1</sub>	-	8.00(16)	13.67(21)	31.67(34)	<b>13.33(18)</b>	96(78)	93(75)	90(71)	82(62)	<b>90(71)</b>	
T <sub>7</sub> S <sub>1</sub>	-	10.00(18)	15.00(22)	36.67(36)	<b>15.42(19)</b>	95(77)	94(76)	91(72)	83(65)	<b>91(72)</b>	
T <sub>8</sub> S <sub>1</sub>	-	7.67(15)	14.00(21)	33.33(35)	<b>13.75(18)</b>	96(78)	96(78)	91(72)	84(66)	<b>92(73)</b>	
T <sub>9</sub> S <sub>1</sub>	-	4.83(12)	13.33(21)	30.67(33)	<b>12.21(16)</b>	98(81)	97(80)	91(72)	85(67)	<b>93(75)</b>	
T <sub>1</sub> S <sub>2</sub>	-	11.67(19)	26.67(30)	44.33(41)	<b>20.67(23)</b>	90(70)	88(70)	82(64)	77(61)	<b>84(66)</b>	
T <sub>2</sub> S <sub>2</sub>	-	11.33(19)	26.33(30)	42.33(40)	<b>20.00(22)</b>	90(70)	88(70)	83(65)	78(62)	<b>84(66)</b>	
T <sub>3</sub> S <sub>2</sub>	-	11.67(19)	17.33(24)	36.33(36)	<b>16.33(20)</b>	93(75)	91(72)	85(67)	82(64)	<b>88(70)</b>	
T <sub>4</sub> S <sub>2</sub>	-	11.50(19)	25.00(29)	43.67(41)	<b>20.04(22)</b>	91(72)	90(71)	86(68)	79(63)	<b>87(69)</b>	
T <sub>5</sub> S <sub>2</sub>	-	10.67(19)	24.00(28)	42.67(40)	<b>19.33(22)</b>	92(73)	91(72)	87(69)	80(63)	<b>87(69)</b>	
T <sub>6</sub> S <sub>2</sub>	-	11.67(19)	17.00(24)	38.67(38)	<b>16.83(20)</b>	94(76)	92(73)	87(69)	80(63)	<b>88(70)</b>	
T <sub>7</sub> S <sub>2</sub>	-	9.00(17)	23.00(28)	40.67(39)	<b>18.17(21)</b>	92(73)	92(73)	86(68)	80(63)	<b>88(70)</b>	
T <sub>8</sub> S <sub>2</sub>	-	8.00(16)	18.33(25)	38.33(38)	<b>16.17(19)</b>	95(77)	93(75)	88(70)	82(64)	<b>90(71)</b>	
T <sub>9</sub> S <sub>2</sub>	-	8.33(16)	16.33(23)	36.00(36)	<b>15.17(19)</b>	95(77)	95(77)	88(70)	83(65)	<b>90(71)</b>	
Ageing (A)	<b>0.00</b>	<b>9.57(17)</b>	<b>18.22(25)</b>	<b>37.93(37)</b>	<b>16.43(20)</b>	<b>91(72)</b>	<b>92(73)</b>	<b>88(70)</b>	<b>80(63)</b>	<b>88(70)</b>	
	<b>F test</b>	<b>S.Em±</b>	<b>CD 5 %</b>	<b>CD 1%</b>		<b>F test</b>	<b>S.Em±</b>	<b>CD 5%</b>	<b>CD 1%</b>		
<b>T</b>	*	<b>1.61</b>	<b>4.49</b>	<b>5.93</b>		<b>T</b>	*	<b>0.38</b>	<b>1.05</b>	<b>1.39</b>	
<b>A</b>	*	<b>0.76</b>	<b>2.12</b>	<b>2.80</b>		<b>A</b>	*	<b>0.18</b>	<b>0.50</b>	<b>0.66</b>	
<b>T X A</b>	NS	-	-	-		<b>T X A</b>	NS	-	-	-	

Accelerated ageing (AA) period showed significant difference for seed health per cent among the accelerated aged seeds, the non aged seeds (A<sub>0</sub>) recorded the lowest (0.00 %) seed infection or infestation per cent and it was highest (37.93 %) with the seed subjected to accelerated ageing for 6 days (A<sub>6</sub>). The results also revealed that the increase in the accelerated ageing period declined the seed health per cent.

Interaction effects due to treatment application during accelerated ageing seeds did not show any significant difference in seed health per cent.

#### **4.3.10 Field emergence (%)**

The data on field emergence per cent during accelerated ageing as influenced by plant density and plant nutrition under different ageing periods depicted in (Table 4.40). The results showed that the significant difference in field emergence per cent was observed among treatments *viz.*, T<sub>9</sub>S<sub>1</sub> recorded significantly higher (93 %) field emergence per cent, while lower Field emergence per cent recorded in treatment *viz.*, T<sub>1</sub>S<sub>2</sub> and T<sub>2</sub>S<sub>2</sub> (84 %).

Accelerated ageing (AA) period showed significant difference for field emergence per cent. Among the accelerated aged seeds, the non aged seeds (A<sub>0</sub>) recorded the higher (91 %) field emergence per cent and it was lower (80 %) with the seed subjected to accelerated ageing for 6 days (A<sub>6</sub>). The results also revealed that the increase in the accelerated ageing period declined the field emergence per cent.

Interaction effects due to treatment application during accelerated ageing seeds did not show any significant difference in field emergence per cent.

# *Discussion*

## V. DISCUSSION

The primary means of augmenting increased quality hybrid seed production are optimum plant population and judicious nutrient management. Further, the interaction of spacing with different fertilizer levels need to be studied for newly developed hybrids to increase the seed yield and quality.

Assessment of pollen viability in hybrid seed production involves an effective, because desired and viable pollens play a vital role in deciding the success of hybrid seed set on female parent. Further in hybrid seed production early or late flowering (non synchrony of parental lines) of restorer line and inadequacy of pollens account for biotic or abiotic factors is very much felt leading to poor seed set. Hence, there is a need to acquire knowledge of pollen viability (Visser 1955).

The seed ageing is a universal physiological phenomenon followed by seed deterioration resulting in loss of viability and vigour. Seed sellers are much concerned with the storage potential of seeds, because of decline in germination percentage below seed certification standards become unsalable resulting in financial loss. Further loss of seed viability during storage and consequent decrease in their vigour results in lower plant stand and thus results in low yield from plant raised from such seeds are greater concern to seed producers and growers.

Therefore, it has become imperative to evolve efficient technologies for quality seed production to resolve the ultimate venture of maximizing production and productivity of seed yield. Keeping these in view the results generated from the studies on

1. To study the effect of plant density and mother plant nutrition on growth, seed yield and quality of hybrid maize.
2. To study the pollen viability in male parent of hybrid maize.
3. To study the seed ageing on seed quality of hybrid maize.

### **5.1 Effect of plant nutrition on plant growth seed yield and quality of maize hybrid NAH-2049**

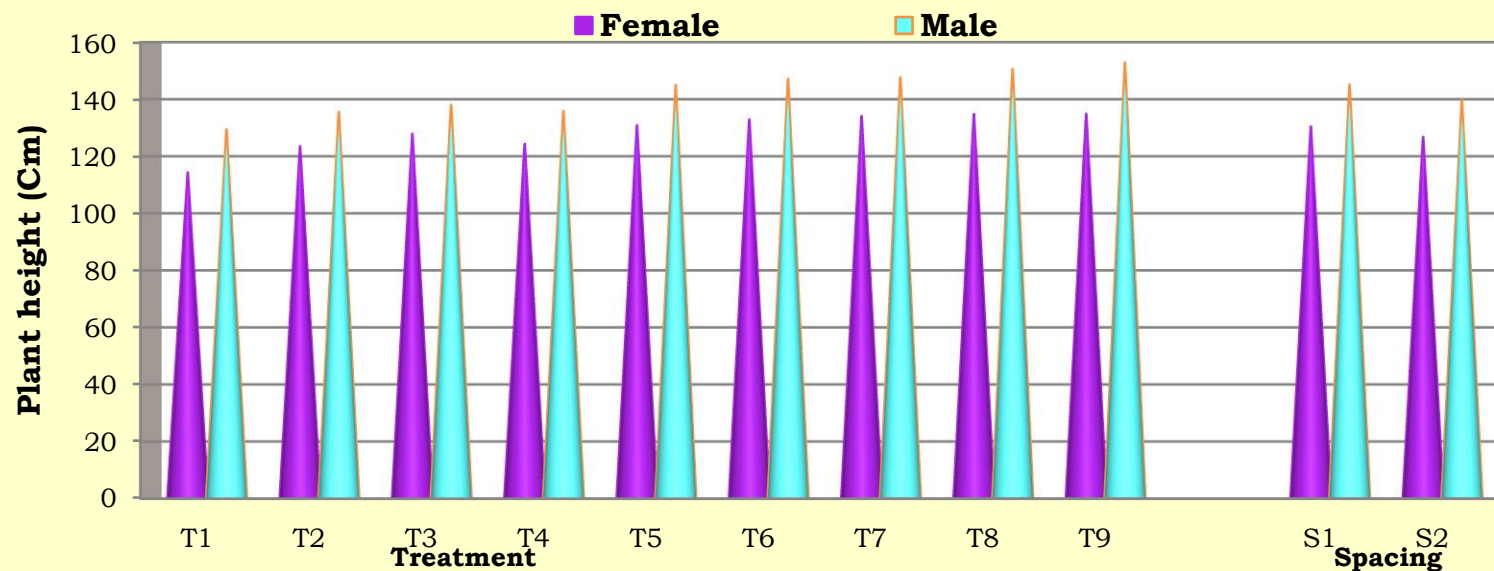
Nourishment of mother plant with balanced nutrition of macro nutrients (nitrogen, phosphorous and potassium), micro nutrients and biofertilizers could help in proper growth and development and cause for exhibiting the potential seed yield.

Micronutrients like iron, zinc and boron are essential for plant growth and cell metabolism. Iron is necessary for the synthesis of chlorophyll, though it actually does not enter into its composition. Iron starved plants develop chlorosis in the young leaves and the veins remaining green. Salts or complex of zinc can easily absorbed directly through leaves. Hence, foliar spray is used for correcting zinc deficiency. The symptoms of zinc deficiency appears generally in younger leaves, starting with interveinal chlorosis leading to a reduction in shoot growth and shortening of internodes, mottle leaf, little leaf etc. The principle function of zinc in plants is a metal activator of enzymes (Wongmo *et al.*, 2004). Due to lack of boron, there is hypertrophy, degeneration and disintegration of cambium cells in the meristematic tissues. Thus, necrosis of tissues is the most important symptom of boron deficiency (Sittichai Lordkaew *et al.*, 2010).

The cost of inorganic fertilizers has been enormously increasing to an extent that they are out of reach of the small and marginal farmers. So, the use of biofertilizers in such situation is, therefore, a practically paying proposal. Phosphate solubilizers are solubilise the unavailable

phosphorus in the soil and make it available for plants. While, *Azotobacter*, a heterotrophic nitrogen fixing organism has been reported to be beneficial and economical on several crops. They are known to improve growth, yield as well as productivity of crops.

The present investigation, higher growth and development exhibited increased seed yield with the application of 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup> + *Azotobacter* + PSB + VAM + Boron spray (1%) (T<sub>9</sub>) recorded significantly higher seed weight plant<sup>-1</sup> (114.2 g) (Fig 5.5), seed yield plot<sup>-1</sup> (2.33 kg) and seed yield ha<sup>-1</sup> (3237.65 kg) (Fig 5.6) on female parent (SKV-50), whereas in male parent (MAI-105) also showed same trend in seed yield plot<sup>-1</sup> (0.56 kg) and seed yield ha<sup>-1</sup> (782.40 kg), tried in the experiment (T<sub>9</sub>) 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup> + *Azotobacter* + PSB + VAM + Boron spray (1%), followed by T<sub>8</sub> as compared to other fertilizer levels. The treatment (T<sub>9</sub>) gives 46% higher seed yield than control (T<sub>1</sub>). This might be due to higher levels of inorganic fertilizers which favors the photosynthetic efficiency during seed setting and seed filling and higher seed yield is the result increased production of photosynthates and their translocation to the developing cobs. The seed yield varied through the variation in yield components viz., cob length, cob weight and cob diameter etc. The phosphobacteria solubilize and increase the availability of organic phosphorus to the plants and its greater uptake. Similar, findings were also reported by (Ganapathy and Savalgi., 2006). *Azotobacter* could be attributed to the effect of growth hormones like IAA, cytokinin produced by *Azotobacter* also stimulated root growth and induced the changes in root morphology, which in turn improved assimilation of nutrients and thus seed yield (Raouf Seyed Sharifi *et al.*, 2011). Increased with increase in fertilizer levels resulted in higher seed yield. These results were similar with the earlier findings of Krishnaveni and Ramaswamy *et al.* (1985). Zinc acts as a catalyst or stimulant in physiological and metabolic process and



**Fig 5.1: Influence of fertilizer levels and spacings on plant height (cm) at 90 DAS on female parent (SKV-50) and male parent (MAI-105) of hybrid maize NAH-2049 (Nithyashree)**

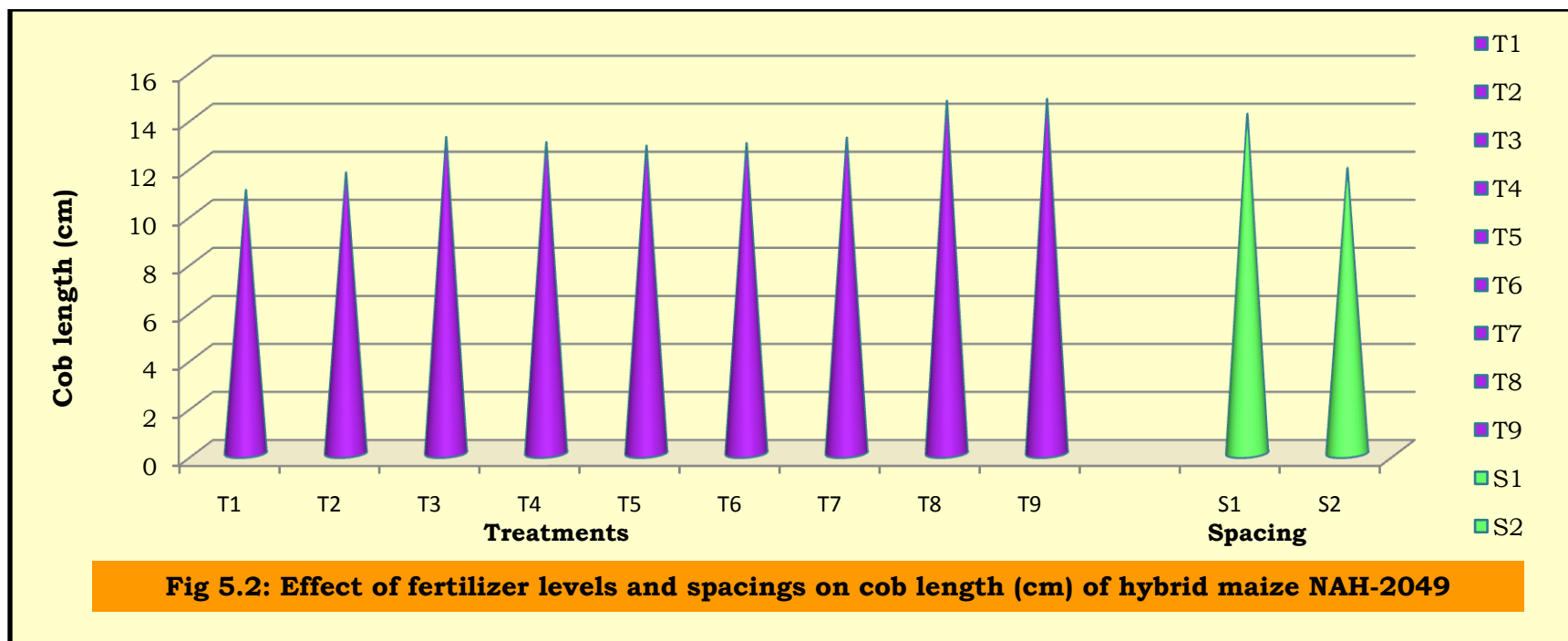
### Treatment Details

- T<sub>1</sub> : (150:75:40NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm

metal activator of enzymes, resulting in higher yield. The foliar application of micronutrients during the grain filling stage significant nutrient uptake leads to increase seed yield (Dranichnikova 1977).

In the present study, the seed yield with treatment 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) (T<sub>9</sub>) has been attributed to the variation in the yield components such as pith weight (32.33 g), cob diameter (12.16 cm), cob length (14.74 cm) (Fig 5.2), 100 seed weight (35.18 g) and cob weight (135.40 g) (Fig 5.3). All these yield components were higher with treatment (T<sub>9</sub>) as compared to T<sub>1</sub>: 150:75:40 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>. Similarly, several workers have reported increase in seed yield due foliar fertilization were applied earlier development stages leads to higher seed yield (Bommegowda 1968), (Barel, 1975). The organic manures supply micronutrients in readily available form to plants, react with native soil nutrients in a way that enhance their availability to crops (Devarajan *et al.* 1988). Increase in yield components and test weight was reported by Khot and Umrani (1992) and also by (Yadav and Singh., 2000). Thus, it is clear that the adequate supply of mother plant nutrition could enhance the yield components and the final seed yield.

The increase in yield components was consequence of better growth parameters. In the present study, treatment 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) (T<sub>9</sub>) caused taller plants at 30, 60, and 90 DAS (Fig 5.1) (36.17, 127.72 and 134.90 cm) respectively in female parent (SKV-50) and in male parent also recorded significant differences plant height (44.27,140.40 and 152.80cm) at 30, 60 and 90 DAS respectively, compared to treatment (T<sub>1</sub>) in female parent (SKV-50) recorded (28.65, 93.13 & 114.32 cm) respectively and male parent (MAI-105) recorded (33.10, 102.97 and 129.45 cm) respectively. Active absorption and metabolism of nitrogen



### Treatment Details

- T<sub>1</sub> : (150:75:40NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm

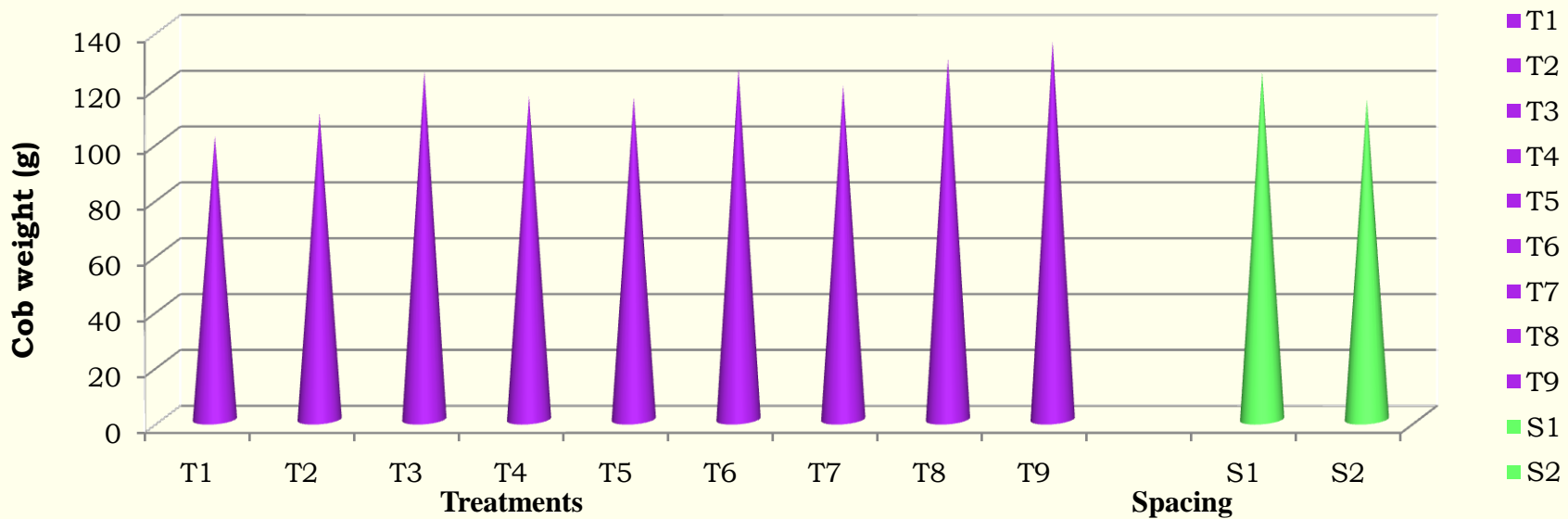


**Plate 4: Influence of fertilizer levels and spacings on cob length of hybrid maize NAH-2049 (Nithyashree)**

results in increase in plant height, it is agreement with the findings of (Prasad and Singh 1990). Likewise, in number of leaves at 30, 60 and 90 DAS (5.20, 10.07 & 11.98), respectively were found in treatment (T<sub>9</sub>) in female parent (SKV-50) and male parent (MAI-105) observed (5.37, 11.73 and 12.85) when compared to treatment (T<sub>1</sub>) (4.43, 8.17 & 10.77) and (4.77, 9.30 and 10.23), respectively in both the parents. The present findings were supported by (Maurya *et al.*, 2004). Increase in plant height and number of leaves may be due to the involvement of zinc in chlorophyll formation, which might have helped to favour cell division, meristematic activity in apical tissue, expansion of cell and formation of new cell wall (Singh *et al.*, 1983), (Roy Singh., 1986) and (Tripathi *et al.*, 1987).

Increase in seed yield and its attributes may be due to the significant increase in growth parameters such as plant height and number of leaves which grown by adequate mother plant nutrition. Because of more number of leaves, photosynthetic activity is also more and enhanced the carbohydrate synthesis, which led to increase in the seed yield and its components. Higher seed set may be due to adequate plant nutrients availability, which contributed more towards the seed yield. Similar findings are also reported by (Kanwal *et al.*, 2010).

With respect days to 50 per cent tasselling and silking significantly differed in application of treatment 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) (T<sub>9</sub>) took (46.83) days to 50 per cent tasselling, compared (56.50) day to 50 per cent tasselling at treatment (T<sub>1</sub>). Likewise with respect days to 50 percent silking, application of treatment (T<sub>9</sub>) has taken less days for 50 percent silking (51.00) compared to (68.00) treatment (T<sub>1</sub>). Early tasseling and silking in both the parents may be due to availability of nutrients and



**Fig 5.3: Effect of fertilizer levels and spacings on cob weight (g) of hybrid maize NAH-2049**

### Treatment Details

- T<sub>1</sub> : (150:75:40NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm

water at all these levels of treatments. These results supported by (Aswathaiah 1977) and (Muniswamy *et al.*, 2007).

With respect to seedling vigour index (Fig 5.8), application of treatment (T<sub>9</sub>) 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) recorded significantly higher seedling vigour index I and II (3240 & 8547 respectively) as against T<sub>1</sub> treatment which was recorded (1845 & 6140), respectively. This increased seedling vigour index with higher dose of fertilizer was a result of significantly higher germination (98%) and mean seedling dry weight (87.45 mg) as against (T<sub>1</sub>) (94 %, 65.22 mg and 34.10 cm), respectively. These results were compared with (Channakeshava *et al.*, 2001), (Virupaksha 2002), (Muniswamy *et al.*, 2007) and (Narayanaswamy and Siddaraju 2011).

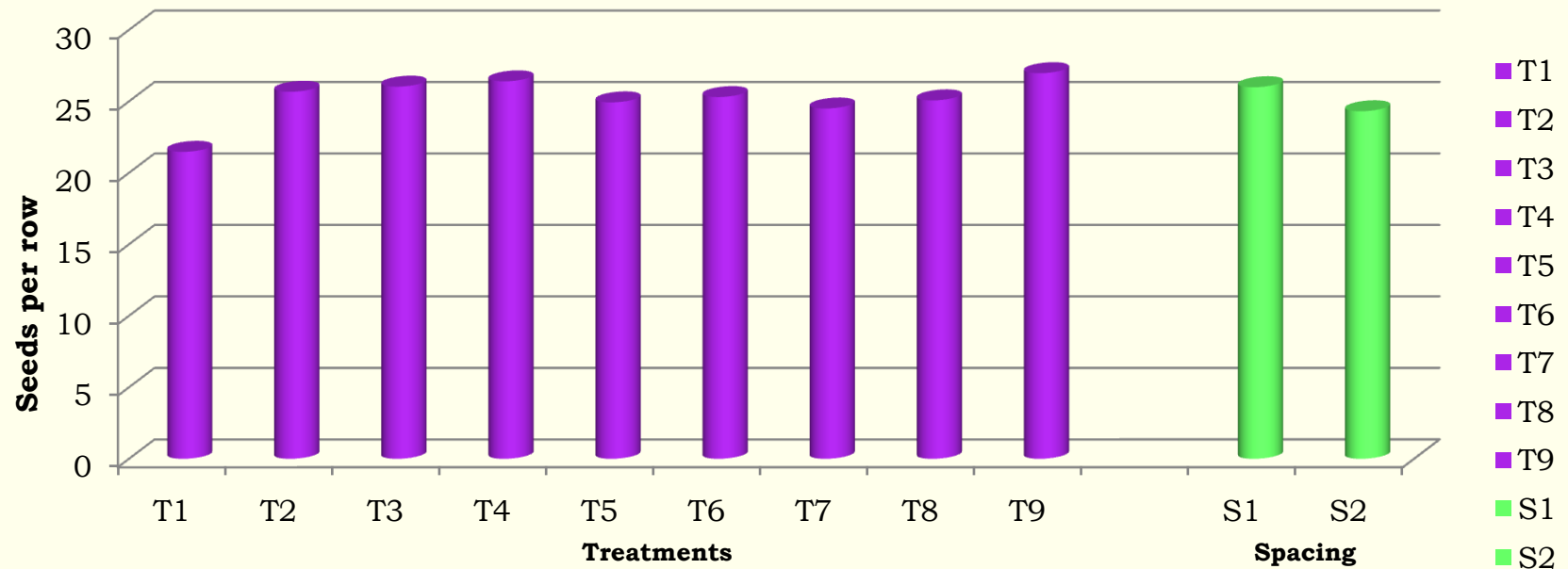
Further, in sorghum (Basavaraju 1982) reported that increase in the levels of nitrogen application to the seed parent significantly increased the germination percentage, seedling vigour of hybrid seed.

In wheat (Holzman 1972) observed that seeds from higher levels of fertilizers were significantly superior in root, shoot length and dry weight of seedling to those seeds obtained from lower levels of fertilizers.

The present study revealed that the treatment T<sub>9</sub>: 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) could be applied to obtain maximum seed yield and quality of the maize hybrid.

## **5.2 Effect of plant density and spacing on crop growth, yield components and quality of maize hybrid NAH-2049 (Nithyashree)**

Seed yield is a complex trait influenced by multiple factors, of which plant density and inter and intra-row spacing plays a dominant



**Fig 5.4: Influence of fertilizer levels and spacings on seeds per row of hybrid maize NAH-2049**

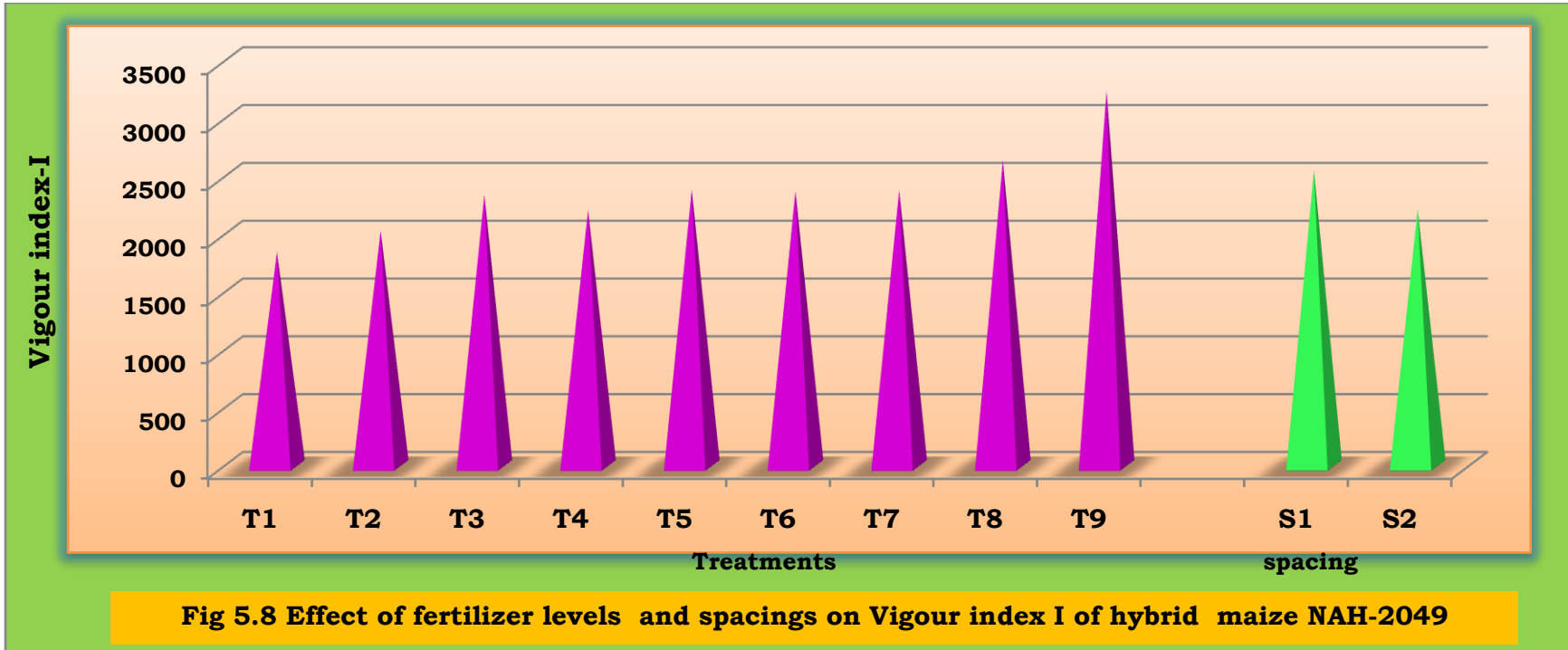
### Treatment Details

- T<sub>1</sub> : (150:75:40NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm

role towards quality seed production. The optimum number of plants per unit area is an important non-monetary input, which decides the maximum productivity. For obtaining higher seed yield and quality, suitable planting distance is necessary for enhancing metabolic activities of the plant which intern influence the plant growth. This would be achieved by efficient utilization of biological resources such as solar energy, water and nutrients (Bangarwa and Kairon, 1993).

Wider spacing of 75 X 30 cm recorded significantly the highest plant height at 30 and 90 DAS (33.66 and 130.45 cm), as against (30.21 and 126.76 cm), respectively with the closer spacing of 60 X 30 cm in female parent (SKV-50). Whereas, at 60 DAS non significant difference in plant height due to reduced spacing levels. Significantly higher plant height (39.70 and 145 cm, respectively) in male parent (MAI-105) was noticed with the spacing of 75 X 30 cm at 30 and 90 DAS as compare to lower spacing of 60 X 30 cm (36.90 and 139.73 cm, respectively). At 60 DAS the spacing levels did not differ significantly with respect to plant height.

Number of leaves per plant differs significantly at 30 and 60 DAS due to spacing levels, higher number of leaves (5.04 and 9.31) was recorded with the spacing of 75 X 30 cm, as compare to lower spacing of 60 X 30 cm (4.61 and 8.90) in female parent (SKV-50). Whereas, at 90 DAS there is no significant difference observed in number of leaves per plant due to spacing levels. At 90 DAS, male parent (MAI-105) recorded significantly higher number of leaves per plant (12.25) with the spacing of 75 X 30 cm, as against 60 X 30 cm (11.67). At 30 and 60 DAS there is no significant differences were identified. The higher plant height and number of leaves per plant may be due to there was low competition for space, mutual shading effect, nutrients and moisture due to reduced plant density per unit area and thus resulted in to taller plants and more



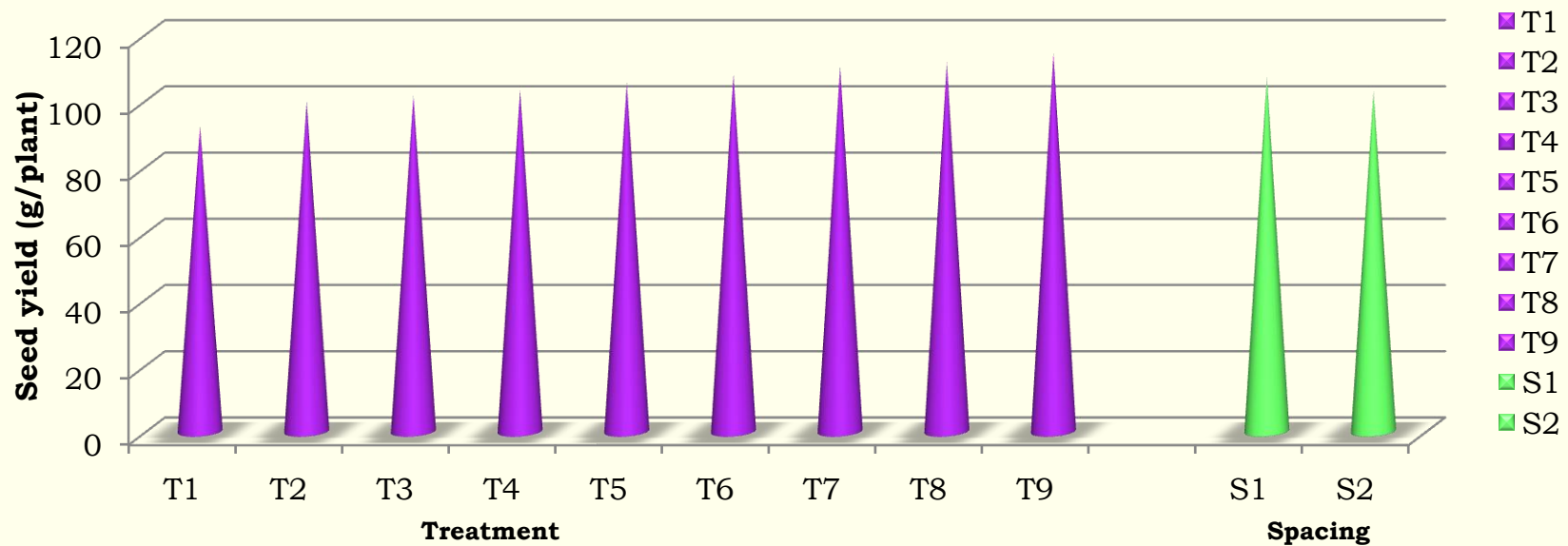
**Treatment Details**

- T<sub>1</sub> : (150:75:40NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>)+ ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm

green leaves per plant in wider spacing resulting to higher growth parameters and these results are agreement with findings of (Tanka and Yamaguchi 1972), (Channakeshava 1998), (Huseyin Gozubenli *et al.*, 2003), (Chutima Koshawatana *et al.*, 2010) and (Narayanaswamy and Siddaraju, 2011).

Days taken to 50 per cent tasseling in pollen parent and silking in seed parent significantly differed due to spacing levels. The early flowering was observed with the spacing of 75 X 30 cm (50.74 and 55.15 days, respectively) as compare to lower spacing of 60 X 30 cm (51.70 and 64.59 days, respectively). In the present study, plants at wider spacing of 75x 30 cm reached early 50 per cent tasseling and silking, while those plants at higher density delayed 50 per cent tasseling and silking, which indicates that closer spacing leads to the barrenness of the plants, which is probably due to increased time lag between tasseling and silking consequent to the competition to biological resources and also water stress at the time of reproductive phase leads to delayed emergence of tassel and silk. More over maize is a C<sub>4</sub> plant the water use efficiency is more compare to C<sub>3</sub> plants and less capable of adjusting itself for the stress created due to increased population and this may lead to prolong the vegetative stage in closer spacing these results are inconformity with the findings of (Krishnamurthy *et al.*, 1974) and (Channakeshava, 1998).

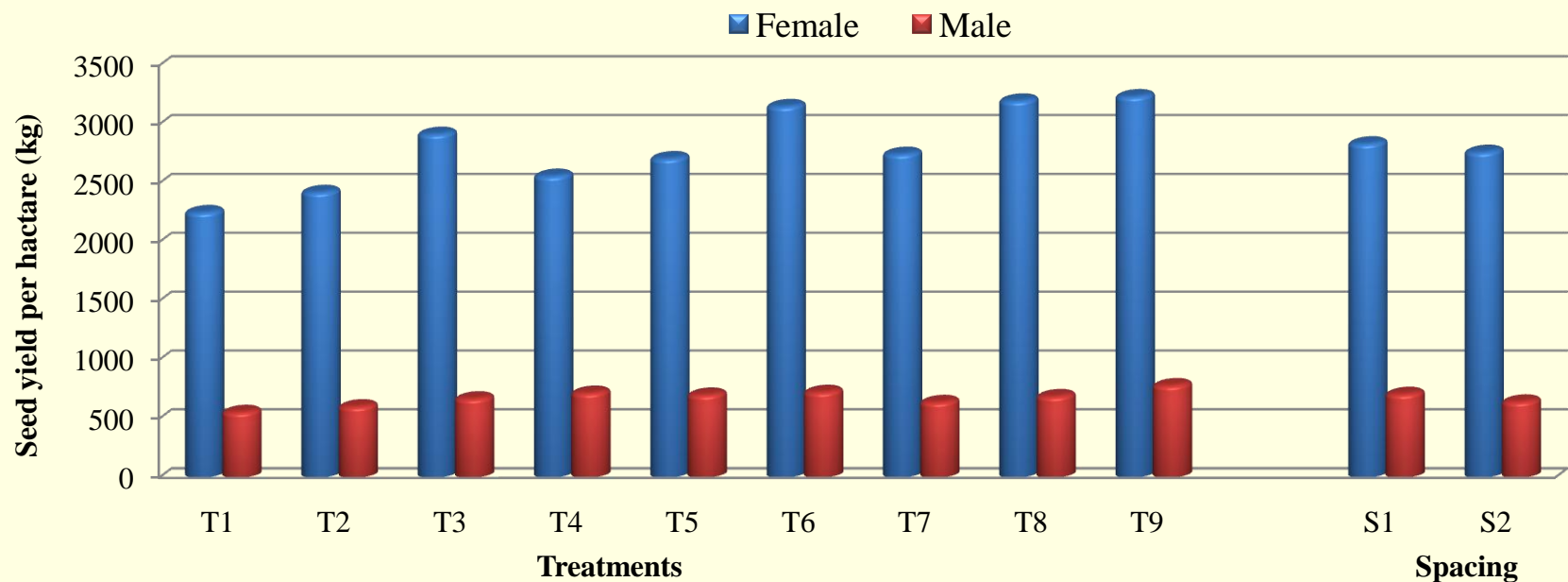
This may be due to the availability of more nutrients per unit area and availability of space for the plants to open up the leaves and better development of the plant & higher photosynthetic efficiency of the leaves. Lanky stem at lower spacing may be due to competition among the plants for light, nutrients, water and light resources. Similar observations were made by (Nunez and Kamprath 1969) and (Muniswamy *et al.*, 2007).



**Fig 5.5 : Effect of fertilizer levels and spacings on seed yield per plant (g) of hybrid maize NAH-2049**

### Treatment Details

- T<sub>1</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm



**Fig 5.6: Effect of fertilizer levels and spacings on hybrid seed yield  $\text{kg ha}^{-1}$  and male parent (MAI-105) seed yield  $\text{kg ha}^{-1}$  of hybrid maize NAH-2049**

### Treatment Details

- T<sub>1</sub> : (150:75:40NPK  $\text{kg ha}^{-1}$ ) + ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK  $\text{kg ha}^{-1}$ ) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK  $\text{kg ha}^{-1}$ ) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK  $\text{kg ha}^{-1}$ ) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK  $\text{kg ha}^{-1}$ ) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK  $\text{kg ha}^{-1}$ ) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm

In the present experiment, the analysis of variance in maize hybrid yield due to different spacings predicted that sowing at 75 x 30 cm has recorded significantly highest seed yield (708.62 kg ha<sup>-1</sup>) in male (MAI-105) compared to closer spacing of 60 x 30 cm recorded (643.96 kg ha<sup>-1</sup>). There is no significant difference due to spacings in female seed yield. These results are in conformity with findings of (Yadav and Singh, 2000), (Virupaksha, 2002), (Muniswamy *et al.*, 2007) and (Ummed singh *et al.*, 2006). The higher seed yield with wider spacing may be attributed to reduced competition among the plants which leads to efficient harvesting of biological resources such as water, solar energy and nutrient. Closer spacing resulted in lower seed yield these findings are in line with the previous findings of (Eik and Hanway, 1965) who inferred that with increased plant population the photosynthetic efficiency was low due to mutual shading of leaves.

Increased seed yield at wider spacing is due to its increased yield components that contribute to the higher seed yield. Similarly, (Krishnamurthy *et al.*, 1973) also observed positive correlation between yield components and seed yield.

Wider spacing of 75 X 30 cm gave significantly higher cob length (14.12 cm), (Plate 4) cob diameter (11.68 cm), cob weight (124.44 g), pith weight (28.64 g), number of seeds per row (25.99) (Fig 5.4) , seed weight per plant (107.26 g) and increased 100 seed weight (34.32 g) these results are in lineage with the observation made by (Singh and Srivastava 1991) and (Nehra *et al.*, 1981) noticed increased seed yield components with decreased plant density.

(Deasi 1987) and (Channakeshavasharma 1990) reported that higher number of cobs per plant, number of kernel per cob, 100 kernal weight at lower plant population. Further, (Krishnaveni and Ramaswamy 1985) recorded improved in length of cob, cob weight, number of seeds

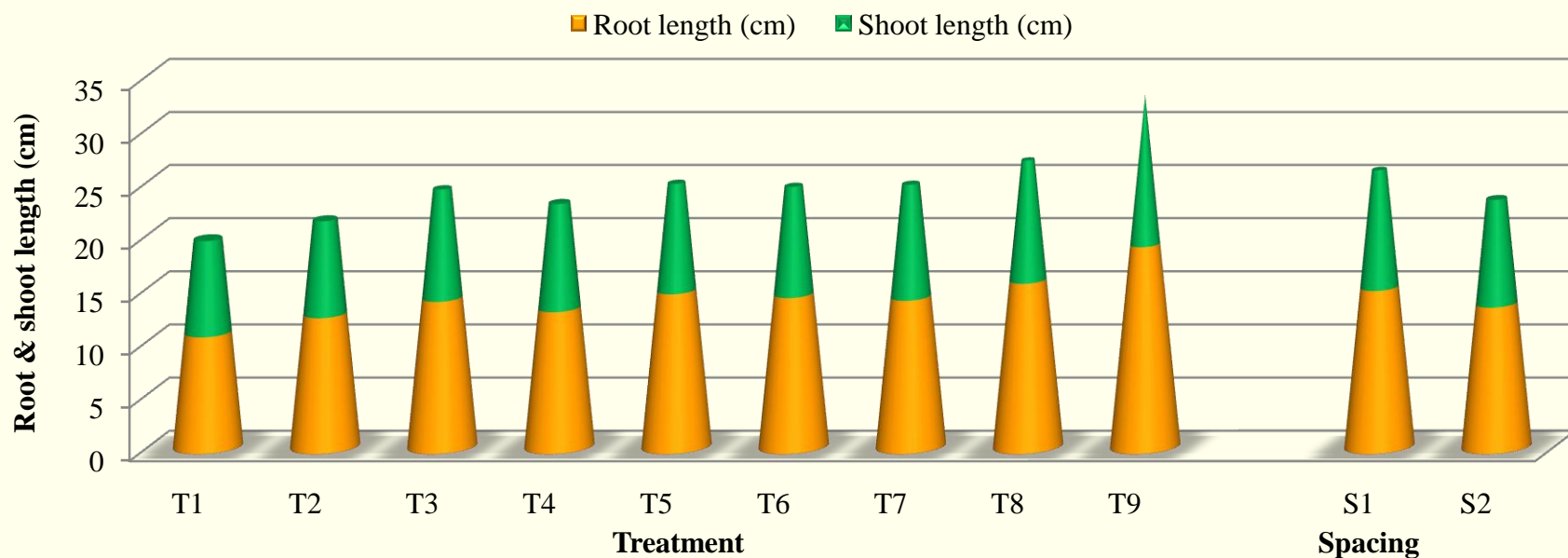
and seed weight per cob with wider spacing. The better yield attributing characters may be attributed to the better translocation of photosynthates from source to sink leading to less number of barren cobs and development of bold seeds at wider spacing compared to narrow spacing.

The seed quality parameters significantly differed due to different spacing levels. Higher spacing of 75 X 30 cm recorded significantly higher seed quality parameters viz., germination percent (98%), seedling dry weight (82.09 mg), shoot length (11.09 cm), root length (15.01 cm) (Fig 5.7), seedling vigour index I (2553), seedling vigour index II (8021), TDH activity (1.39 @ 480nm), field emergence (95 %) and lower electrical conductivity (EC) (0.022 dSm<sup>-1</sup>) as compared to lower spacing of 60 X30 cm. This may be probably due to better seed filling at wider spacing with the better availability of water & nutrients. Wider spacing also resulted in higher test weight with better storage of food reserves in seeds, similar results of improved seed quality were observed by (Presolka, 1981) and (Yadav & Singh, 2000) in maize, the higher seedling vigour index with wider spacing is attributed mainly to the increased seedling length and dry weight of seedling.

Thus the present study suggests that spacing of 75 x 30 cm is best suited for the seed production of the NAH-2049 for higher seed yield and better seed quality.

### **5.3 Interaction effect of spacing and fertilizer levels on crop growth, seed yield and quality of maize hybrid**

Interaction of spacing and fertilizer levels caused non significant variation in seed yield of maize hybrid. Whereas, sowing at wider spacing of 75 x 30 cm along with the application of treatment (T<sub>9</sub>): 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray



**Fig 5.7: Influence of fertilizer levels and spacings on shoot and root length (cm) of hybrid maize NAH-2049 (Nithyashree)**

### Treatment Details

- T<sub>1</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub> : (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub> : (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) +Boron spray (1%)
- T<sub>6</sub> : (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub>spray (2%) + Boron spray (1%)
- T<sub>7</sub> : T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub> : T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub> : T<sub>3</sub>+Azotobacter +PSB+VAM
- S<sub>1</sub> : 75 x 30 cm
- S<sub>2</sub> : 60 x 30 cm

(1%) produced higher seed yield (3265.43 kg ha<sup>-1</sup> and 803 kg ha<sup>-1</sup>) in both the parental lines of NAH-2049 (SKV-50 X MAI-105) respectively, compared to all other treatment combination on the contrary, spacing of 60 x 30 cm with treatment (T<sub>9</sub>) resulted in seed yield (3209.88 kg ha<sup>-1</sup> 761.60 kg ha<sup>-1</sup>) in parental lines compared to all other treatments. This clearly indicates that in maize hybrid maximum seed yield could be obtained only at higher fertility levels with optimum plant population. These results are supported by (Nandapuri., 1965) (Yadav and Singh., 2000).

In the present investigation, the increase in seed yield with wider spacing and higher fertilizer levels was mainly attributed to higher weight of cob (138.53 g), higher cob length (15.67 cm), higher cob diameter (12.24 cm) and higher plant height at 90 DAS (135.47 cm) compared to other treatment combinations. Present results also confirmed the findings of (Reddy *et al.*, 1987).

Krishnamurthy *et al.*, 1974 opined that in maize under normal field condition the major cause for the yield variation was the difference existing in grain weight per cob, length of cob, dry weight of cob and number of seeds per cob due to variations in both seed weight per cob and test weight, were also observed in this present investigation.

In present study treatment combination of (T<sub>9</sub>): 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) at 75 x 30 cm recorded significantly due to the interaction of fertilizer levels and spacing higher seed quality parameters *viz.*, seedling dry weight (90.57 mg), shoot length (15.79 cm) and root length (20.46 cm), seedling vigour index I & II (3290 and 8996), respectively. Increased with increase in fertility levels and row spacing the seed quality is high. These results supported by Yadav and Singh., 2000 and Reddy *et al.*, 1987.

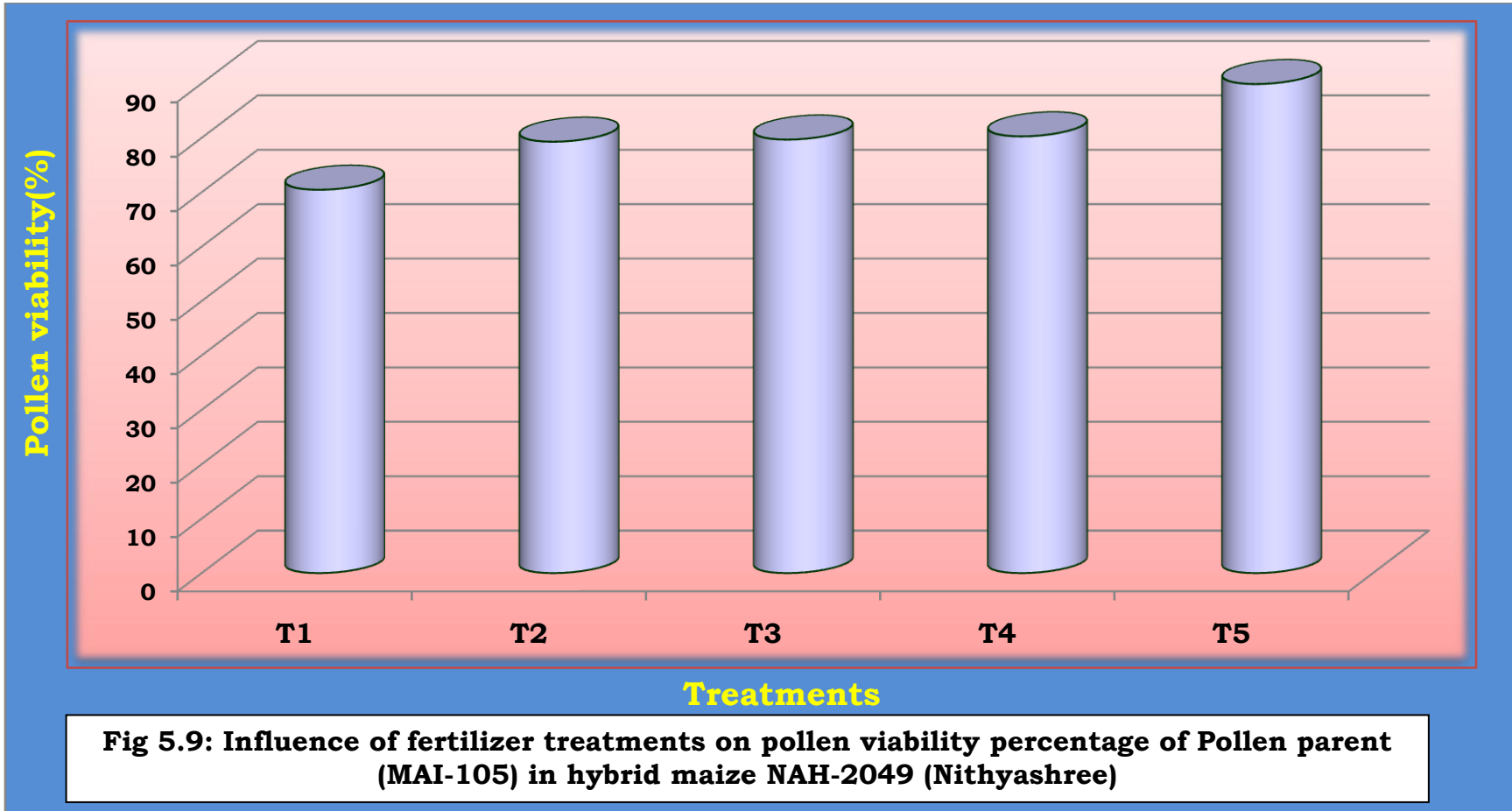
Channakeshava (1998) and Arunkumar *et al.* (2007) reported that seed quality of corn seed increased when crop was grown under high fertility and low plant populations. It is a recognized fact that the soluble protein content of seeds promotes germination and vigour as it imparts strength to the seedlings.

Yield is rather complex trait of a number of attributing characters. In the present study, the most important yield attributing traits *viz.*, cob length, cob diameter, number of seeds per cob, plant height, stem girth were increased with fertilizer doses and row spacing. The present results also confirmed the findings of (Reddy *et al.*, 1987) and Channakeshava (1998). Thus it appears that the interaction effect between fertilizer doses and row spacing were pronounced for most of the variables under study. It was mainly because of better performance of individual plants due to reduced competition among the plants themselves and greater availability of nutrients.

The present study therefore suggests that, spacing of 75 x 30 cm and combination of fertilizer levels 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSO<sub>4</sub> 10 kg ha<sup>-1</sup> + *Azotobacter* + PSB + VAM + Boron spray (1%) needs to be exploited to get maximum yield of the maize hybrid NAH-2049.

#### **5.4 Studies on pollen viability**

Pollens are most essential and precious genetic material transmitting male gametes in sexual reproduction. Hence, success of any hybrid seed production depends upon seed setting percentage on the female parent which will be decided by pollen viability, its fertilizing capacity through development of an effective tube growth. It is also learnt from literature that pollen viability varies significantly from species to species.



**Treatment details :**

T<sub>1</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>)

T<sub>2</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>

T<sub>3</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> spray (2%)

T<sub>4</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg ha<sup>-1</sup> + Boron spray (1%)

T<sub>5</sub> : RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)

The environmental factors particularly higher temperature and higher humidity greatly affect the pollen viability (Golovin,1973).

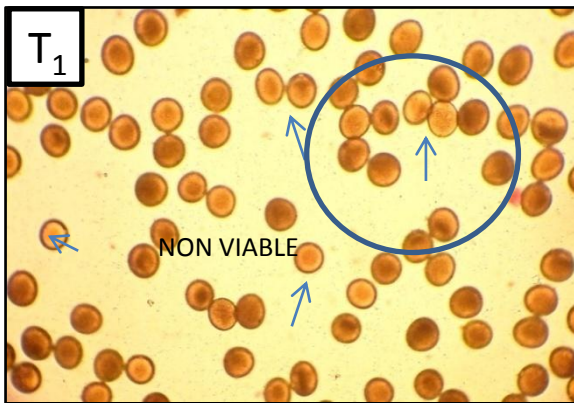
Pollination should be made in time when both parents are synchronous in flowering and delay or earliness of male parent for its flowering leads to problem in hybrid seed production. Hence, there arise thinking of pollen viability and pollen use efficiency. Keeping in view of these problems in the present study, pollen viability have also been paid keen interest under *in vitro* studies.

#### **5.4.1 *In vitro* studies on pollen viability**

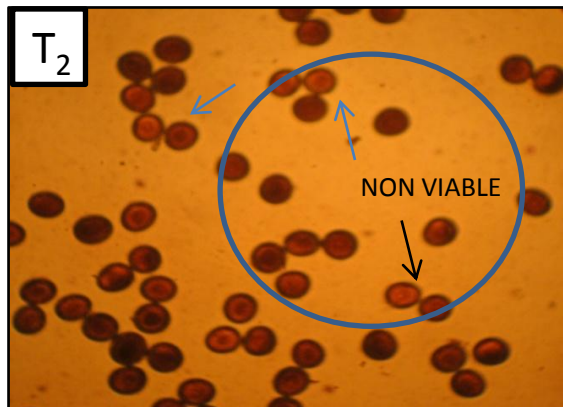
*In vitro* studies on pollen viability were conducted by using acetocarmine stain (2%). Pollen viability percentage of male parent showed significant difference (Fig 5.9). Among the fertilizer treatments T<sub>5</sub> : 150:75:40 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%) recorded higher viability percentage (89.89) (Plate 3) as compare to the other treatments. Similar results noticed that the anther and pollen may be more sensitive to B deficiency than the pistil (Dell and Huang 1997; Brown *et al.*, 2002).

Boron (B) deficient silks may not function properly and seed setting may still fails when healthy pollen is applied to them because healthy pollen requires sufficient B supply to germinate fully. The greater sensitivity to B deficiency of the pistil also means that B analysis of the ear and the silk should give the most direct and precise diagnosis for B deficiency in maize. As many crop species exhibit a wide range of genotypic variation in B efficiency it should be useful to explore this among maize genotypes, with B delivery to the growing ear and silk as the primary criterion (Rerkasem and Jamjod, 1997).

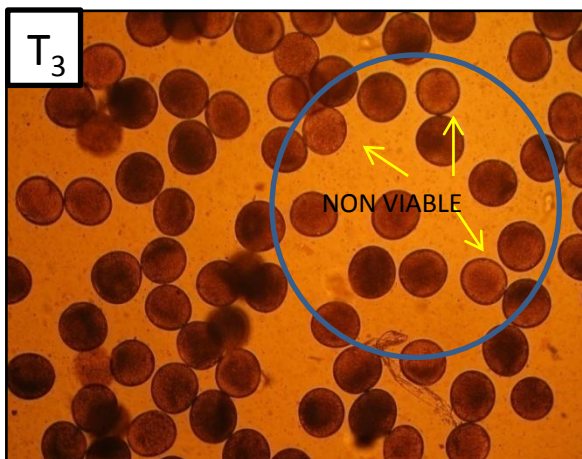
Continued zinc deficiency had effect onset of the reproductive phase, but severely retarded the development of tassels, anthers and pollen



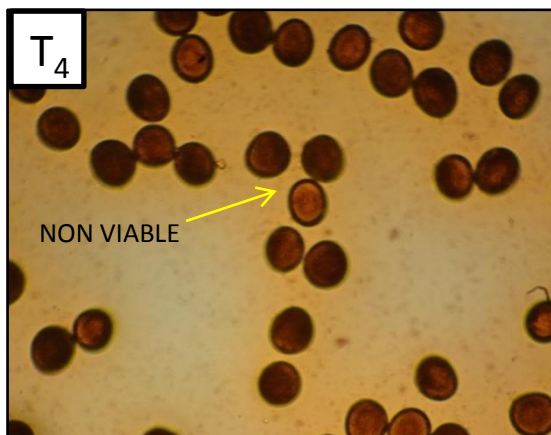
**RDF**



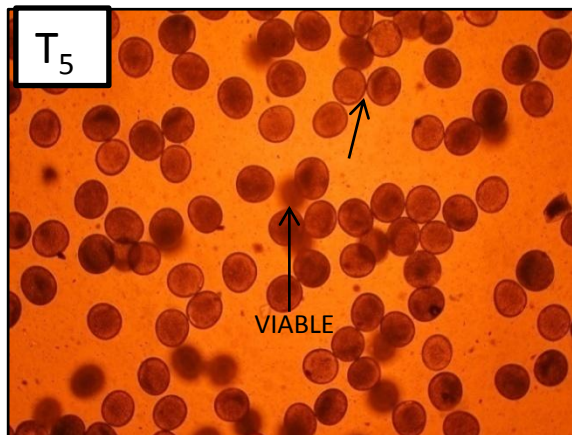
**RDF + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>**



**RDF + ZnSo<sub>4</sub> spray (2%)**



**RDF + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup> +  
Boron spray (1%)**



**RDF + ZnSo<sub>4</sub> spray (2%) +  
Boron spray (1%)**

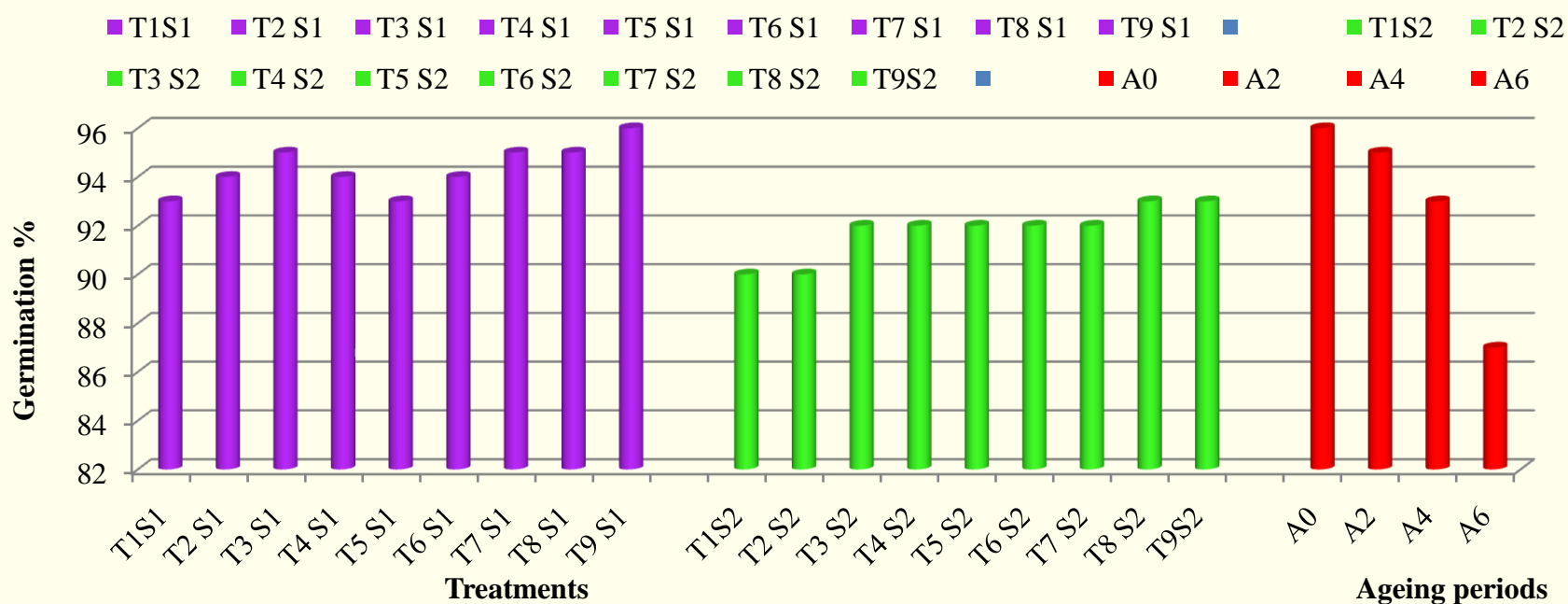
**Plate 3 : viability of male parent (MAI-105) pollen at different fertilizer levels as tested by acetocarmine 2 per cent**

grains. They observed decrease in pollen producing capacity of anthers and pollen fertility in low-zinc plants indicates suppression of male sexuality due to zinc deficiency. The loss of fertility of pollen from zinc-deficient plants was underestimated by the *in vitro* germination of pollen grains, as compared to the seed-set method (Sharma *et al.*, 1991).

### **5.5 Effect of plant population and plant nutrition on accelerated aging on seed quality in maize**

Accelerated aging technique was first developed by Delouche 1965 at the seed technology laboratory, Mississippi State University, U.S.A. This technique is now widely used for evaluating seed vigour and predicting storage potential of seed lots. Before conducting the germination test, the seeds are exposed to high temperature (40–45 °C) and high relative humidity (100 %) for varying periods of time depending on the crop.

In the present study influence of spacing and plant nutrition on hybrid seeds are subjected under different accelerated aging periods showed significant difference (fig 5.10), Among the accelerated aged seeds, the non aged seeds ( $A_0$ ) recorded the highest in higher germination per cent (96 %), seedling dry weight (78.26 mg), shoot and root length (10.50 and 14.24 cm), seedling vigour index I & II (2382 and 7529), total dehydrogenase activity (1.16 OD value) @ 480nm and field emergence (91%) (95.15 %) compared to the 2,4 and 6 days aged seeds .while goes on increased the ageing period linearly reduction of seed quality traits was recorded. Similar trend was reported by many research workers like Delouche and Baskin (1973) in maize, water melon, sorghum and onion; Desai (1976), Dey and Mukherjee (1986), Hussaini *et al.* (1988), Ramamoorthy *et al.* (1989), Drochioiu *et al.* (1993), Cruz-Garcia *et al.* (1995) and Santipracha *et al.* (1997) in maize.



**Fig 5.10: Germination (%) as influenced by plant density and plant nutrition on hybrid maize NAH-2049 (Nithyashree) subjected for accelerated ageing test**

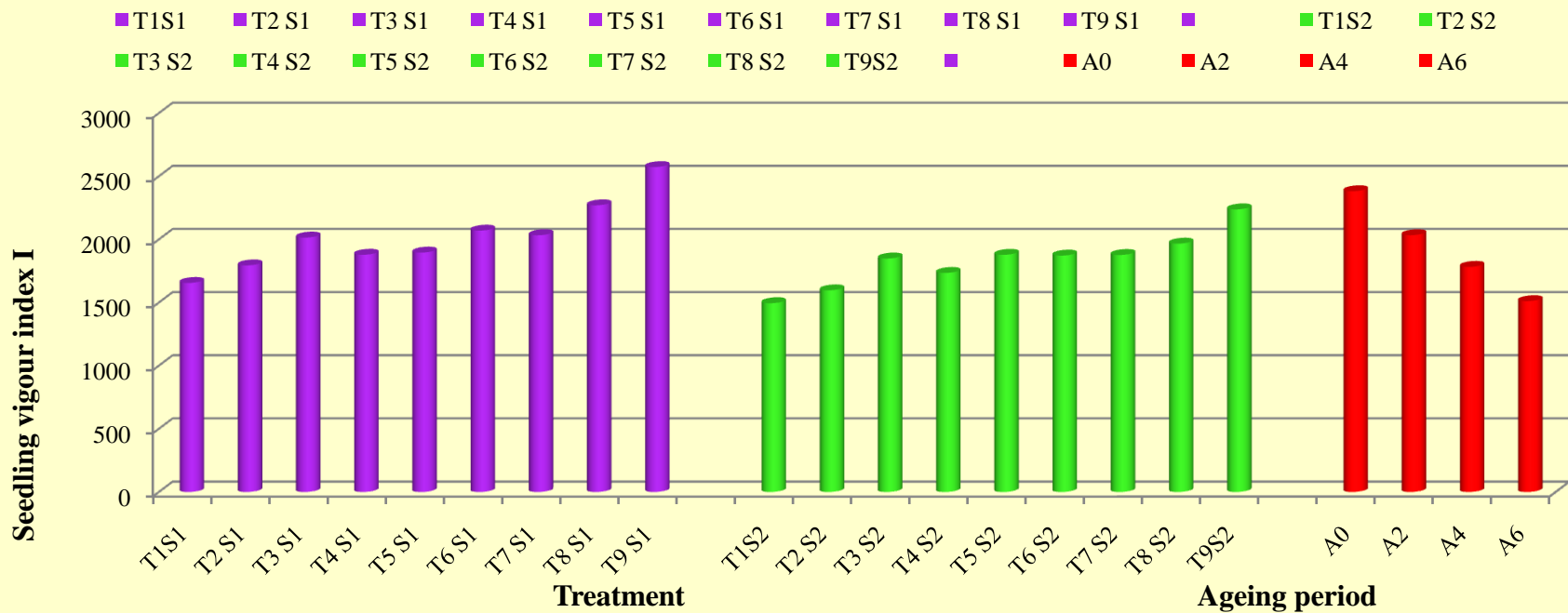
**Treatment Details**

- |                  |  |                  |               |
|------------------|--|------------------|---------------|
| T <sub>1</sub> : | (150:75:40NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 10 kg   | S <sub>1</sub> : | 75 x 30 cm    |
| T <sub>2</sub> : | (187.5:93.5: 50 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg + Boron spray (1%)                             | S <sub>2</sub> : | 60 x 30 cm    |
| T <sub>3</sub> : | (225:112.5:60 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg + Boron spray (1%)                               | A <sub>0</sub> : | Non aged Seed |
| T <sub>4</sub> : | (150:75:40NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 5 kg + ZnSo <sub>4</sub> spray (2%)                        | A <sub>2</sub> : | 2 Days        |
| T <sub>5</sub> : | (187.5:93.5: 50 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg + ZnSo <sub>4</sub> spray (2%) +Boron spray (1%) | A <sub>4</sub> : | 4 Days        |
| T <sub>6</sub> : | (225:112.5:60 NPK kg ha <sup>-1</sup> )+ ZnSo <sub>4</sub> @ 5 kg + ZnSo <sub>4</sub> spray (2%) + Boron spray (1%)  | A <sub>6</sub> : | 6 Days        |
| T <sub>7</sub> : | T <sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)   |                  |               |
| T <sub>8</sub> : | T <sub>2</sub> + Azotobacter +PSB+VAM  |                  |               |
| T <sub>9</sub> : | T <sub>3</sub> +Azotobacter +PSB+VAM   |                  |               |

Seed subjected to accelerated aging maintained a minimum of 90 per cent germination up to four days of aging, then after it declined below the minimum seed certification standards for germination. The seedling vigour parameters like shoot length, root length, seedling dry weight and vigour index of seedlings obtained from accelerated aged seeds also indicated decrease in their trend with increase in aging period, a similar trend was reported by Hussaini *et al.* (1988), Ramamoorthy *et al.* (1989) and Ramlal *et al.* (1995) in maize.

Different treatment combinations seeds subjected for accelerated ageing to predict the seed quality. However, germination (96 %), seedling dry weight (76.67 mg), shoot and root length (12.11 and 14.55 cm), seedling vigour index I & II (2573 and 7373) (Fig 5.11), total dehydrogenase activity (1.17) @ 480 nm (Fig 5.12) and field emergence (93 %) recorded significantly higher in (Fig 5.11) treatment of T<sub>9</sub>S<sub>1</sub> (NPK @ 225:112.5:60 kg ha<sup>-1</sup> +10 kg ZnSO<sub>4</sub> kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM , 75 X 30 cm) as compared to all the treatments. It might be the test weight is more compare to other treatments and lower electrical conductivity leachets are released.

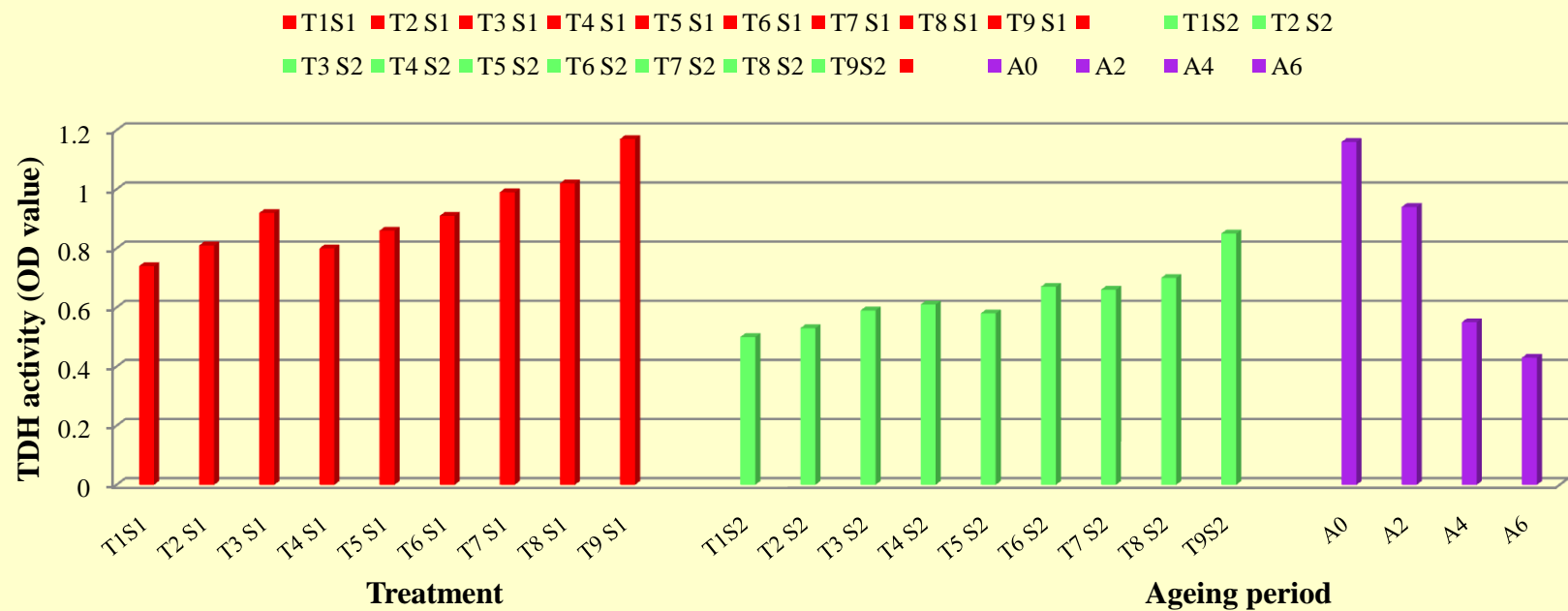
The reduction in germination and seedling vigour may be due to different changes that are reported to take place at different levels during seed deterioration including impairment shifts in metabolic activity, constitutive changes like membrane permeability as evidenced by leakage of electrolytes from accelerated aged seeds (Dey and Mukharjee, 1986; Ashwathaiyah *et al.*, 1987. Pandey, 1989), reduction in food resources in aged seeds (Basavarajappa *et al.*, 1991), accumulation of free fatty acids, increase in lipase activity, changes in the activity of proteinase and several biochemical changes (Christensen and Kauffman, 1969; Perl *et al.*, 1978 and St. angelo and Ory, 1983), free radical formation and lipid peroxidation (Priestley and Leopold, 1979) and



**Fig 5.11: Seedling vigour index I as influenced by plant density and plant nutrition on on hybrid maize NAH-2049 (Nityashree) subjected for accelerated ageing test.**

**Treatment Details**

- |   |                                |
|---|--------------------------------|
| T <sub>1</sub> : (150:75:40NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg  | S <sub>1</sub> : 75 x 30 cm    |
| T <sub>2</sub> : (187.5:93.5: 50 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg + Boron spray (1%)                               | S <sub>2</sub> : 60 x 30 cm    |
| T <sub>3</sub> : (225:112.5:60 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 10 kg + Boron spray (1%)                                 | A <sub>0</sub> : Non aged Seed |
| T <sub>4</sub> : (150:75:40NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 5 kg + ZnSo <sub>4</sub> spray (2%)                          | A <sub>2</sub> : 2 Days        |
| T <sub>5</sub> : (187.5:93.5: 50 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 5 kg + ZnSo <sub>4</sub> spray (2%) + Boron spray (1%) | A <sub>4</sub> : 4 Days        |
| T <sub>6</sub> : (225:112.5:60 NPK kg ha <sup>-1</sup> ) + ZnSo <sub>4</sub> @ 5 kg + ZnSo <sub>4</sub> spray (2%) + Boron spray (1%)   | A <sub>6</sub> : 6 Days        |
| T <sub>7</sub> : T <sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)   |                                |
| T <sub>8</sub> : T <sub>2</sub> + Azotobacter +PSB+VAM  |                                |
| T <sub>9</sub> : T <sub>3</sub> +Azotobacter +PSB+VAM   |                                |



**Fig 5.12: Total dehydrogenase activity (TDH) (OD value) as influenced by plant density and plant nutrition on hybrid maize NAH-2049 (Nithyashree) subjected for accelerated ageing test**

**Treatment Details**

- T<sub>1</sub>: (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg
- T<sub>2</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>3</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 10 kg + Boron spray (1%)
- T<sub>4</sub>: (150:75:40NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%)
- T<sub>5</sub>: (187.5:93.5: 50 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)
- T<sub>6</sub>: (225:112.5:60 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub>@ 5 kg + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%)
- T<sub>7</sub>: T<sub>1</sub> + Azotobacter +PSB+VAM + Boron spray (1%)
- T<sub>8</sub>: T<sub>2</sub>+ Azotobacter +PSB+VAM
- T<sub>9</sub>: T<sub>3</sub>+Azotobacter +PSB+VAM

- S<sub>1</sub>: 75 x 30 cm
- S<sub>2</sub>: 60 x 30 cm
- A<sub>0</sub>: Non aged Seed
- A<sub>2</sub>: 2 Days
- A<sub>4</sub>: 4 Days
- A<sub>6</sub>: 6 Days

cytological and genetic changes (Purkar and Banerjee, 1983; Fluminhan and Kameya, 1997). electrical conductivity of seed leachate tended to increase with the increase in the accelerated aging period, indicating the loss of seed vigour with the advancement of aging period. This is in agreement with the findings of Santipracha *et al.* (1997).

Interaction effect due to treatments and accelerated aging periods showed significant difference. Nithyashree seeds subjected to zero days ( $A_0$ ) aged and treatment  $T_9S_1$  (NPK @ 225:112.5:60 kg ha<sup>-1</sup>+10 kg ZnSo<sub>4</sub>+ Boron spray (1%) +*Azotobacter* +PSB+VAM,75 x 30 cm) recorded the higher (15.79 cm) shoot length, (20.46 cm) root length and (3290) seedling vigour index I. Compared to all the treatment and ageing period combinations.

The reduction in germination and seedling vigour parameters due to accelerated aging may also be due to the interaction of temperature and humidity beyond certain levels, increasing catabolic changes at the cellular levels beyond the threshold of tolerance and leading to lethality (Purkar and Banerjee, 1983). It is assumed that the processes of deterioration under accelerated aging conditions are similar to those under normal conditions but the rate of deterioration is enormously increased (Basu and Gupta, 1974).

## 5.6 Practical utility

From the practical utility of these studies are could be made for the production of quality seeds in hybrid maize NAH-2049.

- ❖ Application of 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) will enhance the seed yield (3237.65 kg ha<sup>-1</sup>) and improves the quality of maize hybrid.

- ❖ Wider spacing of 75 x 30 cm was found to be optimum in realizing higher seed yield (2836.90 kg ha<sup>-1</sup>) apart from maintaining higher germination and seedling vigour.
- ❖ Wider spacing of 75 x 30 cm with an application of 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) recorded higher seed weight cob<sup>-1</sup> (138.53 g) in *kharif* season.
- ❖ Foliar application of Boron and Zinc @ (1% and 2%, respectively), it enhance the viable pollen in male parent in hybrid seed production.
- ❖ Wider spacing of 75 x 30 cm with an application of 225:112.5:60 NPK kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup>+ *Azotobacter* + PSB + VAM + Boron spray (1%) during seed ageing maintained higher seed quality attributes upto six days and shows higher relative storability.

### 5.7 Future line of work

- To exploit the hybrid seed yield potential of maize NAH-2049 on higher levels of spacing and lower levels of fertilizer (RDF) along with biofertilizers application needs further investigation under zone 5 (Southern dry zone of Karnataka).
- Interaction effects of both spacing and fertilizer at higher levels need investigation hybrid maize on seed and quality characters in under Zone 5 (Southern dry zone of Karnataka).
- To study the individual effect of biofertilizers and micro nutrients along with recommended dose of fertilizers on maize hybrid seed yield and quality attributes.
- Investigate the influence of different concentrations, foliar application of Boron and Zinc nutrients on viability of pollen grains *In vitro* and *In vivo* studies.
- Comparative studies on accelerated aging and natural aging in hybrid maize NAH-2049 for relative storability.

# *Summary*

## VI. SUMMARY

The results of the studies on “Innovative practices to enhance seed yield and quality of single cross maize hybrid NAH- 2049 (Nithyashree)” are summarized below:

### I. Influence of plant density and mother plant nutrition on growth, seed yield and quality of maize hybrid NAH-2049

1. Application of NPK @ 225:112.5:60 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM has recorded higher plant height in both female and male (SKV-50 and MAI 105) parents at 90 DAS (134.90 cm and 152.80 cm) respectively, While, application of NPK @ 150:75:40 kg ha<sup>-1</sup>+ ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup> has recorded the lower values.
2. Wider spacing at 75 X 30 cm resulted significantly higher plant height at 90 DAS in both female and male (SKV-50 and MAI 105) parents (130.45 cm and 145.12 cm) respectively, compare to 60 x 30 cm.
3. Male (MAI-105) parent number of leaves per plant differed significantly due to application of fertilizers. Application of NPK @ 225:112.5:60 kg ha<sup>-1</sup> +10 kg ZnSo<sub>4</sub> kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM recorded higher plant height in male parent (13.00). which was on par with fertilizer treatments T<sub>5</sub>,T<sub>6</sub>,T<sub>7</sub>,T<sub>8</sub> . compare to application of NPK @ 150:75:40 kg ha<sup>-1</sup> +10 kg ZnSo<sub>4</sub> .
4. Non significant results were recorded for number of leaves per plant in female (SKV-50) parent due to spacing at 90 DAS. Higher number of leaves was obtained with a spacing of 75 x 30 cm (11.42), compare to 60 x 30 cm .Whereas, in male (MAI-105) parent number

of leaves per plant differed significantly due to spacing. Higher, number of leaves per plant was recorded with a spacing of 75 x 30 cm (12.25) compared to 60 X 30 cm.

5. Plant height and number of leaves per plant did not differ significantly due to interaction of spacing and fertilizer application in both female and male (SKV-50 and MAI 105) parents at 90 DAS respectively.
6. Number of days to 50 percent tasseling in pollen parent (MAI-105) and silking in seed parent (SKV-50) differed significantly due to application of fertilizers. However, application of NPK @ 225:112.5:60 kg ha<sup>-1</sup> +10 kg ZnSo<sub>4</sub> kg ha<sup>-1</sup> + Boron spray (1%)+ *Azotobacter* + PSB + VAM recorded early to 50 percent tasseling and silking (46.83 days and 51 days ), compare to NPK @ 150:75:40 kg ha<sup>-1</sup>+10 kg ZnSo<sub>4</sub> kg ha<sup>-1</sup>.
7. Days to 50 per cent tasseling in pollen parent (MAI-105) and silking in seed parent (SKV-50) differed significantly due to spacing levels. Lower number of days taken to 50 percent tasseling and silking was obtained with a spacing of 75 x 30 cm (50.74 days and 55.15 days) respectively, while followed by 60 x 30 cm.
8. Interaction of fertilizer application and spacing resulted in significant differences in days to 50 percent tasseling in pollen parent (MAI-105) and silking in seed parent (SKV-50). Whereas, fertilizer application of NPK @ 225:112.5:60 kg ha<sup>-1</sup> +10 kg ZnSo<sub>4</sub> kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM and spacing of 75 x 30 cm observed early flowering (45.33 days and 46.67 days) respectively compared to all other treatment combination.

9. Application of NPK @ 225:112.5:60 kg ha<sup>-1</sup> +10 kg ZnSo<sub>4</sub> kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM recorded significantly higher number of cobs plant<sup>-1</sup> (2.1), cob length (14.74 cm), cob diameter (12.16 cm), cob weight (135.40 g), pith weight (32.33 g), seeds per row (26.97), 100 seed weight (35.18 g) and seed yield plant<sup>-1</sup> (114.20 g) compare to other fertilizer levels.
10. Higher number of cobs plant<sup>-1</sup> (1.51), cob length (14.74 cm), cob diameter (11.68 cm), cob weight (124.44 g), pith weight (28.64 g), seeds per row (25.99), 100 seed weight (34.32 g) and seed yield plant<sup>-1</sup> (107.26 g) was recorded with a spacing of 75 x 30 cm, while compared to closer spacing of 60 x 30 cm.
11. Application of NPK @ 225:112.5:60 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM has recorded higher seed yield plot<sup>-1</sup> and seed yield kg ha<sup>-1</sup> in both female and male (SKV-50 and MAI 105) parents (2.33 kg and 0.56 kg) and (3237.65 kg and 782.40 kg ) respectively, compare to other fertilizer levels.
12. plant population plot<sup>-1</sup>, number of cobs plant<sup>-1</sup>, cob length, cob diameter, cob weight, rows per cob, seed yield plant<sup>-1</sup>, seed yield plot<sup>-1</sup> and seed yield kg ha<sup>-1</sup> did not differed significantly due to interaction of spacing and fertilizer application.
13. Treatment combination of NPK @ 225:112.5:60 kg ha<sup>-1</sup> + ZnSo<sub>4</sub> 10 kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM has recorded significantly higher seed germination per cent (98), seedling dry weight (87.45 mg), shoot and root length (14.10 and 19.03 cm), seedling vigour index I & II (3240 and 8547), total dehydrogenase activity (1.45 OD value) @ 480nm and field emergance (96 %) compare to other fertilizer treatments.

14. Wider spacing at 75 X 30 cm resulted significantly higher germination per cent (98), seedling dry weight (82.09 mg), shoot and root length (11.09 and 15.01 cm), total dehydrogenase activity (1.39 OD value) @ 480nm and field emergence (95 %) compare to 60 x 30 cm.
15. Electrical conductivity was lower with the spacing 75 X 30 cm (0.022 dSm<sup>-1</sup>) as compared to 60 X 30 cm (0.049 dSm<sup>-1</sup>)
16. Interaction of fertilizer application and spacing resulted in significant differences of seedling dry weight (35.61 mg), shoot and root length (15.79 and 20.46 cm), seedling vigour index I & II (3290 and 8996) and total dehydrogenase activity (1.39 OD value) @ 480nm on fertilizer application of NPK @ 225:112.5:60 kg ha<sup>-1</sup> +10 kg ZnSo<sub>4</sub> kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM and spacing of 75 x 30 cm observed early flowering (45.33 days and 46.67 days) respectively compared to all other treatment combination.

## **II. To study the pollen viability percentage in male parent (MAI-105) of maize hybrid NAH-2049**

Pollen viability per cent of male parent significantly differed as influenced by different fertilizer treatments. Among the treatments application of RDF (150:75:40 NPK kg ha<sup>-1</sup>) + ZnSo<sub>4</sub> spray (2%) + Boron spray (1%) recorded higher percentage of pollen viability 89.89 %, compare to all other treatment combinations.

## **III. To study the seed ageing on seed quality of maize hybrid NAH-2049**

1. The influence of fertilizer levels and spacing on maize seeds subjected for different accelerated ageing periods to predict the seed quality.

However, germination (96 %), seedling dry weight (76.67 mg), shoot and root length (12.11 and 14.55 cm), seedling vigour index I & II (2573 and 7373), total dehydrogenase activity (1.17 OD value) @ 480nm and field emergence (93 %) recorded significantly higher in treatment of T<sub>9</sub>S<sub>1</sub> (NPK @ 225:112.5:60 kg ha<sup>-1</sup> +10 kg ZnSo<sub>4</sub> kg ha<sup>-1</sup> + Boron spray (1%) + *Azotobacter* + PSB + VAM , 75 X 30 cm) as compared to all the treatments.

2. Accelerated aging periods showed significant difference, Among the accelerated aged seeds, the non aged seeds (A<sub>0</sub>) recorded the highest in higher germination per cent (96 %), seedling dry weight (78.26 mg), shoot and root length (10.50 and 14.24 cm), vigour index I & II (2382 and 7529), total dehydrogenase activity (1.16 OD value) @ 480nm and field emergence (91%) (95.15 %) compared to the 2, 4 and 6 days aged seeds .
3. Interaction effect due to treatments and accelerated aging periods showed significant difference. Nithyashree seeds subjected to zero days (A<sub>0</sub>) aged and treatment T<sub>9</sub>S<sub>1</sub> (NPK @ 225:112.5:60 kg ha<sup>-1</sup>+10 kg ZnSo<sub>4</sub>+ Boron spray (1%) +*Azotobacter* +PSB+VAM,75 x 30 cm) recorded the higher (15.79 cm) shoot length, (20.46 cm) root length and (3290) seedling vigour index I. Compared to all the treatment and ageing period combinations.

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\* Original not seen

# *Appendices*

## APPENDIX-I

**Physical and chemical properties of the soil at Seed Technology  
Research Unit of National Seed Project, GKVK, Bengaluru-560 065**

Sl. No.	Particulars	Value	Method followed
<b>I</b>	<b>Physical properties</b>		
a)	Mechanical analysis		International Pipette method (Piper,1966)
1	Coarse sand	19.90	
2	Fine sand	33.40	
3	Silt	9.20	
4	Clay	35.50	
5	Texture class	Red sandy loam	
<b>II</b>	<b>Chemical properties</b>		
1	Soil pH	6.3	Potentiometric method, pH meter (Piper,1966)
2	Cation exchange capacity (m eq / 100 g of soil)	11.10	Neutral normal NH <sub>4</sub> OAC (Jackson,1967) Walker and Black's well
3	Electrical conductivity (EC) (m. mhos/cm)	0.12	Conductivity (Jackson, 1967)
4	Organic carbon (%)	0.31	Walkley and Black's wet oxidation method (Piper,1966)
5	Available N (kg/ha)	285.28	Alkaline permanganate method (Perur, et al., 1973 )
6	Available P <sub>2</sub> O <sub>5</sub> (kg/ha)	52.44	Baray's extractant method (Hatcher and Wilcox,1950)
7	Available K <sub>2</sub> O(kg/ha)	75.96	Turbidimetry
8	Available boron (kg/ha)	0.45	Compleximetric EDTA titration method
9	Available sulphur (ppm)	3.91	Compleximetric EDTA titration method
10	Exchangeable calcium (meq/100g)	2.40	
11	Exchangeable magnesium meq/100g)	1.62	
12	Zinc (ppm)	0.91	
13	Iron (ppm)	14.83	

## APPENDIX-II

Meteorological data indicating monthly normal, actual and deviation for the experimental period at Z.A.R.S, G.K.V.K,  
Bangalore.2011-12

Month	Total rainfall (mm)			Mean relative humidity (%)			Mean air temperature (°C)						Mean daily bright sunshine hours		
	N	A	D	N	A	D	Maximum			Minimum			N	A	D
							N	A	D	N	A	D			
JUNE-2011	80.8	30	-50.8	69.0	71.0	2.0	29.6	29.1	-0.5	19.5	19.5	0.0	5.9	6.1	0.2
JULY-2011	102.9	95.8	-7.1	72.0	73.5	1.5	28.2	27.8	-0.4	19.0	19.3	0.3	4.4	4.2	-0.2
AUG-2011	131.6	253.2	121.6	73.5	74.5	1.0	27.6	27.3	-0.3	18.8	19.3	0.5	4.8	3.3	-1.5
SEP-2011	201.9	59.7	-142.2	73.0	72.5	-0.5	28.1	28.0	-0.1	18.8	18.9	0.1	5.9	5.9	0.0
OCT-2011	171.0	122.6	-48.4	72.0	72.0	0.0	27.7	28.6	0.9	18.2	19.2	1.0	6.2	5.6	-0.6
NOV-2011	52.9	38	-14.9	72.0	73.0	1.0	26.6	26.6	0.0	16.6	15.9	-0.7	6.6	6.2	-0.4
Total/Mean	741.1	599.3	-141.8	71.9	72.7	0.8	27.9	27.9	0.0	18.5	18.7	0.2	5.6	5.2	-0.4

**Note:** N-Normal, A- Actual, D- Deviation from normal. Normal values are average of years (Total rainfall-1972 to 2010; Max. and Min. Temp. -1972 to 2010; Bright sunshine hours-1972 to 2010; Relative humidity -1972 to 2010)