

Effect of Nutrient Management and Mulching on Growth Parameters, Yield Attributes and Yield of Pearl millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz] in Western Region of India

ABSTRACT

Aim: To assessed the effect of nutrient management and mulching on growth parameters, yield attributes and yield of pearl millet.

Place and Duration of Study: A field experiment was conducted during two consecutive year 2021 and 2022 at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan).

Study Design and methodology: The 16 treatment combinations consist different nutrients and mulching sources with replicated four times and laid out in split plot design. Various plant growth parameters, yield attributes and yield were recorded with standard procedures.

Results: Results showed that Mustard straw mulch @ 2.5 t/ha gave significantly higher growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, weight of grains per ear and number of grains per ear) leading to increased grain yield (1930 kg/ha), stover yield (3748 kg/ha) and biological yield (5678 kg/ha) over control on pooled data basis. Results showed that Liquid *Azospirillum* gave significantly higher growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, weight of grains per ear and number of grains per ear) leading to increased grain yield (1954 kg/ha), stover yield (3742 kg/ha) and biological yield (5697 kg/ha) over control on pooled data basis. Results further indicated that among nitrogen management practices 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS proved significantly superior for growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, weight of grains per ear, number of grains per ear and test weight) and grain yield (1919 kg/ha), stover yield (3742 kg/ha), biological yield (5661 kg/ha) over control and remained at par with treatment RDN through urea and 0.2% foliar spray of nano urea on mean pooled data basis.

Keywords: Nutrient, mulching, *Azospirillum*, yield, growth, pearl millet and western.

1. INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz] is one of the important millet crop of India as well as Rajasthan. Cultivation of pearl millet is mainly confined to semi-arid and arid region of India. In India, pearl millet occupies an area of 6.70 million ha with an average production of 9.62 million tonnes and productivity of 1436 kg/ha [1]. Pearl millet crop occupies an area of 4.3 m ha and annual production of 4.30 million tonnes with a productivity of 1001 kg/ha in the state of Rajasthan [2]. In Rajasthan, pearl millet is mostly cultivated under harsh condition of frequent drought, high temperature, erratic rainfall and

low fertility on marginal and sub marginal soils which are low in nitrogen, phosphorus and organic matter with poor water holding capacity, lead to low yields. Under such adverse growing conditions, selection of appropriate high yielding cultivars, moisture conservation practices and nutrient management practices attains paramount importance. One such common practices of slower evaporation loss from the soil surface, prolonging the moisture availability and reduce water requirement of crop is the use of mulches. Use of mulching in crop fields increases water use efficiency, protect against solar radiation, regulates soil temperature, suppress weed growth, minimizes leaching loss of nutrients, reduces soil erosion, checks excessive evaporation, increase infiltration of rain water and improve soil moisture, production and quality of field crops [18, 23]. Mustard straw is readily available without much investment in the areas where it is grown particularly in arid and semi-arid zone. Quick decomposition of organic residue helped in increased availability of soil nutrients, which led to enhanced in growth and yield attributes and finally the grain yield [7]. Besides chemical fertilization, which involves high cost, biofertilizers are cheaper and renewable sources and contribute to the development strategies which do not lead to rise in consumption of non-renewable forms of energy. The occurrence of nitrogen fixing micro-organism such as *Azospirillum* within the plant of economic importance has been harnessed in Indian agriculture. *Azospirillum* bacteria can promote plant growth. The benefits to plants by inoculation with *Azospirillum* have been primarily attributed to its capacity to fix atmospheric nitrogen, but also to its capacity to synthesize phytohormones, in particular indole-3-acetic acid. Four aspects of *Azospirillum*-plant root interaction are highlighted viz., natural habitat, plant root interaction, nitrogen fixation and biosynthesis of plant growth hormones. *Azospirillum* is recommended for rice, millets, maize, wheat and sorghum etc. and it fixes 20-40 kg N/ha. Nitrogen is deficient in most of the Indian soils particularly the light textured ones. N is involved in the formation of proteins, nucleic acids, growth hormones and vitamins and is an integral part of chlorophyll. An adequate supply of nitrogen is associated with vigorous vegetative growth and dark green color. Nano-fertilizers are a new concept in nutrient management of crops and there is a great thrust area in agriculture for sustainable crop improvement with major importance of nano-nitrogen. The term nano material is based on the prefix nano which originates from Greek word meaning dwarf. More precisely, the word nano means 10^{-9} or one billionth of a metre. The word nanomaterial is generally used for materials with a size ranging between 1 and 100 nm [16]. There are lots of advantages of nano fertilizers, like they increase 55-60 times less requirement to chemical fertilizer, 10-12 times more stress tolerant by the crops, complete bio-source so eco-friendly and 18-54% improvement in the crop yield. Nano urea liquid contains nano scale nitrogen particles which have more surface area and number of particles over conventional urea prilled. The uptake efficiency of nano urea is more than 80% in contrast to urea. Therefore, it is required in lesser amount compared to the conventional urea fertilizer to fulfill plant's nitrogen requirement. Nano urea increased the grain, straw yield and nutrient uptake in rice crop [19]. It was superior in influencing morphology, yield attributes and yield of *rabi* maize [20].

2. MATERIALS AND METHODS

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif* seasons of the 2021 and 2022 to study the Response of hybrid pearl

millet to mulching, biofertilizers and nitrogen management practices grown on loamy sand soils of semi-arid eastern plain zone of Rajasthan. The experiment consisted of two mulching (control and mustard straw mulch @ 2.5 t/ha), two biofertilizers (control and liquid *Azospirillum*) and four nitrogen management practices (control, RDN through urea, 0.2 % foliar spray of nano urea and 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS), thereby making sixteen treatment combinations replicated four times in split plot design keeping mulching and biofertilizers in main plots and nitrogen management practices in sub plots. The hybrid pearl millet variety RHB 223 was sown at a spacing 45 cm between rows. All the recommended agronomic and plant protection measures were adopted to raise crop. Observation recorded on following aspects- growth parameters (plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content), yield attributes (number of effective tillers per metre row length, ear head length, ear head diameter, number of grains per ear, weight of grains per ear and test weight) and yields; grain, stover and biological yield (kg/ha) and harvest index (%). The influence of treatment was tested with 'F' test wherever 'F' test shown their significance. The levels of treatment were compared by critical difference at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Growth parameters

The data referring to growth parameters *viz.*, plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content are presented in table 1 to 4 and figure 1 to 3.

3.1.1. Effect of Mulching

Mulching treatment did not affect significantly the plant height and dry matter accumulation of pearl millet at initial growth stage at 30 DAS. The application of mulching significantly influenced plant height at 60 DAS and at harvest, dry matter accumulation at 60 DAS and at harvest, number of tillers per plant, number of leaves per plant and chlorophyll content in hybrid pearl millet during both the years over control. The plant height, dry matter accumulation, number of tillers per plant, number of leaves per plant and chlorophyll content observed significantly higher under application of mustard straw mulch @ 2.5 t/ha during both the years over control as well as on pooled analysis. It alters the microclimate by conserving more moisture through reduced weed growth, decreased evaporation loss, altered soil temperature and reduced need for irrigation. Additionally, appropriate and proper moisture conservation in plants leads to full cell turgidity, increased meristematic activity, higher rate of photosynthetic activity and ultimately more plant growth and development. These results were highly compatible with those published by Lal *et al.*, 2017 [12] and Kanwar *et al.*, 2017 [10].

3.1.2. Effect of Biofertilizers

At 30 DAS plant height and dry matter accumulation was non-significant due to liquid *Azospirillum* during both the years of experimentation and as well as on pooled analysis. However, application of liquid *Azospirillum* recorded higher plant height and dry matter accumulation at 60 DAS and at harvest, number of tillers per plant, number of leaves per plant and chlorophyll content in hybrid pearl millet as compared to control during both the years of study as well as on pooled analysis. The significant increase in the growth parameters may be due to inoculation of bacterial preparation accelerating plant growth

parameters, providing biologically fixed nitrogen to the inoculated plant and also stimulating plant growth by excreting plant growth promoting substances like, auxins, kinetins, vitamins and gibberellins. Similar findings were also reported by Patidar and Mali, 2004 [14] and Vamsi and Umesha, 2023 [22].

3.1.3. Effect of Nitrogen management

Nitrogen management did not differ significantly in plant height and dry matter accumulation at 30 DAS during both the years of experimentation. Chlorophyll content at 35 DAS treatment RDN through urea was significantly higher with 50% through urea + 0.2% foliar spray of nano urea at 30 DAS, 0.2% foliar spray of nano urea and over control. However, 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS treatment significantly increased plant height at 60 DAS and at harvest and dry matter accumulation per plant at 60 DAS and at harvest, number of tillers per plant, number of leaves per plant and chlorophyll content at 50 DAS over control and treatments, RDN through urea, 0.2% foliar spray of nano urea and 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS are statistically at par with each other during both the years of study as well as on pooled analysis. It improves plant metabolic processes, encourages meristematic activities, ensures higher apical growth and leaf photosynthetic area, triggers enzymes and induces mesophyll synthesis. This would have maintained continuous supply of nitrogen and increased meristematic activity and stimulated cell elongation in plants (Kumar *et al.*, 2021) [11]. This is likely due to the small size of nano urea particles, which have a larger surface area and can more easily penetrate into plant leaves, improving nutrient use efficiency and increasing crop dry matter production. Similar results are found with Rose *et al.*, 2015 [17] and Sahu *et al.*, 2022 [19].

3.2. Yield attributes

The data referring to yield attributes *viz.*, number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) are presented in table 5 to 6 and figure 4 to 5.

Table 1: Effect of mulching, biofertilizers and N management on plant height of pearl millet

| Treatments | Plant height (cm) | | | | | | | | |
|---|-------------------|------|--------|--------|-------|--------|------------|-------|--------|
| | 30 DAS | | | 60 DAS | | | At harvest | | |
| | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled |
| Mulching | | | | | | | | | |
| Control | 35.0 | 35.5 | 35.2 | 120.3 | 120.0 | 120.2 | 137.4 | 138.4 | 137.9 |
| Mustard straw mulch @ 2.5 t/ha | 36.3 | 36.8 | 36.6 | 142.7 | 143.8 | 143.2 | 164.4 | 165.5 | 164.9 |
| SEm± | 0.7 | 0.8 | 0.6 | 2.5 | 2.6 | 2.1 | 2.9 | 2.6 | 2.2 |
| CD (P=0.05) | NS | NS | NS | 7.6 | 7.7 | 6.1 | 8.7 | 7.7 | 6.6 |
| Biofertilizers | | | | | | | | | |
| Control | 35.0 | 35.4 | 35.2 | 119.4 | 119.5 | 119.4 | 137.5 | 138.1 | 137.8 |
| Liquid <i>Azospirillum</i> | 36.3 | 36.9 | 36.6 | 143.6 | 144.4 | 144.0 | 164.3 | 165.8 | 165.0 |
| SEm± | 0.7 | 0.8 | 0.6 | 2.5 | 2.6 | 2.1 | 2.9 | 2.6 | 2.2 |
| CD (P=0.05) | NS | NS | NS | 7.6 | 7.7 | 6.1 | 8.7 | 7.7 | 6.6 |
| Nitrogen management | | | | | | | | | |
| Control | 35.5 | 35.9 | 35.7 | 116.8 | 117.6 | 117.2 | 136.6 | 137.2 | 136.9 |
| RDN through Urea | 35.8 | 36.4 | 36.1 | 136.9 | 137.3 | 137.1 | 156.8 | 158.0 | 157.4 |
| 0.2% foliar spray of Nano Urea | 35.7 | 36.1 | 35.9 | 133.6 | 133.7 | 133.7 | 152.6 | 153.6 | 153.1 |
| 50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS | 35.7 | 36.2 | 36.0 | 138.6 | 139.0 | 138.8 | 157.6 | 159.0 | 158.3 |
| SEm± | 0.7 | 0.8 | 0.5 | 3.0 | 3.1 | 2.2 | 2.1 | 3.1 | 1.9 |
| CD (P=0.05) | NS | NS | NS | 8.6 | 8.8 | 6.1 | 5.9 | 8.7 | 5.3 |

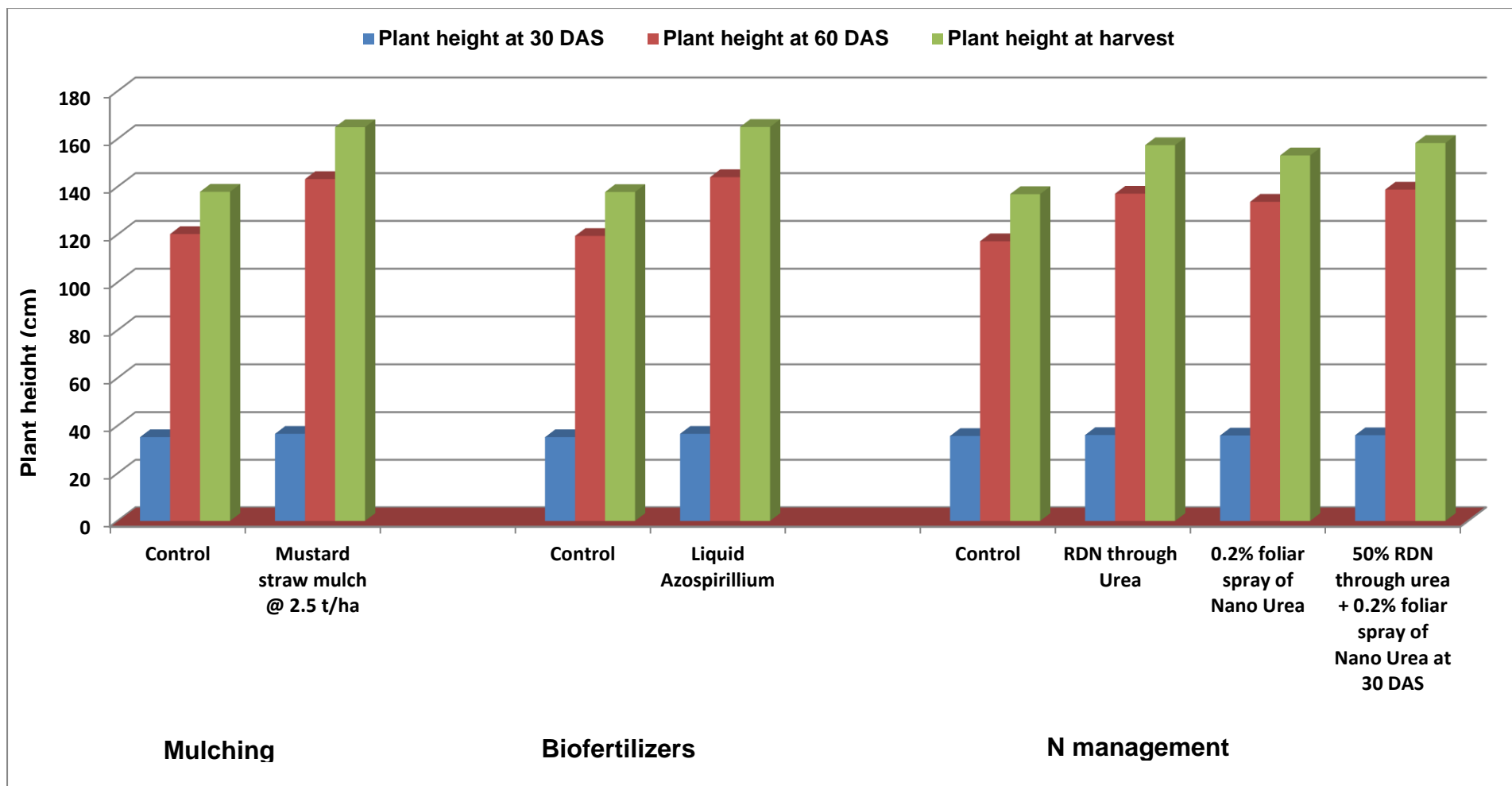


Fig. :1 Effect of mulching, biofertilizers and N management on plant height of pearl millet

Table 2: Effect of mulching, biofertilizers and N management on dry matter accumulation of pearl millet

| Treatments | Dry matter accumulation (g/plant) | | | | | | | | |
|---|-----------------------------------|-------|--------|--------|-------|--------|------------|-------|--------|
| | 30 DAS | | | 60 DAS | | | At harvest | | |
| | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled |
| Mulching | | | | | | | | | |
| Control | 13.89 | 14.02 | 13.96 | 33.49 | 33.68 | 33.58 | 43.30 | 44.06 | 43.68 |
| Mustard straw mulch @ 2.5 t/ha | 14.18 | 14.46 | 14.32 | 37.29 | 37.62 | 37.46 | 53.46 | 54.08 | 53.77 |
| SEm± | 0.25 | 0.27 | 0.21 | 0.35 | 0.47 | 0.34 | 0.89 | 0.77 | 0.68 |
| CD (P=0.05) | NS | NS | NS | 1.04 | 1.41 | 0.99 | 2.67 | 2.32 | 2.00 |
| Biofertilizers | | | | | | | | | |
| Control | 13.82 | 14.03 | 13.92 | 32.61 | 32.93 | 32.77 | 43.33 | 43.89 | 43.61 |
| Liquid <i>Azospirillum</i> | 14.25 | 14.45 | 14.35 | 38.17 | 38.37 | 38.27 | 53.43 | 54.25 | 53.84 |
| SEm± | 0.25 | 0.27 | 0.21 | 0.35 | 0.47 | 0.34 | 0.89 | 0.77 | 0.68 |
| CD (P=0.05) | NS | NS | NS | 1.04 | 1.41 | 0.99 | 2.67 | 2.32 | 2.00 |
| Nitrogen management | | | | | | | | | |
| Control | 13.88 | 13.96 | 13.92 | 32.04 | 32.68 | 32.36 | 43.14 | 43.85 | 43.50 |
| RDN through Urea | 14.19 | 14.77 | 14.48 | 36.62 | 36.72 | 36.67 | 50.65 | 51.35 | 51.00 |
| 0.2% foliar spray of Nano Urea | 13.96 | 14.00 | 13.98 | 36.10 | 36.22 | 36.16 | 48.92 | 49.65 | 49.29 |
| 50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS | 14.10 | 14.23 | 14.17 | 36.80 | 36.98 | 36.89 | 50.80 | 51.42 | 51.11 |
| SEm± | 0.18 | 0.25 | 0.15 | 0.39 | 0.38 | 0.27 | 0.74 | 1.09 | 0.66 |
| CD (P=0.05) | NS | NS | NS | 1.10 | 1.07 | 0.77 | 2.10 | 3.08 | 1.86 |

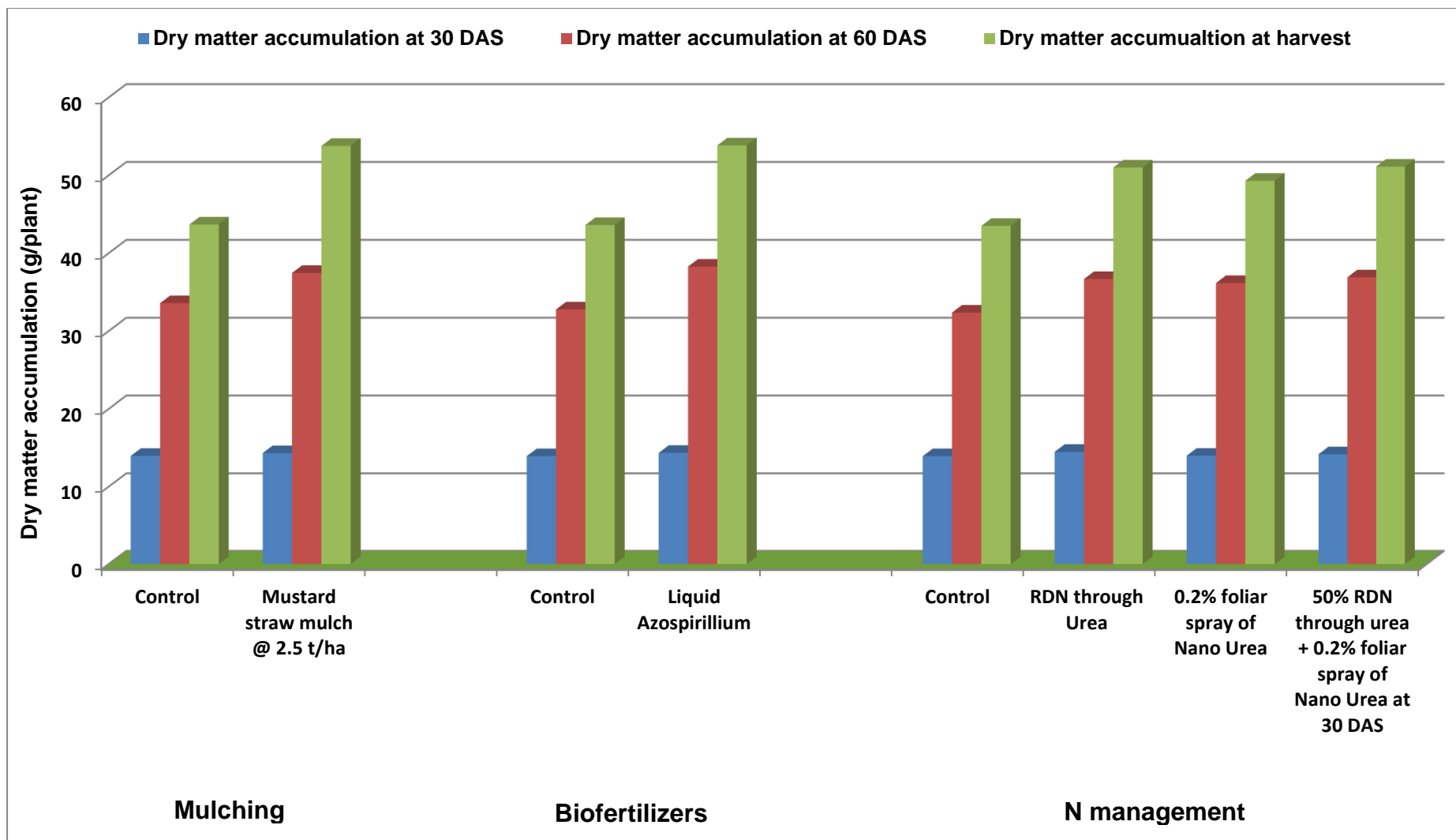


Fig. :2 Effect of mulching, biofertilizers and N management on dry matter accumulation of pearl millet

Table 3: Effect of mulching, biofertilizers and N management on total number of tillers per plant and number of leaves per plant of pearl millet

| Treatments | Total number of tillers/ plant | | | Number of leaves/ plant | | |
|---|--------------------------------|------|--------|-------------------------|-------|--------|
| | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled |
| Mulching | | | | | | |
| Control | 2.70 | 3.13 | 2.92 | 9.17 | 9.19 | 9.18 |
| Mustard straw mulch @ 2.5 t/ha | 3.10 | 3.51 | 3.30 | 11.06 | 11.20 | 11.13 |
| SEm± | 0.07 | 0.08 | 0.06 | 0.18 | 0.19 | 0.15 |
| CD (P=0.05) | 0.21 | 0.23 | 0.18 | 0.54 | 0.56 | 0.44 |
| Biofertilizers | | | | | | |
| Control | 2.72 | 3.11 | 2.91 | 9.21 | 9.30 | 9.26 |
| Liquid <i>Azospirillum</i> | 3.08 | 3.53 | 3.31 | 11.02 | 11.09 | 11.05 |
| SEm± | 0.07 | 0.08 | 0.06 | 0.18 | 0.19 | 0.15 |
| CD (P=0.05) | 0.21 | 0.23 | 0.18 | 0.54 | 0.56 | 0.44 |
| Nitrogen management | | | | | | |
| Control | 2.43 | 2.83 | 2.63 | 9.09 | 9.14 | 9.12 |
| RDN through Urea | 3.10 | 3.49 | 3.30 | 10.50 | 10.59 | 10.55 |
| 0.2% foliar spray of Nano Urea | 2.95 | 3.44 | 3.20 | 10.32 | 10.39 | 10.36 |
| 50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS | 3.12 | 3.52 | 3.32 | 10.55 | 10.66 | 10.61 |
| SEm± | 0.05 | 0.09 | 0.05 | 0.19 | 0.19 | 0.13 |
| CD (P=0.05) | 0.14 | 0.25 | 0.14 | 0.54 | 0.53 | 0.38 |

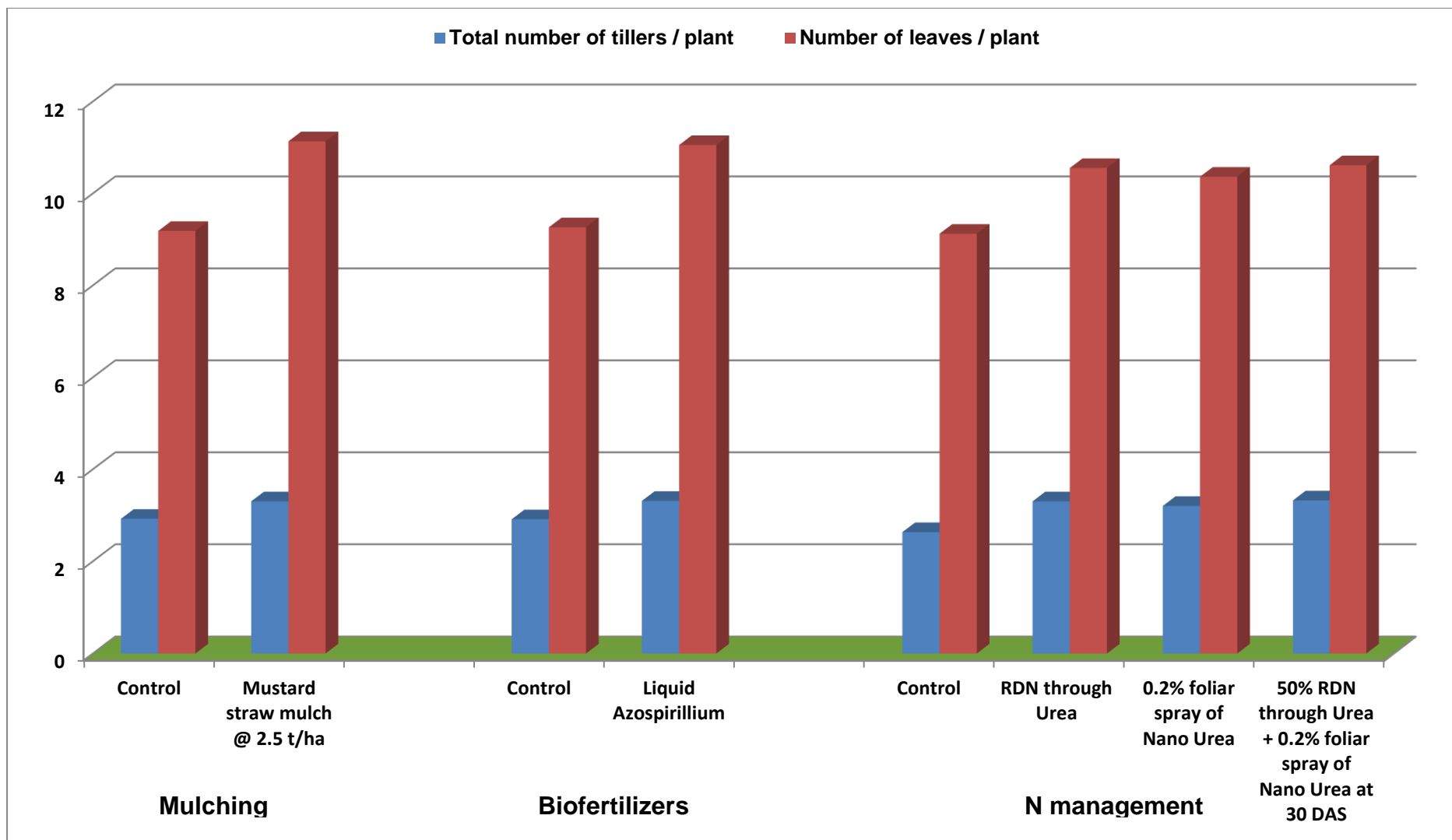


Fig. :3 Effect of mulching, biofertilizers and N management on total number of tillers per plant and number of leaves per plant of pearl millet

Table 4: Effect of mulching, biofertilizers and N management on chlorophyll content of pearl millet

| Treatments | Chlorophyll content (mg/g) | | | | | |
|---|----------------------------|------|--------|--------|------|--------|
| | 35 DAS | | | 50 DAS | | |
| | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled |
| Mulching | | | | | | |
| Control | 2.61 | 2.78 | 2.70 | 2.75 | 2.81 | 2.78 |
| Mustard straw mulch @ 2.5 t/ha | 2.80 | 2.88 | 2.84 | 2.92 | 2.98 | 2.95 |
| SEm± | 0.04 | 0.04 | 0.03 | 0.05 | 0.04 | 0.04 |
| CD (P=0.05) | 0.13 | 0.12 | 0.10 | 0.15 | 0.12 | 0.11 |
| Biofertilizers | | | | | | |
| Control | 2.59 | 2.72 | 2.66 | 2.71 | 2.76 | 2.73 |
| Liquid <i>Azospirillum</i> | 2.83 | 2.94 | 2.88 | 2.96 | 3.03 | 3.00 |
| SEm± | 0.04 | 0.04 | 0.03 | 0.05 | 0.04 | 0.04 |
| CD (P=0.05) | 0.13 | 0.12 | 0.10 | 0.15 | 0.12 | 0.11 |
| Nitrogen management | | | | | | |
| Control | 2.64 | 2.76 | 2.70 | 2.65 | 2.69 | 2.67 |
| RDN through Urea | 2.85 | 2.95 | 2.90 | 2.90 | 2.96 | 2.93 |
| 0.2% foliar spray of Nano Urea | 2.68 | 2.82 | 2.75 | 2.86 | 2.91 | 2.89 |
| 50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS | 2.66 | 2.80 | 2.73 | 2.93 | 3.02 | 2.98 |
| SEm± | 0.04 | 0.06 | 0.04 | 0.04 | 0.06 | 0.04 |
| CD (P=0.05) | 0.12 | 0.16 | 0.10 | 0.11 | 0.17 | 0.10 |

3.2.1. Effect of Mulching

The application of mulching significantly increased number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) in hybrid pearl millet over control during both the years. The number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) was recorded significantly maximum under application of mustard straw mulch @ 2.5 t/ha over control during both the years of study as well as on pooled analysis. The advantage of mustard straw mulch over control at 2.5 t/ha can be attributed to its ability to reduce evaporation losses by obstructing external evaporation processes and supplying energy to evaporating sites by reflecting some of the solar radiation that hits the soil surface. Mulch is more efficient at reducing evaporative loss, adjusting temperature and controlling weed growth than other landscaping materials. These findings are familiar with those of Kanwar *et al.*, 2017 [10] and Rummana *et al.*, 2018 [18].

3.2.2. Effect of Biofertilizers

Yield attributes (number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight) was significantly increased under application of liquid *Azospirillum* over control during both the years of experimentation and as well as on pooled analysis. This might be attributed due to increase height, leaf area and dry matter production which accrued because of positive effects of seed bacterization that is mainly due to nitrogen fixation and other factors like, release of hormones, increase of plant growth promoting substances (PGPS) and nutrient uptake. The results of almost similar nature were reported by Guggari and Kalaghatagi, 2005 [5] and Vamsi and Umesha, 2023 [22].

3.3.3. Effect of Nitrogen management

Number of effective tillers per metre row length, ear head length (cm), ear head diameter (cm), number of grains per ear, weight of grains per ear (g), test weight (g) was significantly influenced by nitrogen management. Application of 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS was significantly higher over control, however, it remained at par with other two treatments namely, RDN through urea and 0.2% foliar spray of nano urea. Application of nano-urea, which comprises nitrogen particles with a small size and a high density of surfaces that may easily pass through cell walls and reach the plasma membrane, may boost yield qualities. Stomatal pores can be penetrated by large particles. They are also transported to other plant parts by phloem cells via plasmodesmata, which promotes meristematic activities, ensures higher apical growth and leaf photosynthetic area and activates enzymes, amino acids/protein content, chlorophyll content, nucleic acid, photosynthates, etc. in the plant. All of these activities promote plant growth, which in turn increases the number of productive tillers and other yield characteristics. Nutrient treatment to the foliage is crucial when the roots are unable to provide the crop with the essential nutrients. This enables the crop to quickly absorb the nutrients it needs for increased output. These results were highly compatible with those published by Kumar *et al.*, 2021 [11] and Sahu *et al.*, 2022 [19].

3.3. Yields

The data referring to yields *viz.*, grain (kg/ha), stover (kg/ha) and biological yield (kg/ha) are presented in table 7 and figure 6. Harvest index (%) of pearl millet crop did not differ significantly due to application of mulching, biofertilizers and nitrogen management during both the years of experimentation and as well as on mean pooled analysis.

3.3.1. Effect of Mulching

The application of mulching significantly influenced grain, stover and biological yield of hybrid pearl millet over control during both the years of study. Application of mustard straw mulch @ 2.5 t/ha recorded significantly higher grain, stover and biological yield over control during both the years of study and as well as on pooled analysis. Mulching increase in soil moisture and altered temperature that led to the addition of nutrients to the soil and a decrease in the number of days needed to reach the necessary heat units for proper vegetative growth and development of plants could be attributed to the improvement in yield attributes and yield of hybrid pearl millet under mulching practices, which in turn improved the yield attributes and yield under light textured soils of semi-arid regions. The highest grain and fodder yield recorded under mulch were because of the fact that mulch plays an important role in changing hydro-thermal regime of soil and conserving soil moisture. Hence, congenial soil moisture is available for favourable growth during major life period of crop and consequently the higher growth and yield attributing characters reflected higher grain and fodder yield of pearl millet. These findings are in conformity with those obtained by Kachhadiya *et al.*, 2010 [9], Kumar and Gautam, 2004 [7] and Parihar *et al.*, 2012 [15].

3.3.2. Effect of Biofertilizers

Biofertilizers application significantly influenced grain, stover and biological yield of pearl millet over control during both the years of study. The use of liquid *Azospirillum* observed significantly higher grain, stover and biological yield over control during both the years of experimentation and as well as on pooled analysis. The higher yield obtained as a result of the nitrogen fixed by the plants, which encouraged germination and increased plant biomass. The results obtained with this study are in close agreement with the finding of Bhargava *et al.*, 1981 [3], Verma *et al.*, 1991 [21], Dalvi *et al.*, 1993 [4]. Use of *Azospirillum* significantly influenced the grain yield as this bacteria fixes atmospheric nitrogen and produces growth hormones like IAA, GA and Cytokinin. Golada *et al.*, 2012 [6] also observed that *Azospirillum* application significantly increased pearl millet yield as compared to untreated plots and similar findings were given by Khambalkar *et al.*, 2012 [8].

3.3.3. Effect of Nitrogen management

Nitrogen management treatments brought a significant improvement in grain, stover and biological yield of pearl millet during both the years of experimentation and on pooled analysis. Application of 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS recorded maximum grain, stover and biological yield of pearl millet over control, however, it remained statistically at par with 0.2% foliar spray of nano urea and RDN through urea during both the years of study on mean pooled basis. Application of nano-urea, which comprises nitrogen particles with a small size and a high density of surfaces that may easily pass through cell walls and reach the plasma membrane, may boost yield qualities. Due to the

Table 5: Effect of mulching, biofertilizers and N management on yield attributes (number of effective tillers per metre row length, ear head length and ear head diameter) of pearl millet

| Treatments | Number of effective tillers/ metre row length | | | Ear head length (cm) | | | Ear head diameter (cm) | | |
|---|---|-------|--------|----------------------|------|--------|------------------------|------|--------|
| | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled |
| Mulching | | | | | | | | | |
| Control | 16.84 | 16.94 | 16.89 | 24.1 | 24.1 | 24.1 | 5.7 | 5.8 | 5.7 |
| Mustard straw mulch @ 2.5 t/ha | 19.78 | 19.93 | 19.85 | 26.7 | 27.0 | 26.8 | 6.3 | 6.4 | 6.4 |
| SEm _± | 0.31 | 0.28 | 0.24 | 0.4 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| CD (P=0.05) | 0.93 | 0.84 | 0.71 | 1.2 | 1.1 | 0.9 | 0.3 | 0.3 | 0.2 |
| Biofertilizers | | | | | | | | | |
| Control | 16.85 | 16.94 | 16.89 | 24.0 | 24.1 | 24.0 | 5.7 | 5.8 | 5.8 |
| Liquid <i>Azospirillum</i> | 19.77 | 19.93 | 19.85 | 26.8 | 27.0 | 26.9 | 6.3 | 6.4 | 6.3 |
| SEm _± | 0.31 | 0.28 | 0.24 | 0.4 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| CD (P=0.05) | 0.93 | 0.84 | 0.71 | 1.2 | 1.1 | 0.9 | 0.3 | 0.3 | 0.2 |
| Nitrogen management | | | | | | | | | |
| Control | 16.98 | 17.18 | 17.08 | 23.4 | 23.7 | 23.5 | 5.6 | 5.7 | 5.7 |
| RDN through Urea | 18.76 | 18.89 | 18.83 | 26.0 | 26.1 | 26.1 | 6.1 | 6.3 | 6.2 |
| 0.2% foliar spray of Nano Urea | 18.45 | 18.55 | 18.50 | 25.9 | 26.0 | 25.9 | 6.0 | 6.2 | 6.1 |
| 50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS | 19.05 | 19.11 | 19.08 | 26.3 | 26.5 | 26.4 | 6.2 | 6.3 | 6.3 |
| SEm _± | 0.36 | 0.33 | 0.25 | 0.4 | 0.5 | 0.3 | 0.1 | 0.1 | 0.1 |
| CD (P=0.05) | 1.03 | 0.93 | 0.69 | 1.1 | 1.3 | 0.8 | 0.3 | 0.3 | 0.2 |

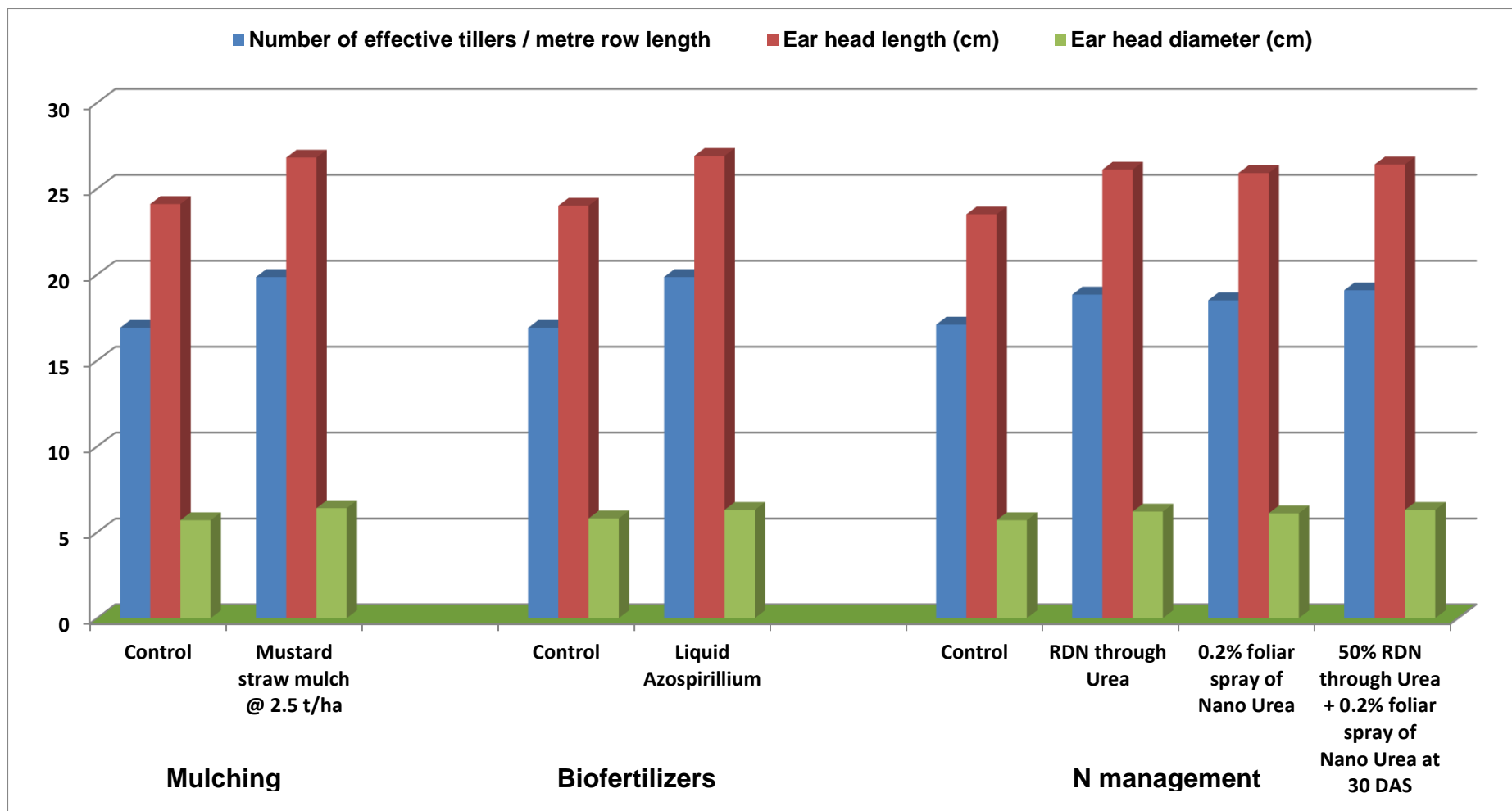


Fig. :4 Effect of mulching, biofertilizers and N management on yield attributes (number of effective tillers per metre row length, ear head length and ear head diameter) of pearl millet

Table 6: Effect of mulching, biofertilizers and N management on yield attributes (number of grains per ear, weight of grains per ear and test weight) of pearl millet

| Treatments | Number of grains/ ear | | | Weight of grains/ ear (g) | | | Test weight (g) | | |
|---|-----------------------|-------|--------|---------------------------|------|--------|-----------------|------|--------|
| | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled |
| Mulching | | | | | | | | | |
| Control | 1403 | 1417 | 1410 | 7.34 | 7.53 | 7.43 | 5.90 | 5.96 | 5.93 |
| Mustard straw mulch @ 2.5 t/ha | 1612 | 1632 | 1622 | 8.55 | 8.75 | 8.65 | 7.13 | 7.19 | 7.16 |
| SEm _± | 21.89 | 20.70 | 17.40 | 0.12 | 0.12 | 0.10 | 0.07 | 0.11 | 0.07 |
| CD (P=0.05) | 65.99 | 62.40 | 51.32 | 0.35 | 0.36 | 0.28 | 0.22 | 0.32 | 0.22 |
| Biofertilizers | | | | | | | | | |
| Control | 1399 | 1415 | 1407 | 7.25 | 7.40 | 7.33 | 5.88 | 5.92 | 5.90 |
| Liquid <i>Azospirillum</i> | 1616 | 1635 | 1626 | 8.63 | 8.88 | 8.75 | 7.14 | 7.22 | 7.18 |
| SEm _± | 21.89 | 20.70 | 17.40 | 0.12 | 0.12 | 0.10 | 0.07 | 0.11 | 0.07 |
| CD (P=0.05) | 65.99 | 62.40 | 51.32 | 0.35 | 0.36 | 0.28 | 0.22 | 0.32 | 0.22 |
| Nitrogen management | | | | | | | | | |
| Control | 1385 | 1405 | 1395 | 6.91 | 7.10 | 7.01 | 6.19 | 6.25 | 6.22 |
| RDN through Urea | 1552 | 1561 | 1556 | 8.31 | 8.45 | 8.38 | 6.66 | 6.69 | 6.68 |
| 0.2% foliar spray of Nano Urea | 1525 | 1545 | 1535 | 8.10 | 8.39 | 8.25 | 6.51 | 6.60 | 6.56 |
| 50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS | 1568 | 1588 | 1578 | 8.45 | 8.61 | 8.53 | 6.69 | 6.75 | 6.72 |
| SEm _± | 22.34 | 24.24 | 16.50 | 0.14 | 0.15 | 0.10 | 0.09 | 0.10 | 0.07 |
| CD (P=0.05) | 63.21 | 68.59 | 46.49 | 0.40 | 0.42 | 0.29 | 0.25 | 0.28 | 0.19 |

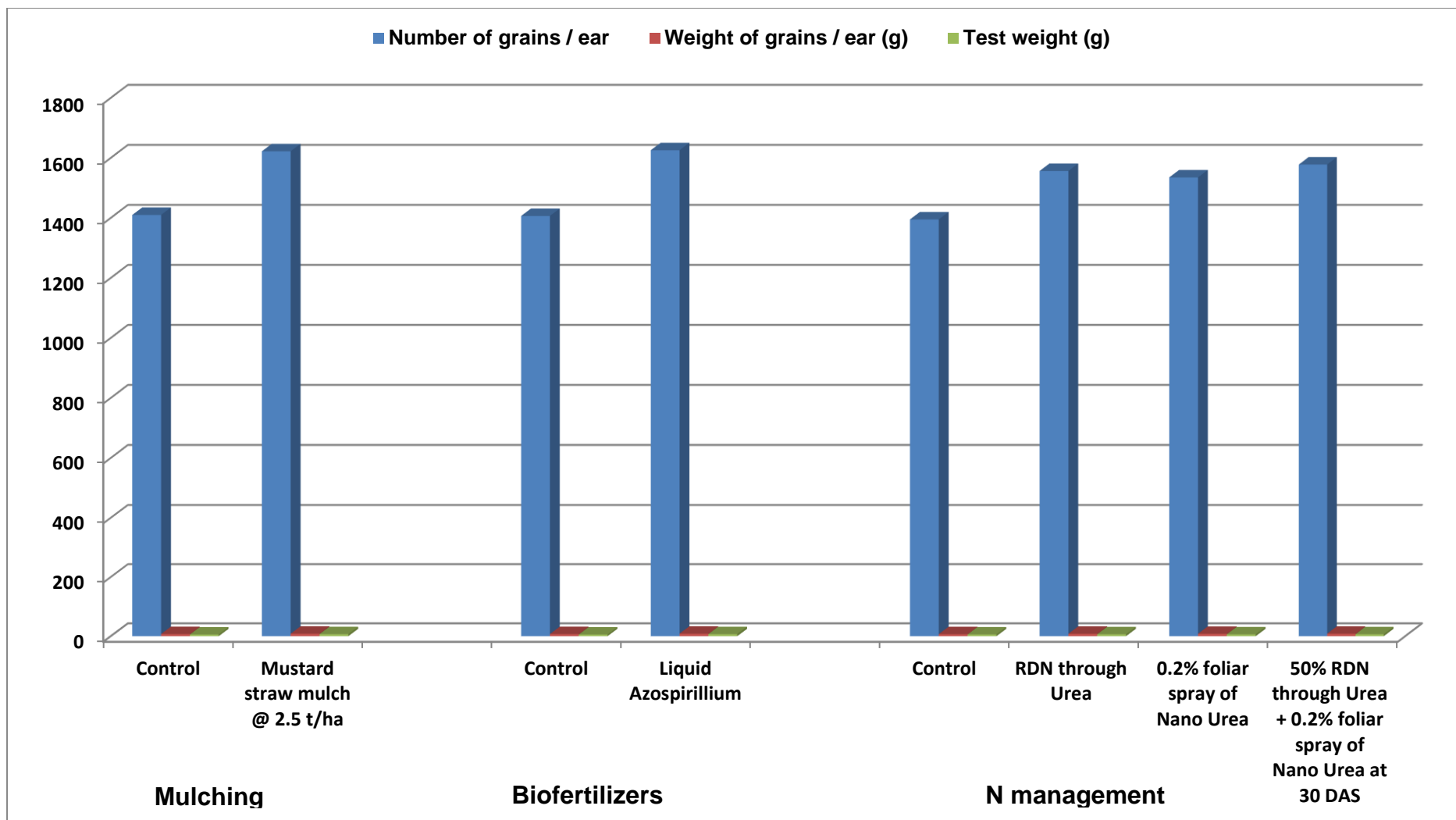


Fig. :5 Effect of mulching, biofertilizers and N management on yield attributes (number of grains per ear, weight of grains per ear and test weight) of pearl millet

Table 7: Effect of mulching, biofertilizers and N management on grain, stover and biological yield and harvest index of pearl millet

| Treatments | Grain yield (kg/ha) | | | Stover yield (kg/ha) | | | Biological yield (kg/ha) | | | Harvest index (%) | | |
|---|---------------------|------|--------|----------------------|------|--------|--------------------------|------|--------|-------------------|-------|--------|
| | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled | 2021 | 2022 | Pooled |
| Mulching | | | | | | | | | | | | |
| Control | 1622 | 1711 | 1666 | 3311 | 3357 | 3334 | 4933 | 5067 | 5000 | 32.82 | 33.69 | 33.26 |
| Mustard straw mulch @ 2.5 t/ha | 1902 | 1958 | 1930 | 3724 | 3772 | 3748 | 5627 | 5730 | 5678 | 33.75 | 34.10 | 33.93 |
| SEm _± | 38 | 36 | 30 | 54 | 58 | 46 | 87 | 95 | 74 | 0.62 | 0.69 | 0.53 |
| CD (P=0.05) | 115 | 110 | 90 | 164 | 174 | 135 | 262 | 285 | 219 | NS | NS | NS |
| Biofertilizers | | | | | | | | | | | | |
| Control | 1623 | 1661 | 1642 | 3327 | 3353 | 3340 | 4950 | 5013 | 4982 | 32.74 | 33.10 | 32.92 |
| Liquid <i>Azospirillum</i> | 1901 | 2008 | 1954 | 3709 | 3776 | 3742 | 5609 | 5784 | 5697 | 33.83 | 34.69 | 34.26 |
| SEm _± | 38 | 36 | 30 | 54 | 58 | 46 | 87 | 95 | 74 | 0.62 | 0.69 | 0.53 |
| CD (P=0.05) | 115 | 110 | 90 | 164 | 174 | 135 | 262 | 285 | 219 | NS | NS | NS |
| Nitrogen management | | | | | | | | | | | | |
| Control | 1516 | 1585 | 1551 | 3096 | 3128 | 3112 | 4612 | 4713 | 4663 | 32.81 | 33.56 | 33.19 |
| RDN through Urea | 1845 | 1910 | 1878 | 3650 | 3715 | 3683 | 5495 | 5625 | 5560 | 33.51 | 33.89 | 33.70 |
| 0.2% foliar spray of Nano Urea | 1795 | 1896 | 1846 | 3610 | 3645 | 3628 | 5405 | 5541 | 5473 | 33.15 | 34.15 | 33.65 |
| 50% RDN through urea + 0.2% foliar spray of Nano Urea at 30 DAS | 1892 | 1946 | 1919 | 3715 | 3769 | 3742 | 5607 | 5715 | 5661 | 33.68 | 33.98 | 33.83 |
| SEm _± | 38 | 41 | 28 | 70 | 72 | 50 | 100 | 102 | 71 | 0.75 | 0.76 | 0.53 |
| CD (P=0.05) | 107 | 115 | 79 | 199 | 205 | 142 | 282 | 287 | 201 | NS | NS | NS |

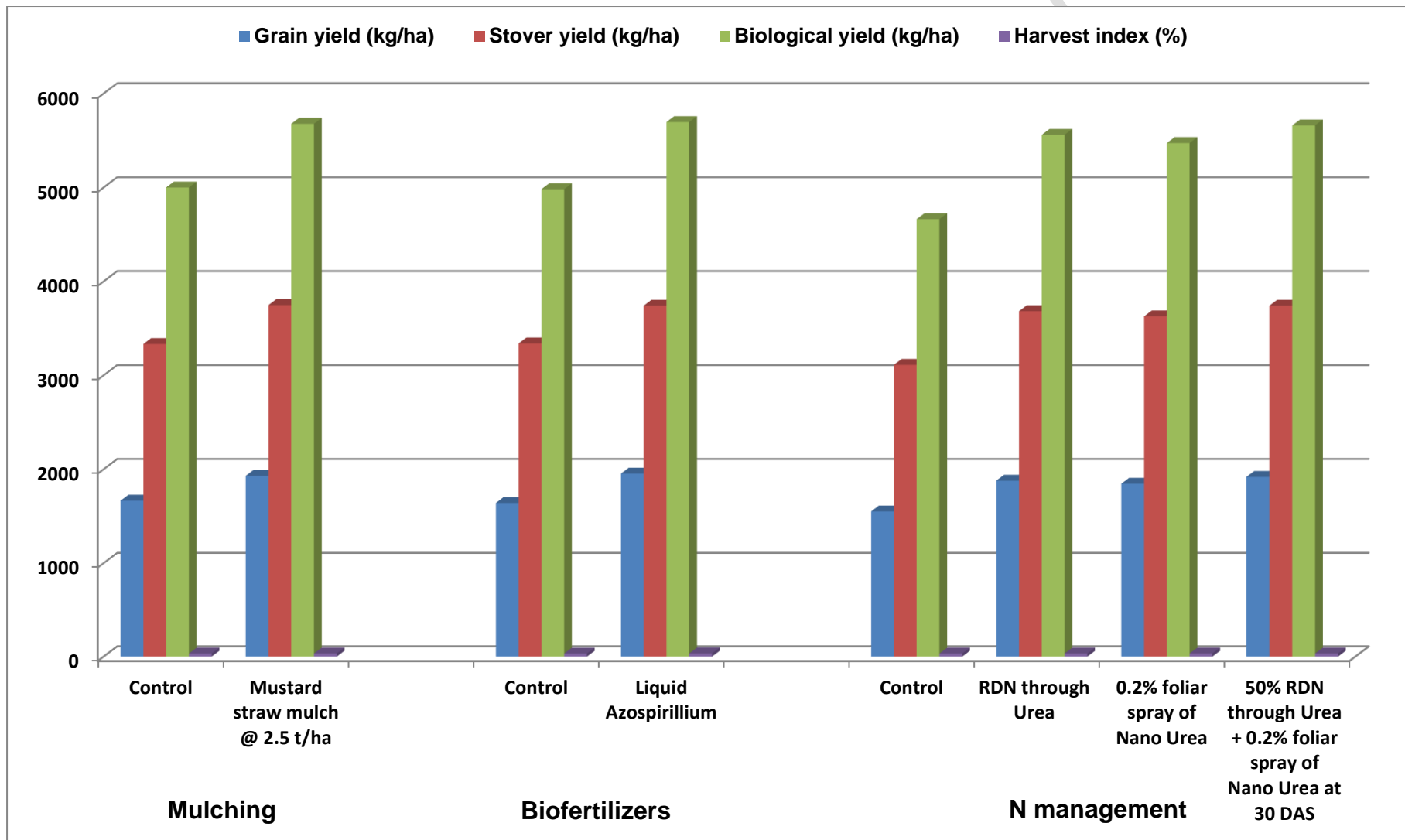


Fig. :6 Effect of mulching, biofertilizers and N management on grain, stover, biological yields and harvest index of pearl millet

use of two foliar nano urea sprays, an increase in effective tillers, grain, stover and biological yield was made possible. As it improves plant metabolic processes, encourages greater apical growth, leaf photosynthetic area and stimulates cell elongation in plants, it ultimately results in greater nutrient uptake by the plant, increasing grain and straw yield in pearl millet. These results were highly compatible with those published by Kumar *et al.*, 2021 [11], Sahu *et al.*, 2022 [19] and Midde *et al.*, 2022 [13].

4. CONCLUSION

- Use of mustard straw mulch @ 2.5 t/ha proved superior to obtain significantly higher growth parameters, yield attributes and yield of pearl millet.
- Application of liquid *Azospirillum* recorded significantly maximum growth parameters, yield attributes and yield of pearl millet.
- Application of 50% RDN through urea + 0.2% foliar spray of nano urea at 30 DAS proved to be the most suitable nitrogen management practice as it provided significantly increased growth parameters, yield attributes and yield of pearl millet over control and it remained at par with 0.2% foliar spray of nano urea and RDN through urea.

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