Influence of Zeolite application on growth, yield and yield attributes of Finger millet (*Eleusine coracana* L.) in Rainfed condition

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ABSTRACT

A field experiment was conducted at Zonal Agricultural Research Station, Gandhi Krishi vigyana Kendra, Bengaluru during *kharif*-2017 and 2018 to study the influence of zeolite application on growth and yield of finger millet crop. The pooled analysis showed significantly higher plant height recorded in the treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Recommended dose of fertilizer) which was at par with the treatment which received zeolite 50 kg ha^{-1} +100 per cent RDF in 30, 60, 90 and at Harvest stage. The number of tillers per hill (3.44), total dry matter production (41.67 g $hill^{-1}$), number of fingers per ear head (5.95), straw yield (36.07 q ha^{-1}) and grain yield (48.00 q ha^{-1}) was recorded in the treatment received zeolite 50 kg ha^{-1} +125 per cent RDF which was at par with the treatment which received zeolite 50 kg ha^{-1} +100 per cent RDF in pooled analysis.

Key words: Graded Fertilizers, Dry matter, Fingers, Straw yield

INTRODUCTION

Zeolites are microporous, aluminosilicate minerals commonly used as commercial adsorbents and catalysts (Yapparov*et al*. 1988; Mumpton, 1999). Zeolites occur naturally and are also produced synthetically on large scale. Zeolites have been classified on the basis of their morphological characteristics, crystalline structure, chemical composition, effective pore diameter, natural occurrence etc. The unique ion exchange, dehydration–rehydration and adsorption properties of zeolite are the reason for its use in agriculture and aquaculture technologies. Zeolite applications are suitable for water-efficient agricultural uses (Xiubin and Zhanbin, 2001). Clinoptilolite is the most common natural zeolite used agriculture (Mumpton, 1999; Ramesh *et al*. 2010). Zeolite contains some macronutrients and micronutrients such as N, K, Ca, Mg, Zn, Mn and Cu (Navrotsky *et al*. 1995; Mumpton, 1999). Zeolite has been used on a variety of soil types and a number of crops such as potatoes, maize, rice, tomatoes, eggplant, and carrots, and an increase in the yield of these crops have been observed (Burriesci *et al.* 1984; Yapparov *et al.* 1988).

Finger millet is one of the important cereals which occupy the highest area under cultivation among the small millets. A predominant food crop of the southern Karnataka, mainly grown under rainfed conditions. In India it is grown in an area of 1.19 m ha with a production of

1.98 m t with an average productivity of 1661 kg ha^{-1}. Karnataka is the largest producer of finger millet grown in an area of 1.05 m ha with a production of 1.57 million tons with an average productivity of 1889 kg ha^{-1}(Anon., 2015).

Intensification of production and increasing yield on limited arable land are important in securing an adequate food supply apart from extending the area under rainfed situation with suitable package of practices. Erratic distribution of rainfall severely affects the crop yield; in order to conserve the moisture for longer period during the cropping season, absorbents like zeolite can be applied to soil (Eleonora Cataldo *et. al.* 2021). The research findings on application of zeolite for finger millet in Rainfed condition are very scanty. Hence an experiment was conducted to study the effects of different levels of zeolite and fertilizer applications on finger millet growth, yield and yield attributes under rainfed conditions.

MATERIAL AND METHODS

Site and experimental details

A field experiment was conducted during *kharif*, 2017 and 2018 at the Zonal Agricultural Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru.

The soil of the experimental site was sandy clay loam in texture, acidic pH (5.52), electrical conductivity (0.032 dS m^{-1}), medium organic carbon (0.42%), nitrogen, phosphorus and potassium contents of the soil were 207.29, 56.28 and 128.67 kg ha^{-1}, respectively. Iron, manganese, copper and zinc content of soil were 3.28, 11.20, 0.72 and 0.58 mg kg,$^{-1}$ respectively.

The experiment consists of 5 different levels of zeolite (0, 20, 30, 40 and 50 kg ha^{-1}) and 4 different levels of fertilizer NPK (50, 75, 100 and 125% Recommended dose of fertilizer (RDF)) were tried in factorial randomized complete block design (RCBD) with 3 replications. Finger millet (GPU-28) was taken up as a test crop and recommended dose of fertilizer is 50: 40: 37.5 kg of N, P_2O_5 and K_2O per ha. Calculated quantities of nitrogen, phosphorus and potassium were applied treatment wise, in the form of urea, SSP and muriate of potash respectively. Nitrogen was applied in two split doses, that is 50 per cent nitrogen at initial and another 50 per cent at tillering stage, whereas P_2O_5 and K_2O was applied as basal dose. Zeolite was applied along with fertilizers initially. Manual weeding was done at 30 days after sowing and since there was no pest and disease incidence, no plant protection chemical was sprayed. Since the research was taken in rainfed situation, no protective irrigation was given.

Treatment details:

Zeolite levels (Z)

Z_0 : Control
Z_1 : Zeolite @ 20 kg ha^{-1}
Z_2 :Zeolite @ 30 kg ha^{-1}
Z_3 :Zeolite @ 40 kg ha^{-1}
Z_4 : Zeolite @ 50 kg ha^{-1}

Fertilizer levels (F)

F_1: 50% RDF
F_2: 75% RDF
F_3: 100% RDF
F_4: 125% RDF

Treatment combinations (Z×F)

T_1: Z_0F_1: Control + 50% RDF
T_2: Z_0F_2: Control + 75% RDF
T_3: Z_0F_3: Control + 100% RDF
T_4: Z_0F_4: Control + 125% RDF
T_5: Z_1F_1: Zeolite @ 20 kg ha^{-1}+ 50% RDF
T_6: Z_1F_2: Zeolite @ 20 kg ha^{-1}+ 75% RDF
T_7: Z_1F_3: Zeolite @ 20 kg ha^{-1}+100% RDF
T_8: Z_1F_4: Zeolite @ 20 kg ha^{-1}+125% RDF
T_9: Z_2F_1: Zeolite @ 30 kg ha^{-1}+ 50%RDF
T_{10}: Z_2 F_2:Zeolite @ 30 kg ha^{-1}+ 75% RDF
T_{11}: Z_2F_3: Zeolite @ 30 kg ha^{-1}+ 100% RDF
T_{12}: Z_2F_4: Zeolite @ 30 kg ha^{-1}+ 125% RDF
T_{13}: Z_3F_1: Zeolite @ 40 kg ha^{-1}+ 50% RDF
T_{14}: Z_3F_2: Zeolite @ 40 kg ha^{-1}+ 75% RDF
T_{15}: Z_3F_3: Zeolite @ 40 kg ha^{-1}+ 100% RDF
T_{16}: Z_3F_4: Zeolite @ 40 kg ha^{-1} + 125% RDF
T_{17}: Z_4F_1: Zeolite @ 50 kg ha^{-1}+ 50% RDF
T_{18}: Z_4F_2: Zeolite @ 50 kg ha^{-1}+ 75% RDF
T_{19}: Z_4F_3: Zeolite @ 50 kg ha^{-1}+ 100% RDF
T_{20}: Z_4F_4: Zeolite @ 50 kg ha^{-1}+ 125% RDF

Details of observation for growth, yield and yield attributes of finger millet

The plant height of five randomly selected plants was measured, from base of the plant to fully emerged leaf. After emergence of panicle, the height was measured from base of plant to tip of the panicle during 30, 60, and 90 days after sowing (DAS) and at harvest stage. Total numbers of tillers $hill^{-1}$ were counted in tagged hills manually and averaged to get number of tillers per $hill^{-1}$ at harvest stage. Five randomly selected hills from sampling area of a plot were used to record the dry matter production. The sampled hills were separated into leaves, stem and reproductive parts. The samples were dried at 65°C until they attained constant dry weight. Dry weight of straw was recorded separately. The dry weights of all the parts were summed up to obtain the total dry matter production which was expressed as g $hill^{-1}$. Total number of fingers and number of ear heads in five tagged hills were counted manually and averaged to get the finger number ear^{-1}.

RESULTS AND DISCUSSION

Effect of application of different levels of zeolite and fertilizers on yield and yield attributes of finger millet

Plant height at 30DAS

Plant height observed over crop growth stages in all the treatments is presented in Table1 and Figure 1. The application of zeolite at different levels showed significant differences. The plant height varied from 12.93 cm (Z_0) to 15.80 cm (Z_4) in pooled means. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly higher plant height (15.95, 15.66 and 15.80 cm) compared to rest of the treatments in first, second season and pooled data, respectively. Fertilizer application significantly influenced the plant height. Significantly higher plant height was recorded in treatment which received 125 per cent RDF (F_4) (14.89, 15.06 and 14.98 cm) which was at par with the treatment which received 100 per cent RDF (F_3) (14.87, 14.85 and 14.86 cm) during first, second season and pooled analysis, respectively. Whereas, lowest plant height was recorded in treatment which received 50 per cent RDF (12.97 cm in pooled data). Significant differences in plant height were observed due to interaction of zeolite and fertilizer levels. The treatment which received 50 kg zeolite ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher plant height (16.79 and 16.55 cm) which was on par with the treatment which received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (16.43 16.19 cm) and 50 kg ha^{-1} +75 per cent RDF (Z_4F_2) (15.87 and 15.37 cm), Whereas, lower plant height was recorded in treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (10.44 and 11.02 cm) at 30 and 60 DAS, respectively. Significantly higher plant height was recorded in the treatment that received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) (53.75, 73.18 and 77.65 cm) which was at par with treatment received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) and treatment which received zeolite 50 kg ha^{-1} +75 per cent RDF (Z_4F_3) (15.37 cm). The pooled analysis showed significantly higher plant height recorded in the treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) (16.67 cm) which was at par with the treatment which received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (16.31 cm). Whereas, lowest plant height was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (10.73 cm in pooled data).

Plant height at 60 DAS

The application of zeolite at different levels showed significant differences. The plant height varied from 34.98 cm (Z_0) to 51.92 cm (Z_4) in pooled means. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly higher plant height (51.70, 52.14 and 51.92 cm) compared to rest of the treatments during first, second season and pooled data, respectively. Fertilizer application significantly influenced the plant height. Significantly higher plant height was recorded in treatment which received 125 per cent RDF (F_4) (47.02 cm) which was at par with the treatment that received 100 per cent RDF (F_3) (46.32 cm) during first season. Whereas, in second season and pooled analysis, significantly higher plant height was recorded in the treatment which received 125 per cent RDF (F_4) that is 48.10 and 47.56 cm respectively. Whereas, lower plant height was recorded in treatment which received 50 per cent RDF (F_1) (41.26, 40.14 and 40.70 cm, respectively). Significant difference in plant height was observed due to interaction of zeolite and fertilizer levels. In the first year, the treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher plant height (53.75 cm) which was at par with treatment received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (52.64 cm) and zeolite 50 kg ha^{-1} +75 per cent RDF (Z_4F_2) (51.78 cm), in second season (2018), the treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher plant height (53.86 cm) which was at par with treatment received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (53.43 cm). In pooled analysis, the treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher plant height (53.80 cm) which was par with treatment received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (53.04 cm) and zeolite 50 kg ha^{-1} +75 per cent RDF (Z_4F_2) (52.18 cm). Whereas, lowest plant height was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (30.17 cm in pooled).

Plant height at 90 DAS

The application of zeolite at different levels showed significant differences. The plant height varied from 61.61 cm (Z_0) to 69.70 cm (Z_4) in pooled means. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly higher plant height (70.34, 69.05 and 69.70 cm) compared to rest of the treatments during first, second season and pooled data, respectively. Fertilizer application significantly influenced the plant height. Significantly higher plant height was recorded in treatment that received 125 per cent RDF (F_4) (66.55 cm) which was at par with the treatment which received 100 per cent RDF (F_3) (66.38 cm) in first season. Whereas, in second season and in pooled analysis, significantly higher plant height was recorded in the treatment which received 125 per cent RDF (F_4) that is 68.46 and 67.51 cm respectively. Whereas, lower plant height was recorded in the treatment which received 50 per cent RDF (F_1) (64.37, 63.32 and 63.85 cm, respectively). Significant difference in plant height was observed due to interaction of zeolite and fertilizer levels. The treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher plant height (73.18, 73.88 and 73.53 cm) which was at par with treatment that received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (72.80, 72.58 and 72.69) in first, second season and pooled data, respectively. Whereas, lowest plant height was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (60.11, 61.23 and 60.67 cm, respectively).

Plant height at harvest

The application of zeolite at different levels showed significant differences. The plant height varied from 67.73 cm (Z_0) to 76.00 cm (Z_4) in pooled means. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly higher plant height (76.17, 75.84 and 76.00 cm) compared to rest of the treatments during first, second season and pooled data, respectively Significantly higher plant height was recorded in treatment which received 125 per cent RDF (F_4) (74.50 cm) which was at par with the treatment which received 100 per cent RDF (F_3) (72.02 cm) during first season. Whereas, in second season and pooled analysis, significantly higher plant height was recorded in the treatment which received 125 per cent RDF (F_4) that is 73.22 and 73.03 cm respectively. Whereas, lower plant height was recorded in the treatment which received 50 per cent RDF (F_1) (67.54, 69.94 and 70.43 cm, respectively).

Significant difference in plant height was observed due to interaction of zeolite and fertilizer levels. The treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher plant height (77.65, 78.63 and 78.14 cm) which was on par with treatment received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (76.88, 77.74 and 77.31cm) during first, second season and pooled data, respectively. Whereas, lowest plant height was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (67.28, 66.77 and 67.03 cm, respectively).

Zeolite incorporated with chemical fertilizer gave positive effect for plant growth (Valente *et al.*1982). Zeolite increased the plant height significantly regardless of growth stages. Plants were significantly taller than conventional fertilized plants irrespective of levels of application this could be due to enhanced availability and uptake of nutrients in these treatments. The results revealed that increased levels of fertilizer and zeolite which was significantly increased plant height and also interaction effect of fertilizer and zeolite showed significant effects. A similar result for plant height was also obtained by Taotao *et al*. (2017). With respect to fertilizer levels plant height was higher in the treatment that received 125 per cent RDF at 90 DAS and at harvest stage might be due to higher application of fertilizers along with the zeolite at its maximum level of 50 kg ha^{-1} might have held these nutrients for longer period compared to the normal levels of fertilizer application. These results were also noticed by Mumpton (1999). Saha *et al.* (2017) also concluded that more plant height might be due to more availability of nitrogen which has released slowly from zeolite pores as well as simultaneous reduction in loss of nitrogen. As nitrogen is an important element required for cell division, application of zeolite increased the availability of nitrogen and that brought positive effect on plant height.

4.2.2 Number of tillers per hill

The data pertaining to number of tillers per hill were presented in Table 2. Application of zeolite at different levels showed significant differences. The number of tillers per hill varied from 3.63 (Z_0) to 4.72 (Z_4) in pooled data. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly higher number of tillers per hill (4.70, 4.75 and 4.72) compared to rest of the treatments during first, second season and pooled data, respectively. The lowest number of tillers per hill was recorded in control (Z_0) (3.68, 3.58 and 3.63 respectively). Fertilizer application significantly influenced the number of tillers. Significantly higher number of tillers per hill was recorded in treatment which received 125 per cent RDF (F_4) (4.69, 4.46 and 4.58) which was on par with the treatment which received 100 per cent RDF (F_3) (4.62, 4.42 and 4.52) during first, second season and pooled data, respectively. Whereas, lowest number of tillers per hill was recorded in the treatment which received 50 per cent RDF (F_1) (3.61 in pooled data). Among interactions of zeolite with fertilizer treatments, the treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher number of tillers per hill (5.27, 5.30 and 5.29) which was on par with treatment that received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (5.22, 5.21 and 5.22) in first, second season and pooled data, respectively. Whereas, lowest number of tillers per hill was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (3.15 in pooled data). The results revealed that, increased levels of fertilizer and zeolite significantly increased number of tillers $hill^{-1}$ and also interaction effect of fertilizer and zeolite showed significant effect on number of tillers $hill^{-1}$. Similar results were also obtained by Taotao *et al*. (2017). More number of tillers observed might be due to more availability of nitrogen which has released slowly from zeolite canal or pores as well as simultaneous reduction in loss of nitrogen. Nitrogen is an important element required for cell division, increased availability of nitrogen might positively influenced number of tillers which was probably due to higher uptake of applied nitrogen and greater availability of soil nutrients (Saha *et al.*, 2017).

Number of fingers per earhead

Significant differences were observed among the treatments with respect to total number of fingers per ear head of finger millet with the application of different levels of fertilizer and zeolite (Table 2). The number of fingers per ear head varied from 5.13 (Z_0) to 5.96 (Z_4) in pooled means. The treatment which received 50 kg ha^{-1} zeolite (Z_4) recorded significantly highest number of fingers ear head (5.97, 5.95 and 5.96) compared to rest of the treatments during first, second season and pooled data, respectively. Fertilizer application significantly influenced the number of fingers per ear head. Significantly higher number of fingers per ear head was recorded in treatment which received 125 per cent RDF (F_4) (5.79, 5.88 and 5.84) which was at par with 100 per cent RDF (F_3) (5.64, 5.65 and 5.64) during first, second season and pooled data, respectively.

Significant differences in number of fingers per ear head were observed due to interaction of zeolite and fertilizer levels. The treatment which received zeolite 50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher number of fingers per earhead (5.94, 5.96 and 5.95) which was on par with treatment that received zeolite 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (5.86, 5.92 and 5.89) during first, second season and pooled data, respectively. Whereas, lowest number of fingers per ear head was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (4.43 in pooled data).

Total dry matter production (g $hill^{-1}$) as influenced by application of different levels of zeolite and fertilizers

Application of zeolite at different levels showed significant differences in total dry matter production. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly highest total dry matter production (40.36, 39.75 and 40.05 g hill^{-1}) compared to rest of the treatments during first, second season and pooled data, respectively. Whereas, the least total dry matter production was recorded in control (Z_0) (33.60 g hill^{-1} in pooled data) (Table 2). Fertilizer application significantly influenced the total dry matter production. Significantly higher total dry matter production was recorded in treatment which received 125 per cent RDF (F_4) (38.49, 38.14 and 38.32 g hill^{-1}) which was on par with 100 per cent RDF (F_3) (37.85, 37.70 and 37.78 g hill^{-1}) during first, second season and pooled data, respectively. Whereas, lower total dry matter production was recorded in the treatment which received 50 per cent RDF (F_1) (35.12 g hill^{-1} in pooled data). Significant differences in total dry matter production were observed due to interaction of zeolite and fertilizer levels. The treatment which received zeolite @50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly highest total dry matter production (41.89, 41.45 and 41.67 g hill^{-1}) which was on par with treatment that received zeolite @50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (41.17, 40.95 and 41.06 g hill^{-1}) during first, second season and pooled data, respectively. Whereas, lowest total dry matter production was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (31.21 g hill^{-1} in pooled). The significant increase in the plant yield parameters like number of tillers per hill, dry matter production and number of fingers per earhead might be due to the combination of chemical fertilizers with zeolite. Zeolite favors water infiltration and retention in the soil and acts as a natural wetting agent due to its porous property and the capillary suction it exerts. In order to assist water distribution through soils, zeolite act as excellent amendment and also the availability of nutrients might have increased at optimum soil moisture (Ferguson *et al.*, 1989; Huang and Petrovic, 1995). Fertilizers and zeolite levels showed significant effect on increasing dry matter production. The dry matter production was increased with increasing fertilizer and zeolite application might be due to more use of nitrogen in photosynthetic activity, enhancing the carbohydrate metabolism and ultimately increasing the dry matter accumulation. Highest dry matter production was recorded in Z_4F_4 (50 kg ha^{-1} +125 per cent RDF) compared to other treatments might due to increased nutrient availability and uptake which might be responsible for profuse tillering and higher growth rate. Similar result related to dry matter production in sunflower were obtained by Gholam hoseini *et al.* (2013). Qi *et al*. (2016) who reported that, higher dose of nitrogen and zeolite showed significant effect on dry matter of root, stem, leaf and spike.

Grain and straw yield

Significant differences were observed among the treatments with respect to grain and straw yield of finger millet as influenced by application of different levels of fertilizer and zeolite as presented in Table 3 and Figure 2.

The application of zeolite at different levels showed significant differences in total grain yield. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly higher grain yield (34.84, 34.77 and 34.81 q ha^{-1}) during first, second and pooled data, respectively. Whereas, the lowest grain yield was recorded in control (Z_0) (30.86 q ha^{-1} in pooled). Fertilizer application significantly influenced the grain yield. Significantly highest total grain yield was recorded in treatment which received 125 per cent RDF (F_4) (33.88, 33.99 and 33.93 q ha^{-1}) which was on par with the treatment which received 100 per cent RDF (F_3) (33.71, 33.74 and 33.72 q ha^{-1}) during first, second season and pooled data, respectively. Whereas, lowest grain yield was recorded in the treatment which received 50 per cent RDF (F_1) (31.41 q ha^{-1} in pooled data). Significant differences in grain yield were observed due to interaction of zeolite and fertilizer levels. The treatment which received zeolite @50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher grain yield (36.32, 35.82 and 36.07 q ha^{-1}) which was on par with treatment received zeolite @50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (35.89, 35.62 and 35.75 q ha^{-1}) during first, second season and pooled data, respectively. Whereas, lowest grain yield was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (29.86 q ha^{-1} in pooled data).

The application of zeolite at different levels showed significant differences in straw yield. The straw yield varied from 39.55 (Z_0) to 46.26 q ha^{-1} (Z_4) in pooled means. The treatment that received 50 kg ha^{-1} zeolite (Z_4) recorded significantly higher straw yield(46.22, 46.30 and 46.26 q ha^{-1}) compared to rest of the treatments during first, second season and pooled data, respectively. The lower straw yield was recorded in control (Z_0) (39.55 q ha^{-1} in pooled data). Fertilizer application significantly influenced the straw yield. Significantly higher straw yield was recorded in treatment which received 125 per cent RDF (F_4) (44.08, 44.62 and 44.35 q ha^{-1}) which was on par with the treatment that received 100 per cent RDF (F_3) (43.72, 44.28 and 44.00 q ha^{-1}) during first, second season and pooled data, respectively. Whereas, lower straw yield was recorded in the treatment which received 50 per cent RDF (F_1) (40.83 q ha^{-1}in pooled data).

Significant difference in straw yield was observed due to interaction of zeolite and fertilizer levels. The treatment which received zeolite @50 kg ha^{-1} +125 per cent RDF (Z_4F_4) showed significantly higher straw yield(48.30, 47.70 and 48.00 q ha^{-1}) which was on par with treatment received zeolite @ 50 kg ha^{-1} +100 per cent RDF (Z_4F_3) (47.73, 47.43 and 47.58 q ha^{-1}) during first, second season and pooled data, respectively. Whereas, lower straw yield was recorded in the treatment which received 50 per cent RDF with no zeolite (Z_0F_1) (38.27 q ha^{-1} in pooled data).

Grain yield depends upon growth and yield parameters, *viz*., number of tillers, number of fingers per earhead and other parameters which were superior at higher levels of fertilizer and zeolite application. The results of present study agree with Taotao *et al*. (2017) who reported that grain yield increases consistently by increasing application rate of zeolite and fertilizers. It also influenced significantly on straw yield and their interaction also showed significant effect on straw yield. Kavoosi (2007) reported that grain yield was increased significantly by the application of zeolite and nitrogen. The increased grain yield in treatment combination of Z_4F_4 (36.07 q ha^{-1} in pooled) due to sorption capability of zeolite and its ability towards uniform release of nutrients into the soil along with its ion exchange ability that prevents against their quick elution. The controlled release and unique properties of zeolites allow a gradual and controlled introduction of necessary nutrients *i.e.* potassium, ammonium or phosphates into the soil (Perry and Keeling-Tucker, 2000) thus enhanced the growth and yield parameters of finger millet.

The straw yield of finger millet was significantly increased with the combination of chemical fertilizer with zeolite, due to the slow release of nutrients which are imbibed in the zeolite, so that plants get the nutrients sufficiently for longer period that lead to the increased grain and straw yield. Similar results were reported by Valente *et al*. (1982), Mazur *et al*. (1986) and Ferguson *et al.* (1989).

Conclusion

Zeolite application @ 50 kg ha^{-1} along with the recommended dose (100% RDF) of fertilizer and 125% RDF showed higher growth attributes like plant height, number of tillers per hill and total dry matter production. Similarly yield and yield parameters also recorded in the treatment which received zeolite @ 50 kg ha^{-1} along with 125 % and 100 % recommended dose of fertilizer. This study clearly emphasis the goodness of zeolite inclusion in nutrient management practices. Thus in the future year's inclusion of zeolite with fertilizer application would be an important component in nutrient management. Application of zeolite along with recommended dose of fertilizer enhances growth, yield and yield attributes of finger millet.

REFERENCES

ANONYMOUS, 2015., Directorate of Economics and Statistics, www.agricoop.nic.in.

BURRIESCI, N., VALENTE, S., OTTANÀ, R., CIMINO, G. AND ZIPELLI, C., 1984, Utilization of zeolites in spinach growing. *Zeolites*. **4**:5–8.

ELEONORA CATALDO, LINDA SALVI, FRANCESCA PAOLI, MADDALENA FUCILE, GRAZIA MASCIANDARO, DAVIDE MANZI, COSIMO MARIA MASINI AND GIOVAN BATTISTA MATTII., 2021, Application of Zeolites in Agriculture and Other Potential Uses: A Review. *Agronomy*, **7**:3-14.

FURGUSON, G. A., PEPER, I. L. AND KNEEBONE., W. R., 1989, Growth of cropping bentgrass on new medium for turfgrass growth. Clinoptilolite zeolite-amended sand. *Agro. J.*, **78**(6):1095-1098.

GHOLAMHOSEINI, M., GHALAVAND, A., JOGHAN, A.K., DOLATABADIAN, A., ZAKIKHANI, H. AND FARMANBAR, E., 2013, Zeolite-amended cattle manure effects on sunflower yield, seed quality, water use efficiency and nutrient leaching. *Soil and Tillage Res.* **126**: 193-202.

HUANG, Z. T. AND PETROVIC. A. M., 1995, Clinoptilolite zeolite effect on evaporation rate and shoot growth rate of bentgrass on sand base grass. *J. of Turgrass Management.*, **12**:154-168.

KAVOOSI, M. 2007. Effects of zeolite application on rice yield, nitrogen recovery, and nitrogen use efficiency, *Commun Soil Sci Plant Anal*, 38:1-2, 69-76.

MAZUR, G. A., MEDVID, G. K. AND GVIGORA. I. T., 1986, Use of natural zeolite to increase the fertilizer of coarse soils. *Soviet Soil Sci.*, **16**(4):105-111.

MUMPTON, F. A., 1999, La Roca Magica: uses of natural zeolites in agriculture and industry. Proc. Natl. Acad. Sci. USA. 96:3463–3470. doi:10.1073/pnas.96.7.3463.

NAVROTSKY, A., PETROVIC, I., HU, Y., CHEN, C. Y. AND DAVIS, M. E., 1995, Energetics of microporous materials. *J.Noncrystalline Solids*. **19**:474–477.

PERRY, CC. AND KEELING-TUCKER, T., 2000, Biosilicification: the role of the organic matrix in structure control. *J BiolInorg Chem*., **5**:537–550.

QI. XIA, G., TAOTAO, C., ZHENG, J., FANGANG, B & DAOCAI, C.2016. Effects of nitrogen and zeolite on rice grain yield, water and nitrogen use, and soil total nitrogen in coastal region of northeast china. *Commu. Soil Sci and Plant Anal*. **47**:18, 2103-2114.

RAMESH K, BISWAS AK, SOMASUNDARAM J, RAO AS. 2010. Nanoporous zeolites in farming: current status and issues ahead. Current Sci. 99:760–765.

SAHA,B., PANDA,P., PATRA, P.S., PANDA, R., KUNDU, A., SINGHA, A.K., ROY AND MAHATO, N.2017. Effect of different levels of nitrogen on growth and yield of rice (oryza sativa l.) cultivars under terai-agro climatic situation. International Journal of Current Microbiology and Applied Sciences. **6**(7): 2408-2418.

TAOTAO, C., XIA, G., QI W., ZHENG, J., JIN, Y., DEHUAN, S., WANG, S AND DAOCAI, C. 2017. The influence of zeolite amendment on yield performance, quality characteristics, and nitrogen use efficiency of paddy rice. Crop Science Society of America. **57**:1–11.

VALENTE, S. N., BURRIESCI, S., CAVALLARO, S., GALVAGNO, S. AND ZIPELLI, C., 1986, Utilization of zeolite as soil conditioner in tomato growing. *Zeolites,***2**(4):271-274.

XIUBIN, H. AND ZHANBIN, H., 2001, Zeolite application for enhancing water infiltration and retention in loess soil. *ConservRecyling*. **34**:45–52.

YAPPAROV-FSH, SHILOVSKII, LP, TSITSISHVILI, G. V., AND RONIKASHVILI, T. G., 1988, Growing certain vegetables on substrates containing natural zeolites. *Hort. Abstr*. **2**:117–121.

Table 1. Plant height (cm) of finger millet at different stages of crop as influenced by different levels of zeolite and fertilizer application.

Treatments	30 Days			60 Days			90 Days			At harvest		
	2017	**2018**	**Pooled**	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
Zeolite levels												
Z_0 : Control	12.73	12.94	12.93	34.73	35.23	34.98	60.77	62.45	61.61	67.54	67.92	67.73
Z_1 : Zeolite @ 20 kg ha^{-1}	13.10	13.14	13.02	43.36	43.22	43.29	64.87	65.38	65.12	69.25	70.31	69.78
Z_2 : Zeolite @ 30 kg ha^{-1}	14.25	14.19	14.22	45.73	44.71	45.22	65.36	66.34	65.85	72.02	71.29	71.65
Z_3 : Zeolite @ 40 kg ha^{-1}	14.57	14.69	14.63	46.67	46.11	46.39	66.54	66.59	66.57	74.50	73.19	73.85
Z_4 : Zeolite @ 50 kg ha^{-1}	15.95	15.66	15.80	51.70	52.14	51.92	70.34	69.05	69.70	76.17	75.84	76.00
S.Em±	**0.20**	**0.11**	**0.16**	**0.47**	**0.31**	**0.29**	**0.26**	**0.29**	**0.23**	**0.23**	**0.18**	**0.18**
CD (P=0.05)	**0.62**	**0.32**	**0.48**	**1.34**	**0.93**	**0.84**	**0.74**	**0.83**	**0.65**	**0.66**	**0.52**	**0.51**
Fertilizer levels												
F_1: 50% RDF	13.00	12.92	12.97	41.26	40.14	40.70	64.37	63.32	63.85	67.54	69.94	70.43
F_2: 75% RDF	13.72	13.64	13.68	43.15	43.05	43.10	64.99	65.03	65.01	69.25	71.59	71.63
F_3: 100% RDF	14.87	14.85	14.86	46.32	45.84	46.08	66.38	67.04	66.71	72.02	72.10	72.12
F_4: 125% RDF	14.89	15.06	14.98	47.02	48.10	47.56	66.55	68.46	67.51	74.50	73.22	73.03
S.Em±	**0.18**	**0.10**	**0.14**	**0.42**	**0.28**	**0.26**	**0.23**	**0.26**	**0.20**	**76.17**	**0.16**	**0.16**
CD (P=0.05)	**0.52**	**0.29**	**0.41**	**1.20**	**0.80**	**0.75**	**0.66**	**0.74**	**0.58**	**0.23**	**0.46**	**0.45**
Zeolite levels X Fertilizer levels												
Z_0F_1: Control + 50% RDF	10.44	11.02	10.73	29.90	30.44	30.17	60.11	61.23	60.67	67.28	66.77	67.03
Z_0F_2: Control + 75% RDF	11.76	11.21	11.49	33.02	32.93	32.97	60.00	62.01	61.01	67.37	67.74	67.56
Z_0F_3: Control + 100% RDF	12.10	12.33	12.22	37.37	37.44	37.41	60.33	63.04	61.69	67.42	67.75	67.59
Z_0F_4: Control + 125% RDF	12.18	12.61	12.40	38.62	40.13	39.37	62.63	63.50	63.07	68.45	69.41	68.93

Table contd...

Treatments	30 Days			60 Days			90 Days			At harvest		
	2017	**2018**	**Pooled**	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
Z_1F_1: Zeolite @ 20 kg ha^{-1}+ 50% RDF	11.77	12.17	11.97	39.97	39.24	39.60	64.00	62.65	63.33	67.76	69.57	68.67
Z_1F_2: Zeolite @ 20 kg ha^{-1}+ 75% RDF	12.15	12.66	12.41	42.31	41.93	42.12	65.39	65.04	65.22	67.69	69.80	68.75
Z_1F_3: Zeolite @ 20 kg ha^{-1} +100% RDF	13.23	13.61	13.42	45.46	45.39	45.42	65.70	66.69	66.20	70.30	70.62	70.46
Z_1F_4: Zeolite @ 20 kg ha^{-1} +125% RDF	13.78	14.12	13.95	45.68	46.34	46.01	64.38	67.13	65.76	71.25	71.25	71.25
Z_2F_1: Zeolite @ 30 kg ha^{-1} + 50%RDF	11.85	13.49	12.67	42.99	41.39	42.19	64.99	64.06	64.53	68.40	69.71	69.06
Z_2F_2:Zeolite @ 30 kg ha^{-1} + 75% RDF	14.36	13.94	14.15	44.60	43.93	44.27	64.03	65.75	64.89	69.73	71.73	70.73
Z_2F_3:Zeolite @ 30 kg ha^{-1} + 100% RDF	14.36	14.60	14.48	47.22	44.91	46.07	66.37	66.60	66.48	72.73	71.53	72.13
Z_2F_4:Zeolite @ 30 kg ha^{-1} + 125% RDF	14.44	14.72	14.58	48.12	48.58	48.35	66.04	68.95	67.49	72.86	72.20	72.53
Z_3F_1: Zeolite @ 40 kg ha^{-1} + 50% RDF	14.24	14.09	14.17	44.81	40.92	42.87	65.34	64.26	64.80	70.85	72.47	71.66
Z_3F_2: Zeolite @ 40 kg ha^{-1} + 75% RDF	14.46	14.46	14.46	44.05	43.88	43.97	66.84	65.99	66.42	71.68	72.86	72.27
Z_3F_3: Zeolite @ 40 kg ha^{-1} + 100% RDF	15.25	14.93	15.09	48.90	48.03	48.47	67.44	67.30	67.37	74.40	73.58	73.99
Z_3F_4: Zeolite @ 40 kg ha^{-1} + 125% RDF	15.34	15.31	15.33	48.93	51.59	50.26	66.54	68.82	67.30	74.68	75.86	75.27
Z_4F_1: Zeolite @ 50 kg ha^{-1} + 50% RDF	14.69	14.50	14.60	48.62	48.69	48.66	67.43	64.39	65.91	73.25	73.16	73.21
Z_4F_2: Zeolite @ 50 kg ha^{-1} + 75% RDF	15.87	15.37	15.62	51.78	52.58	52.18	68.70	66.35	67.52	74.62	75.82	75.22
Z_4F_3: Zeolite @ 50 kg ha^{-1} + 100% RDF	16.43	16.19	16.31	52.64	53.43	53.04	72.80	72.58	72.69	76.88	77.74	77.31
Z_4F_4: Zeolite @ 50 kg ha^{-1} + 125% RDF	16.79	16.55	16.67	53.75	53.86	53.80	73.18	73.88	73.53	77.65	78.63	78.14
S.Em±	**0.41**	**0.23**	**0.32**	**0.94**	**0.62**	**0.59**	**0.52**	**0.58**	**0.45**	**0.46**	**0.36**	**0.35**
CD (P=0.05)	**1.17**	**0.65**	**0.91**	**2.68**	**1.78**	**1.68**	**1.49**	**1.66**	**1.29**	**1.32**	**1.04**	**1.01**

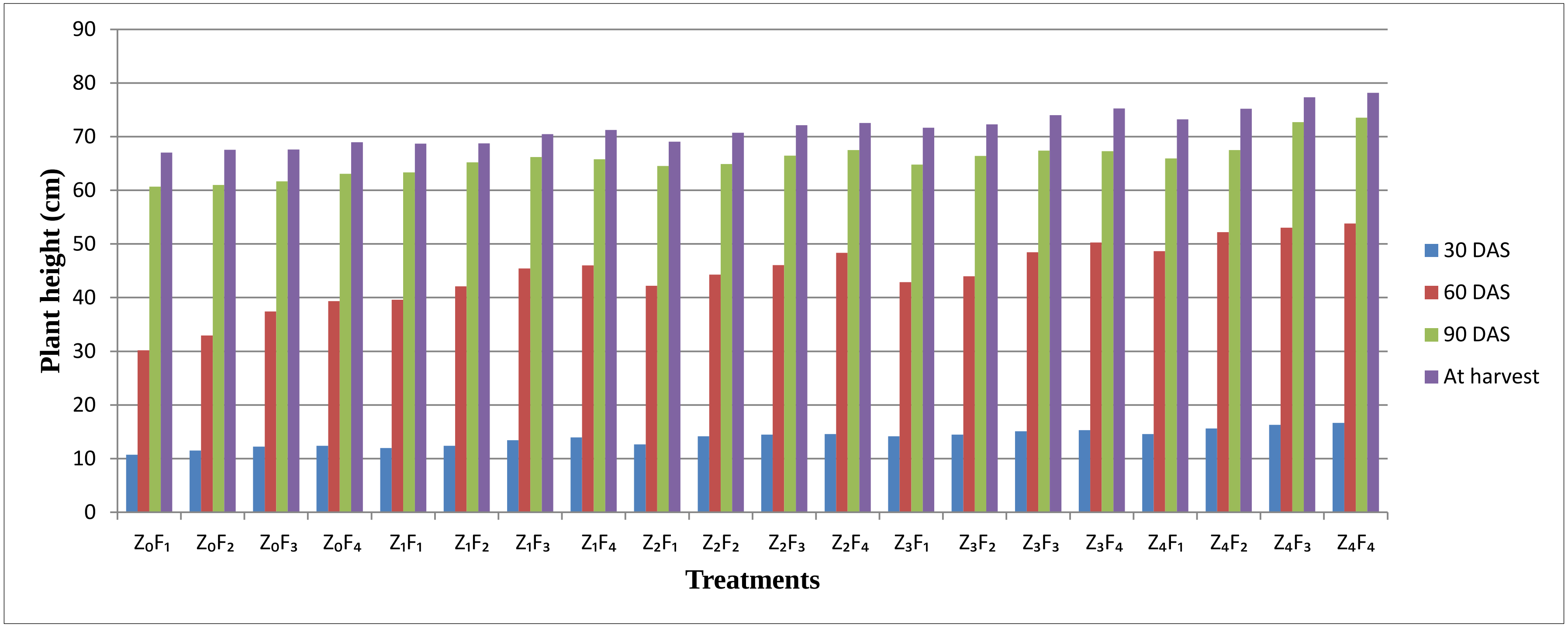

Fig.1 Plant height of finger millet crop at different growth stages as influenced by different levels of zeolite and fertilizer application

Factor I: Zeolite levels	**Factor II: Fertilizer levels**
Z_0 : Control	F_1: 50% RDF
Z_1 : Zeolite @ 20 kg ha^{-1}	F_2: 75% RDF
Z_2 :Zeolite @ 30 kg ha^{-1}	F_3: 100% RDF
Z_3 :Zeolite @ 40 kg ha^{-1}	F_4: 125% RDF
Z_4 : Zeolite @ 50 kg ha^{-1}	

Table 2. Yield parameters of finger millet as influenced by different levels of zeolite and fertilizer application.

Treatments	Number of fingers per earhead			Number of tillers per hill			Test weight (1000 Seeds)			Total dry matter production (g $hill^{-1}$)		
	2017	2018	pooled	2017	2017	Pooled	2017	2018	Pooled	2017	2018	Pooled
Zeolite levels												
Z_0 : Control	5.31	4.94	5.13	3.68	3.58	3.63	3.36	3.33	3.34	34.16	33.05	33.60
Z_1 : Zeolite @ 20 kg ha^{-1}	5.67	5.48	5.58	3.77	3.69	3.73	3.46	3.32	3.39	36.25	34.87	35.56
Z_2 : Zeolite @ 30 kg ha^{-1}	5.63	5.58	5.61	4.27	3.85	4.06	3.37	3.34	3.36	37.33	36.92	37.12
Z_3 : Zeolite @ 40 kg ha^{-1}	5.73	5.67	5.70	4.60	4.32	4.46	3.42	3.31	3.37	37.90	37.28	37.59
Z_4 : Zeolite @ 50 kg ha^{-1}	5.97	5.95	5.96	4.70	4.75	4.72	3.42	3.33	3.38	40.36	39.75	40.05
S.Em±	**0.03**	**0.03**	**0.02**	**0.04**	**0.03**	**0.02**	**0.03**	**0.01**	**0.02**	**0.30**	**0.19**	**0.18**
CD (P=0.05)	**0.08**	**0.10**	**0.07**	**0.11**	**0.09**	**0.06**	**NS**	**NS**	**NS**	**0.87**	**0.55**	**0.52**
Fertilizer levels												
F_1: 50% RDF	5.50	5.14	5.32	3.69	3.52	3.61	3.42	3.31	3.36	36.04	34.20	35.12
F_2: 75% RDF	5.73	5.41	5.57	4.08	3.88	3.98	3.38	3.33	3.36	37.02	35.85	36.43
F_3: 100% RDF	5.64	5.65	5.64	4.62	4.42	4.52	3.43	3.33	3.38	37.85	37.70	37.78
F_4: 125% RDF	5.79	5.88	5.84	4.69	4.46	4.58	3.39	3.33	3.36	38.49	38.14	38.32
S.Em±	**0.03**	**0.03**	**0.02**	**0.03**	**0.03**	**0.02**	**0.03**	**0.01**	**0.01**	**0.27**	**0.17**	**0.16**
CD (P=0.05)	**0.07**	**0.09**	**0.06**	**0.10**	**0.08**	**0.05**	**NS**	**NS**	**NS**	**0.78**	**0.49**	**0.47**
Zeolite levels X Fertilizer levels												
Z_0F_1: Control + 50% RDF	4.55	4.31	4.43	3.16	3.14	3.15	3.31	3.32	3.31	32.36	30.05	31.21
Z_0F_2: Control + 75% RDF	5.58	4.60	5.09	3.48	3.32	3.40	3.34	3.32	3.33	33.02	32.05	32.54
Z_0F_3: Control + 100% RDF	5.49	5.15	5.32	3.79	3.77	3.78	3.39	3.34	3.37	35.13	34.85	34.99

Table contd...

Treatments	Number of fingers per earhead			Number of tillers per hill			Test weight (1000 Seeds)			Total dry matter production (g hill^{-1})		
	2017	**2018**	**pooled**	**2017**	**2017**	**Pooled**	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
Z_0F_4: Control + 125% RDF	5.64	5.69	5.67	4.27	4.10	4.19	3.38	3.35	3.37	36.11	35.25	35.68
Z_1F_1: Zeolite @ 20 kg ha^{-1}+ 50% RDF	5.52	5.05	5.29	3.37	3.30	3.34	3.55	3.29	3.42	34.68	33.73	34.21
Z_1F_2: Zeolite @ 20 kg ha^{-1}+ 75% RDF	5.71	5.40	5.56	3.74	3.61	3.68	3.34	3.32	3.33	36.27	33.25	34.76
Z_1F_3: Zeolite @ 20 kg ha^{-1} +100% RDF	5.74	5.61	5.68	3.81	3.83	3.82	3.56	3.34	3.45	36.24	35.16	35.70
Z_1F_4: Zeolite @ 20 kg ha^{-1} +125% RDF	5.76	5.86	5.81	4.48	4.24	4.36	3.38	3.35	3.36	37.82	37.33	37.58
Z_2F_1: Zeolite @ 30 kg ha^{-1} + 50%RDF	5.58	5.26	5.42	4.10	3.48	3.79	3.38	3.33	3.36	36.82	33.71	35.27
Z_2F_2:Zeolite @ 30 kg ha^{-1} + 75% RDF	5.74	5.58	5.66	4.25	3.69	3.97	3.39	3.36	3.38	38.27	37.58	37.93
Z_2F_3:Zeolite @ 30 kg ha^{-1} + 100% RDF	5.79	5.68	5.74	4.21	3.98	4.10	3.37	3.32	3.35	38.43	37.97	38.20
Z_2F_4:Zeolite @ 30 kg ha^{-1} + 125% RDF	5.67	5.88	5.78	4.54	4.26	4.40	3.36	3.33	3.35	38.65	38.41	38.53
Z_3F_1: Zeolite @ 40 kg ha^{-1} + 50% RDF	5.68	5.40	5.54	4.14	3.76	3.95	3.42	3.31	3.37	37.18	36.17	36.68
Z_3F_2: Zeolite @ 40 kg ha^{-1} + 75% RDF	5.78	5.63	5.71	4.35	4.23	4.29	3.44	3.35	3.40	38.30	37.11	37.71
Z_3F_3: Zeolite @ 40 kg ha^{-1} + 100% RDF	5.79	5.77	5.78	4.94	4.69	4.82	3.42	3.29	3.35	38.56	38.28	38.42
Z_3F_4: Zeolite @ 40 kg ha^{-1} + 125% RDF	5.82	5.87	5.84	5.21	4.62	4.92	3.41	3.29	3.35	38.67	38.47	38.57
Z_4F_1: Zeolite @ 50 kg ha^{-1} + 50% RDF	5.77	5.68	5.73	3.93	3.93	3.93	3.42	3.31	3.37	39.15	37.35	38.25
Z_4F_2: Zeolite @ 50 kg ha^{-1} + 75% RDF	5.82	5.86	5.87	4.59	4.54	4.57	3.41	3.30	3.36	39.22	39.24	39.23
Z_4F_3: Zeolite @ 50 kg ha^{-1} + 100% RDF	5.86	5.92	5.89	5.22	5.21	5.22	3.42	3.37	3.40	41.17	40.95	41.06
Z_4F_4: Zeolite @ 50 kg ha^{-1} + 125% RDF	5.94	5.96	5.95	5.27	5.30	5.29	3.44	3.35	3.40	41.89	41.45	41.67
S.Em±	**0.03**	**0.03**	**0.05**	**0.07**	**0.06**	**0.04**	**0.06**	**0.02**	**0.03**	**0.61**	**0.38**	**0.36**
CD (P=0.05)	**0.08**	**0.08**	**0.14**	**0.21**	**0.18**	**0.12**	**NS**	**NS**	**NS**	**1.74**	**1.10**	**1.04**

Table 3. Grain and straw yield of finger millet as influenced by different levels of zeolite and fertilizer application.

Treatments	Grain yield ($q\ ha^{-1}$)			Straw yield ($q\ ha^{-1}$)		
	2017	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
Zeolite levels						
Z_0 : Control	30.59	31.14	30.86	38.89	40.21	39.55
Z_1 : Zeolite @ 20 kg ha^{-1}	31.80	32.05	31.93	40.82	41.53	41.18
Z_2 : Zeolite @ 30 kg ha^{-1}	32.74	33.10	32.92	42.36	43.54	42.95
Z_3 : Zeolite @ 40 kg ha^{-1}	33.51	33.73	33.62	43.92	44.62	44.27
Z_4 : Zeolite @ 50 kg ha^{-1}	34.84	34.77	34.81	46.22	46.30	46.26
S.Em±	**0.11**	**0.10**	**0.09**	**0.15**	**0.14**	**0.12**
CD (P=0.05)	**0.32**	**0.29**	**0.26**	**0.42**	**0.39**	**0.34**
Fertilizer levels						
F_1: 50% RDF	31.26	31.56	31.41	40.30	41.36	40.83
F_2: 75% RDF	32.11	32.64	32.38	41.77	42.84	42.31
F_3: 100% RDF	33.71	33.74	33.72	43.72	44.28	44.00
F_4: 125% RDF	33.88	33.99	33.93	44.08	44.62	44.35
S.Em±	**0.10**	**0.09**	**0.08**	**0.13**	**0.12**	**0.11**
CD (P=0.05)	**0.29**	**0.26**	**0.23**	**0.38**	**0.35**	**0.30**
Zeolite levels X Fertilizer levels						
Z_0F_1: Control + 50% RDF	29.46	30.25	29.86	37.46	39.07	38.27
Z_0F_2: Control + 75% RDF	30.11	30.92	30.52	38.29	39.93	39.11
Z_0F_3: Control + 100% RDF	31.17	31.44	31.31	39.63	40.61	40.12
Z_0F_4: Control + 125% RDF	31.60	31.93	31.77	40.18	41.24	40.71
Z_1F_1: Zeolite @ 20 kg ha^{-1}+ 50% RDF	30.27	30.66	30.47	38.49	39.73	39.11
Z_1F_2: Zeolite @ 20 kg ha^{-1}+ 75% RDF	31.21	31.55	31.38	40.18	40.89	40.53
Z_1F_3: Zeolite @ 20 kg ha^{-1} +100% RDF	32.70	32.82	32.76	42.11	42.53	42.32
Z_1F_4: Zeolite @ 20 kg ha^{-1} +125% RDF	33.01	33.18	33.09	42.50	42.99	42.75
Z_2F_1: Zeolite @ 30 kg ha^{-1} + 50%RDF	31.05	31.22	31.14	39.98	41.08	40.53
Z_2F_2:Zeolite @ 30 kg ha^{-1} + 75% RDF	32.49	32.62	32.56	42.10	42.92	42.51
Z_2F_3:Zeolite @ 30 kg ha^{-1} + 100% RDF	33.60	34.15	33.87	43.53	44.93	44.23
Z_2F_4:Zeolite @ 30 kg ha^{-1} + 125% RDF	33.84	34.39	34.12	43.84	45.25	44.55
Z_3F_1: Zeolite @ 40 kg ha^{-1} + 50% RDF	32.22	32.35	32.29	41.75	42.57	42.16
Z_3F_2: Zeolite @ 40 kg ha^{-1} + 75% RDF	32.89	33.77	33.33	43.27	44.75	44.01
Z_3F_3: Zeolite @ 40 kg ha^{-1} + 100% RDF	34.29	34.16	34.23	45.12	45.28	45.20
Z_3F_4: Zeolite @ 40 kg ha^{-1} + 125% RDF	34.63	34.63	34.63	45.56	45.90	45.73
Z_4F_1: Zeolite @ 50 kg ha^{-1} + 50% RDF	33.30	33.30	33.30	43.81	44.35	44.08
Z_4F_2: Zeolite @ 50 kg ha^{-1} + 75% RDF	33.85	34.34	34.10	45.02	45.73	45.38
Z_4F_3: Zeolite @ 50 kg ha^{-1} + 100% RDF	35.89	35.62	35.75	47.73	47.43	47.58
Z_4F_4: Zeolite @ 50 kg ha^{-1} + 125% RDF	36.32	35.82	36.07	48.30	47.70	48.00
S.Em±	**0.23**	**0.20**	**0.18**	**0.30**	**0.27**	**0.24**
CD (P=0.05)	**0.65**	**0.59**	**0.51**	**0.85**	**0.77**	**0.67**

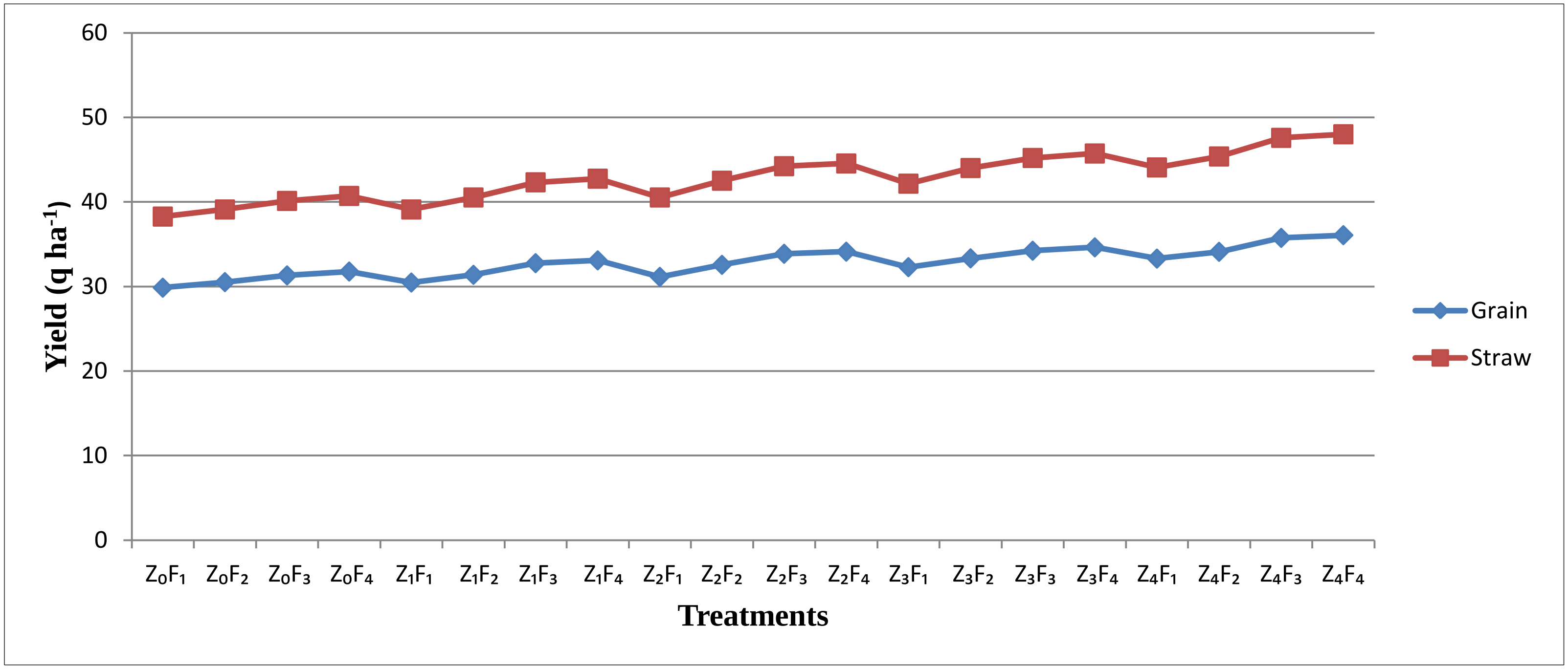

Fig.2 Grain and straw yield of finger millet crop as influenced by different levels of zeolite and fertilizer application

Factor I: Zeolite levels	**Factor II: Fertilizer levels**
Z_0 : Control	F_1: 50% RDF
Z_1 : Zeolite @ 20 kg ha^{-1}	F_2: 75% RDF
Z_2 :Zeolite @ 30 kg ha^{-1}	F_3: 100% RDF
Z_3 :Zeolite @ 40 kg ha^{-1}	F_4: 125% RDF
Z_4 : Zeolite @ 50 kg ha^{-1}	