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# Influence of drip fertigation schedule and fertilizer sources on water productivity and microbial population dynamics in direct seeded rice system

**Sathisha GS, Narayana S Mavarkar, Dinesh Kumar M, Sridhara CJ, Ganapathi and Nandish MS**

## Abstract
A field experiment was conducted at Agricultural and Horticultural research station, Bhavikere, Karnataka in red sandy clay loam soil during *summer*-2020 to study the influence of drip fertigation schedule and fertilizer sources on water productivity and microbial population dynamics in direct seeded rice system. Research was carried out in split plot design consisting of three levels of drip fertigation schedule in the main plot and four different combinations of fertilizer sources in sub plot, it was replicated thrice. The experimental results revealed that, higher water productivity of 104.04 kg ha-cm$^{-1}$ recorded in drip fertigation scheduling once in five days and among the sources of fertilizer used 100% water soluble fertilizer recorded higher water productivity of 106.93 kg ha-cm$^{-1}$. Whereas, with respect to the microbial population studied, fertigation scheduling once in five days recorded higher number of bacterial, fungal and actinomycetes population at harvest in soil (56.91cfu×10$^{5}$/g of soil, 27.90 cfu×10$^{4}$/g of soil and 13.89 cfu×10$^{3}$/g of soil, respectively) and among the sources of fertilizer used 100% water soluble fertilizer used plots recorded higher number of bacterial, fungal and actinomycetes population at harvest in soil (58.67cfu×10$^{5}$/g of soil, 28.60 cfu×10$^{4}$/g of soil and 13.93cfu×10$^{3}$/g of soil, respectively).

**Keywords:** Direct seeded rice, Fertigation, water productivity and microbial population

## Introduction
Rice (*Oryza sativa* L.) is one of the most ancient food crops and a primary food source for over one third of the world's population being cultivated in 117 countries across the world and hence called as 'global cereal'. It is one of the oldest domesticated crops known to mankind with farmers having grown it under irrigated condition for more than 4,000 years. In India, it is a staple food for over two thirds of the population.

Rice is cultivated in different methods, among them transplanting is the most prominent and traditional method of rice cultivation under flood irrigation, as it consumes around 3000-5000 litres of water to produce one kilogram of rice. Thus it is not only consumes more water but also causes wastage of water that leads to degradation of land. The scarcity of water due to climate change, erratic rainfall and unavailability of sufficient water to tail end rice growers has lead to researchers to develop production technologies for cultivation of rice under less water condition.

In Direct seeded rice system, wherein the crop is established in non-puddled, non-flooded fields and rice is grown like an upland crop (unsaturated condition) with adequate inputs and supplementary irrigation when rainfall is insufficient. DSR refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery.

Use of fertilizers in conventional rice cultivation has been reported to have poor nutrient use efficiency due to excessive use of water and readily available nature of nutrients in fertilizers.

Water soluble fertilizers are fast-acting fertilizers that are good to use when plants are under stressful period, such as transplanting the plant or during times of extreme drought. Granular fertilizers are much slower to break down and benefit the plant. Standardization, quantification and scheduling of water soluble fertilizer as drip fertigation for cereal crops of the region will help in promoting plant growth and lower the corrosive effects on the plants. Application of water soluble fertilizers to the crops through irrigation or direct spray in small quantity will saves labour, cost of production, and reduce compaction of soil.

The role and importance of biofertilizers in sustainable crop production has been reported by several research workers (Wani Lee, 1995 and Katyal *et al*. 1994) [10, 3]. Soil harbours a huge population of microorganisms and their abundance play a key role in making plant nutrients available to plants and keep the soil productive for crop production. Among the varied form of biological nitrogen fixing biofertilizers in rice cultivation Azospirillum has a prime role and has been recognized as a potential nitrogen fixing diazotroph colonizing root environment of paddy and other cereal crops. It fixes atmospheric N2, enhances uptake of nutrients and also produces plant growth promoting substances.

Keeping all these points in view, the paper entitled "influence of drip fertigation schedule and fertilizer sources on water productivity and microbial population dynamics in direct seeded rice system". was carried out.

## Material and Methods

### Location of the experimental site

The experiment was conducted at Agricultural and Horticultural Research Station, Bhavikere which is situated between 75°51` E longitude and 13°42` N with an altitude of 695 meters above the mean sea level and is located in Zone-7 of Karnataka.

### Experimental details

The experiment was laid out in split plot design and comprised of two factors for study *viz.*, main plot treatments were comprised of fertigation schedules *viz.*, $M_1$: Once in 5 days, $M_2$: Once in 10 days and $M_3$: Once in 15 days and subplot treatments were sources of fertilizer *viz.*, $S_1$: 100% water soluble fertilizer (WSF), $S_2$: 75% WSF + 25% normal fertilizer (NF), $S_3$: 50% WSF + 50% NF and $S_4$: 100% NF. The gross plot size was 4.8 m × 3.0 m and net plot size was 3.6 m × 2.6 m. The spacing given was 30 cm × 10 cm.

### Drip system installation and water management

Drip irrigation system which includes pump, filter units, fertigation tank, ventury, main line and sub line for each replication and a lateral for each plot. The water source was bore well. Water was pumped through 5 HP motor and it was conveyed to the main field using mains after filtering through sand and screen filter which was in turn connected with sub mains. Further, sub mains were laid perpendicular to replications of the experiment; the laterals were attached to the sub main at 60 cm interval in such a way that the laterals were parallel to the rows of direct seeded rice. The water was made to discharge through inline emitters @ 2 lph @ 2 kg $cm^2$ pressure.

The drip irrigation was given by using 1.0 IW/CPE ratio and the irrigation scheduled once in 5 days by adding the evaporation data of the successive 5 days from the USWB class A Open Pan Evaporimeter. By multiplying the amount of water evaporated and area of the plot, the volume of water required was calculated. The daily evaporation data collected from USWB class A pan evaporimeter (*summer* 2020) is furnished in the Table 1.

Volume of water required (l) = Depth of irrigation or CPE × area of the plot

Time of operation of drip system to deliver required volume of water per plot was computed based on the formula

$$\text{Time of application} = \frac{\text{Volume of water required (l)}}{\text{Emitter discharge (l ha}^{-1})\times\text{No. of emitters plot}^{-1}}$$

**Table 1:** Daily evaporation and rainfall data during the crop period *summer* -2020

| Date | Evaporation (mm) | Rainfall (mm) | Date | Evaporation (mm) | Rainfall (mm) | Date | Evaporation (mm) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|
| 16-Feb | 6.3 | - | 31-Mar | 6.4 | - | 14-May | 4.7 | 8.6 |
| 17-Feb | 5.9 | - | 01-Apr | 7.2 | - | 15-May | 5 | - |
| 18-Feb | 6 | - | 02-Apr | 7 | - | 16-May | 4.9 | - |
| 19-Feb | 6.3 | - | 03-Apr | 7.9 | - | 17-May | 4.8 | - |
| 20-Feb | 6.1 | - | 04-Apr | 7.8 | - | 18-May | 3.2 | 25 |
| 21-Feb | 6.3 | - | 05-Apr | 8 | - | 19-May | 5.6 | - |
| 22-Feb | 6.5 | - | 06-Apr | 7 | - | 20-May | 4.6 | - |
| 23-Feb | 6 | - | 07-Apr | 6.2 | - | 21-May | 4.6 | - |
| 24-Feb | 6.2 | - | 08-Apr | 6.7 | - | 22-May | 4.8 | - |
| 25-Feb | 5.6 | - | 09-Apr | 6.9 | - | 23-May | 5 | - |
| 26-Feb | 5.7 | - | 10-Apr | 7.2 | - | 24-May | 4.7 | - |
| 27-Feb | 6 | - | 11-Apr | 7 | - | 25-May | 5.3 | - |
| 28-Feb | 6.1 | - | 12-Apr | 7.5 | - | 26-May | 4.9 | 3.8 |
| 29-Feb | 6.4 | - | 13-Apr | 8 | - | 27-May | 6.7 | - |
| 01-Mar | 5.9 | - | 14-Apr | 9 | - | 28-May | 7.8 | - |
| 02-Mar | 3.9 | - | 15-Apr | 6.9 | - | 29-May | 4.7 | - |
| 03-Mar | 4.7 | - | 16-Apr | 6.2 | - | 30-May | 5.2 | - |
| 04-Mar | 4.9 | - | 17-Apr | 6 | - | 31-May | 5 | 13.6 |
| 05-Mar | 4.9 | - | 18-Apr | 6.1 | - | 01-Jun | 5.9 | - |
| 06-Mar | 5.3 | - | 19-Apr | 5.9 | - | 02-Jun | 6.8 | - |
| 07-Mar | 5.6 | - | 20-Apr | 7.8 | - | 03-Jun | 5.2 | - |
| 08-Mar | 5.9 | - | 21-Apr | 6.5 | - | 04-Jun | 7.8 | - |
| 09-Mar | 6.7 | - | 22-Apr | 5.9 | 4 | 05-Jun | 2.7 | - |
| 10-Mar | 6 | - | 23-Apr | 5.6 | - | 06-Jun | 3.2 | - |
| 11-Mar | 5.8 | - | 24-Apr | 5.6 | - | 07-Jun | 5.6 | - |
| 12-Mar | 6.3 | - | 25-Apr | 6.2 | - | 08-Jun | 4.7 | - |
| 13-Mar | 6 | - | 26-Apr | 6.2 | - | 09-Jun | 5 | - |
| 14-Mar | 6.2 | - | 27-Apr | 5.7 | - | 10-Jun | 6 | - |
| 15-Mar | 6.1 | - | 28-Apr | 7.4 | - | 11-Jun | 6 | - |
| 16-Mar | 5.6 | - | 29-Apr | 5.9 | - | 12-Jun | 2 | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 17-Mar | 7 | - | 30-Apr | 6.2 | - | 13-Jun | 1.8 | - |
| 18-Mar | 7 | - | 01-May | 6.8 | - | 14-Jun | 1.6 | - |
| 19-Mar | 7.2 | - | 02-May | 7 | - | 15-Jun | 2.3 | - |
| 20-Mar | 7.4 | - | 03-May | 4.3 | 8.8 | 16-Jun | 2.3 | - |
| 21-Mar | 7.4 | - | 04-May | 7.9 | - | 17-Jun | 2 | - |
| 22-Mar | 7.8 | - | 05-May | 4.2 | 16.6 | 18-Jun | 1.5 | - |
| 23-Mar | 7.5 | - | 06-May | 6.6 | - | 19-Jun | 4 | - |
| 24-Mar | 6.7 | - | 07-May | 7.2 | - | 20-Jun | 5.1 | - |
| 25-Mar | 6.8 | - | 08-May | 4.4 | 8.4 | 21-Jun | 4 | - |
| 26-Mar | 7.8 | - | 09-May | 6.3 | - | 22-Jun | 3.8 | - |
| 27-Mar | 6 | - | 10-May | 6.7 | - | | | |
| 28-Mar | 6.5 | - | 11-May | 4.6 | 0.7 | | | |
| 29-Mar | 6.3 | - | 12-May | 4.8 | 3.2 | | | |
| 30-Mar | 6.7 | - | 13-May | 4.9 | - | | | |

**Application of the microbial consortia along g with Manure and fertilizer application**

At the time of FYM application, recommended dose of FYM (10 t ha$^{-1}$) was mixed with the liquid plant growth promoting rhizomicrobial consortia (*Azospirillum* + PSB + KSB) at 625 ml ha$^{-1}$ and it was applied two weeks before sowing for all the treatments in all the three experiments. The recommended dose of fertilizers (100: 50: 50 of N:$P_2O_5$:$K_2O$ kg ha$^{-1}$ and zinc sulphate @ 20 kg ha$^{-1}$) were applied as per the treatments.

The NPK was applied as per the treatment details through drip fertigation method by using ventury system to each plot up to 80 days after sowing starting from 20 DAS (Table 2), where 20% of the RDF was applied at the time of sowing by using urea, di ammonium phosphate and murate of potash. The remaining 80% of the nutrients were given through fertigation as per the treatment details by using water soluble fertilizers and normal fertilizers. The sources of nutrients were urea, di ammonium phosphate and murate of potash for normal fertilizers and for water soluble fertilizers 19:19:19 and calcium nitrate (15.5% N and 17% Ca).

**Table 2:** Quantity of fertilizers (kg ha$^{-1}$) applied for the Experiment III as per the treatment details

| Treatments | 100% WSF | | 75% WSF + 25% NF | | | | | 50% WSF + 50% NF | | | | | 100% NF | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 19:19:19 | $CaNO_3$ | 19:19:19 | $CaNO_3$ | Urea | DAP | MOP | 19:19:19 | $CaNO_3$ | Urea | DAP | MOP | Urea | DAP | MOP |
| Total | 210.5 | 258.06 | 157.87 | 193.54 | 35.00 | 21.75 | 16.70 | 105.25 | 129.03 | 69.90 | 43.50 | 33.33 | 139.90 | 87.00 | 66.70 |
| Once in 5 days (13 splits) | 16.19 | 19.85 | 12.14 | 14.88 | 2.69 | 1.63 | 1.28 | 8.09 | 9.92 | 5.37 | 3.34 | 2.56 | 10.76 | 6.69 | 5.13 |
| Once in 10 days (7 splits)) | 30.07 | 36.86 | 22.55 | 27.64 | 5.00 | 3.10 | 2.38 | 15.03 | 18.43 | 9.98 | 6.21 | 4.76 | 19.98 | 12.42 | 9.52 |
| Once in 15 days (5 splits) | 42.10 | 51.61 | 31.57 | 38.70 | 7.00 | 4.35 | 3.34 | 21.05 | 25.80 | 13.98 | 8.70 | 6.66 | 27.98 | 17.40 | 13.34 |

**Observation on grain yield**

After thorough drying, the plants along with panicles in each net plot were threshed; cleaned and seed weight in each plot was recorded in kilograms. Based on this, yield ha$^{-1}$ was calculated and expressed in kg ha$^{-1}$.

**Calculation of water use efficiency (WUE)**

Water use efficiency was worked out from the yield of direct seeded rice and the amount of water used (Viets, 1972) [9] and expressed in kg ha-cm$^{-1}$.

$$\text{WUE} = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Quantity of total water applied (cm)}}$$

**Analysis of biological properties of soil**

**Total microbial count in soil**

Dilution and plate count technique was used for enumerating the total bacteria, fungi and actinomycetes where 10 g soil (soil sample obtained from individual gross plot at 60, 90 and at harvest) was suspended in 100 ml water to obtain $10^1$ dilutions. One ml of this suspension was added to 9 ml water to get a dilution of $10^2$. Similarly, the dilution was continued until $10^6$ dilutions were obtained. From $10^5$ dilution 1ml was added to sterile Petri plate for enumeration of bacteria and 1ml from $10^4$ and $10^3$ dilutions for fungi and actinomycetes, respectively.

Then 15 ml of the appropriate media (Table 3) was added to each plate and rotated in the clockwise and anticlockwise direction. After solidification, the plates were incubated in an inverted position at room temperature. After the incubation period, the colonies were counted assuming that each viable cell will give rise to a single colony. Finally, the number of colonies (CFU) in 1g of soil was calculated by using the following formula as described by Skinner *et al*. (1952) [7].

$$\text{No. of colonies per gram of soil (CFU)} = \frac{\text{No. of colonies} \times \text{Dilution factor}}{\text{ml taken for dilution} \times \text{Weight of soil (g)}}$$

**Table 3:** Different growth media and their composition used for microbial counts in soil

| Media | Bacteria | Fungi | Actinomycetes |
|---|---|---|---|
| | Nutrient agar (NA) | Martin rose Bengal agar media (MRBA) | Kuster's agar (KA) |
| Beef extract (g) | 3.0 | - | - |
| Peptone (g) | 5.0 | 5.0 | - |
| Glucose (g) | 5.0 | - | - |
| NaCl (g) | 5.0 | - | 2.0 |
| Agar (g) | 20.0 | 20.0 | 20.0 |
| Dextrose (g) | - | 10.0 | 2.0 |
| $KH_2PO_4$ (g) | - | 1.0 | 0.02 |
| $MgSO_47H_2O$ (g) | - | 0.5 | 0.05 |
| Rose Bengal (g) | - | 0.3 | - |
| Glycerol (g) | - | - | 10.0 |
| Casein (g) | - | - | 0.3 |
| $KNO_3$ (g) | - | - | 2.0 |
| $CaCO_3$ (g) | - | - | 0.02 |
| $FeSO_4$ (g) | - | - | 0.1 |
| Water (ml) | 1000.0 | 1000.0 | 1000.0 |
| pH | 7.0 | 6.0 | 7.1-7.2 |

## Results and Discussion

### Grain yield of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources

The data related to grain yield of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources furnished in the Table 4.

### Grain yield

Among the three intervals of fertigation schedule, scheduling fertigation at once in five days recorded significantly higher grain yield (7283 kg ha$^{-1}$), whereas significantly lower grain yield (6497 kg ha$^{-1}$) was noticed in scheduling of drip fertigation once in fifteen days. It is due to frequent split application of fertilizers in drip irrigation coincided with the actual needs and favoured good growth, which resulted maximum yield. In this study also frequent application of fertilizers coincided with the nutrient demand and supplied more nutrients at peak time without any nutrient stress which might have resulted in higher yield attributes and yield. Scheduling fertigation once in fifteen days might have not match with season demand for nutrients. This led to reduced yield under low fertigation intervals. This result was in accordance with Anusha (2015) [1] and Yamuna *et al.* (2018) [11].

Application of nutrients through drip fertigation with 100% WSF recorded significantly higher difference on grain yield (7485 kg ha$^{-1}$) which was on par with application of nutrients through drip fertigation with 75% WSF + 25% NF combination (7206 kg ha$^{-1}$). Application of nutrients through drip fertigation with 100% NF recorded significantly grain yield (6067 kg ha$^{-1}$). Application of nutrients through WSF increased solubility and availability of nutrients to the root zone. Application of 75% water soluble fertilizer in combination with 25% normal fertilizers recorded on par yield with application of 100% water soluble fertilizer. Application of straight fertilizers in combination with water soluble fertilizers is best alternative source to water soluble fertilizers alone. Similar results were reported by Ponnuswamy and Santhy (2008) [5], Nagaraju *et al.* (2014) [4], Rekha (2014) [6], Anusha (2015) [1] and Yamuna *et al.* (2018) [11].

With respect to the interaction between the drip fertigation schedule and sources of fertilizer combination, significantly higher grain yield (7859 kg ha$^{-1}$) was recorded in scheduling fertigation once in five days with the 100% WSF and significantly lower grain yield (5706 kg ha$^{-1}$) was observed in drip fertigation scheduling once in fifteen days with the 100% NF.

### Total water used (mm) and water use efficiency (kg ha-cm$^{-1}$) of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources

The data on irrigation water used, total water used and water use efficiency under drip fertigation in direct seeded rice treatments are presented in the Table 5.

The irrigation water applied was 608 mm for all the treatments under drip fertigation treatments.

The total water used applied was 700 mm for all the treatments under drip fertigation treatments.

Significantly higher water use efficiency (104.04 kg ha-cm$^{-1}$) and significantly lower water use efficiency (92.82 kg ha-cm$^{-1}$) were noticed in drip fertigation scheduling of once in five days and fifteen days, respectively.

Among the combination of fertilizer sources significantly higher water use efficiency (106.93 kg ha-cm$^{-1}$) was recorded in drip fertigation with 100% WSF and it was at par with drip fertigation with 75% WSF + 25% NF combination (102.94 kg ha-cm$^{-1}$). Whereas, significantly lower water use efficiency (86.67 kg ha-cm$^{-1}$) was noticed in drip fertigation with 100% NF.

Water use efficiency recorded non-significant difference in the interaction between drip fertigation schedule and sources of fertilizer combination. Wherein, fertigation scheduling once in five days with the 100% WSF recorded highest water use efficiency (112.27 kg ha-cm$^{-1}$) and drip fertigation scheduling once in fifteen days with 100% NF noticed lowest water use efficiency (81.52 kg ha-cm$^{-1}$).

### Microbial population of soil at different growth stages

### Bacterial population of soil at different growth stages

The data on bacterial population of soil at 60, 90 DAS and at harvest showed significant difference by the fertigation intervals and sources of fertilizer combination (Table 6).

Significantly higher bacterial population at 60, 90 DAS and at harvest (66.36, 72.67 and 56.91 cfu×10$^5$/g of soil, respectively) were recorded in fertigation scheduling once in five days and significantly lower microbial population (57.32, 62.73 and 48.33 cfu×10$^5$/g of soil, respectively) were noticed in scheduling of fertigation at once in fifteen days.

Among the combination of fertilizer sources, significantly higher bacterial population at 60, 90 DAS and at harvest (68.03, 74.44 and 58.67 cfu×10$^5$/g of soil, respectively) were recorded in drip fertigation with 100% WSF and it was at par with drip fertigation with 75% WSF + 25% NF combination (65.71, 72.02 and 56.43 cfu×10$^5$/g of soil, respectively). Significantly least bacterial population was observed with 100% NF (53.56, 58.60 and 44.67 cfu×10$^5$/g of soil, respectively).

The interaction of drip fertigation schedule and sources of fertilizer combination recorded non-significant difference on bacterial population of soil. However, higher bacterial population at 60, 90 DAS and at harvest (73.03, 80.01 and 63.50 cfu×10$^5$/g of soil, respectively) were recorded in scheduling of drip fertigation once in five days with 100% WSF and scheduling drip fertigation once in fifteen days with 100% NF noticed lower bacterial population (50.25, 54.87 and 41.60 cfu×10$^5$/g of soil, respectively).

### Fungal population of soil at different growth stages

The data on fungal population of soil at different growth stages showed significant difference by the fertigation intervals and sources of fertilizer combination (Table 7).

Significantly higher fungal population of soil at 60, 90 DAS and at harvest (32.54, 35.63 and 27.90 cfu×10$^4$/g of soil, respectively) was recorded in fertigation scheduling once in five days and significantly lower fungal population (27.33, 29.91 and 23.05 cfu×10$^4$/g of soil, respectively) was noticed in scheduling of fertigation at once in fifteen days.

Among the combination of fertilizer sources, significantly higher fungal population of soil at 60, 90 DAS and at harvest (33.16, 36.29 and 28.60 cfu×10$^4$/g of soil, respectively) was recorded in drip fertigation with 100% WSF and it was at par with drip fertigation with 75% WSF + 25% NF combination (31.99, 35.05 and 27.47 cfu×10$^4$/g of soil, respectively). Whereas, significantly least fungal population was observed with 100% NF (25.34, 27.72 and 21.13 cfu×10$^4$/g of soil, respectively).

The interaction between drip fertigation schedule and sources of fertilizer combination recorded non-significant difference on fungal population at all the stages of crop growth. However, higher fungal population at 60, 90 DAS and at harvest (35.65, 39.06 and 31.00 cfu×10$^4$/g of soil, respectively) was recorded in scheduling of drip fertigation once in five days with 100% WSF and scheduling drip fertigation once in fifteen days with 100% NF noticed lower fungal population (22.71, 24.80 and 18.80 cfu×10$^4$/g of soil, respectively).

**Actinomycetes population of soil at different growth stages**

The data on actinomycetes population of soil at 60, 90 DAS and at harvest showed significant difference by the fertigation intervals and sources of fertilizer combination (Table 8).

Significantly higher actinomycetes population at 60, 90 DAS and at harvest (16.20, 17.73 and 13.89 cfu×10$^3$/g of soil, respectively) were recorded in fertigation scheduling once in five days and significantly lower actinomycetes population (13.24, 14.49 and 11.16 cfu×10$^3$/g of soil, respectively) were noticed in scheduling of fertigation at once in fifteen days.

Among the combination of fertilizer sources, significantly higher actinomycetes population at 60, 90 DAS and at harvest (16.15, 17.68 and 13.93 cfu×10$^3$/g of soil, respectively) were recorded in drip fertigation with 100% WSF and it was at par with drip fertigation with 75% WSF + 25% NF combination (15.64, 17.14 and 13.43 cfu×10$^3$/g of soil, respectively). Significantly least actinomycetes population was observed with 100% NF (13.08, 14.31 and 10.91 cfu×10$^3$/g of soil, respectively).

The interaction of drip fertigation schedule and sources of fertilizer combination recorded non-significant difference on actinomycetes population of soil. However, higher actinomycetes population of soil at 60, 90 DAS and at harvest (17.71, 19.40 and 15.40 cfu×10$^3$/g of soil, respectively) were recorded in scheduling of drip fertigation once in five days with 100% WSF and scheduling drip fertigation once in fifteen days with 100% NF noticed lower actinomycetes population (12.01, 13.11 and 9.94 cfu×10$^3$/g of soil, respectively).

The increased microbial population with increased interval of fertigation schedule with the water soluble fertilizer helps in increasing the biomass, root exudates and ultimately provides carbon and energy to the soil microbes resulting into multiplication of microbial population (Vessey, 2003; Hanuman prasad *et al*., 2014) [8, 2].

**Table 4:** Grain yield of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources

| | Grain yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|
| | **M$_1$** | **M$_2$** | **M$_3$** | **Mean** |
| S$_1$ | 7859$^a$ | 7467$^{ab}$ | 7130$^{bc}$ | 7485 |
| S$_2$ | 7481$^{ab}$ | 7214$^b$ | 6922$^{bc}$ | 7206 |
| S$_3$ | 7218$^b$ | 6874$^{bc}$ | 6231$^{de}$ | 6775 |
| S$_4$ | 6574$^{cd}$ | 5921$^e$ | 5706$^e$ | 6067 |
| Mean | 7283 | 6869 | 6497 | |
| | S.Em.± | | CD (P=0.05) | |
| Main plot (M) | 79 | | 236 | |
| Sub plot (S) | 106 | | 315 | |
| Interaction (MXS) | 178 | | NS | |

Main plot: Drip fertigation schedule (M) Sub plot: Sources of fertilizer (S)
M$_1$: Once in 5 days S$_1$: 100% water soluble fertilizer (WSF)
M$_1$: Once in 10 days S$_2$: 75% WSF + 25% normal fertilizer (NF)
M$_1$: Once in 15 days S$_3$: 50% WSF + 50% NF
S$_4$: 100% NF
**Note:** Values followed by different alphabets are significantly differ from each other

**Table 5:** Total water used (mm) and water use efficiency (kg ha-cm$^{-1}$) of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources

| | Irrigation water applied (mm) | | | | Total water applied (I$_R$ + E$_R$) | | | | Water use efficiency (kg ha-cm$^{-1}$) | | | | Number if irrigations given | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M$_1$ | M$_2$ | M$_3$ | Mean | M$_1$ | M$_2$ | M$_3$ | Mean | M$_1$ | M$_2$ | M$_3$ | Mean | M$_1$ | M$_2$ | M$_3$ | Mean |
| S$_1$ | 608 | 608 | 608 | 608 | 700 | 700 | 700 | 700 | 112.27 | 106.67 | 101.86 | 106.93 | 22.00 | 22.00 | 22.00 | 22.00 |
| S$_2$ | 608 | 608 | 608 | 608 | 700 | 700 | 700 | 700 | 106.87 | 103.05 | 98.89 | 102.94 | 22.00 | 22.00 | 22.00 | 22.00 |
| S$_3$ | 608 | 608 | 608 | 608 | 700 | 700 | 700 | 700 | 103.12 | 98.21 | 89.01 | 96.78 | 22.00 | 22.00 | 22.00 | 22.00 |
| S$_4$ | 608 | 608 | 608 | 608 | 700 | 700 | 700 | 700 | 93.91 | 84.58 | 81.52 | 86.67 | 22.00 | 22.00 | 22.00 | 22.00 |
| Mean | 608 | 608 | 608 | | 700 | 700 | 700 | | 104.04 | 98.13 | 92.82 | | 22.00 | 22.00 | 22.00 | |
| | | S.Em± | C.D.(P=0.05) | | S.Em± | | C.D. (P=0.05) | | S.Em± | C.D. (P=0.05) | | | S.Em± | | C.D.(P=0.05) | |
| Main plot (M) | | NA | NA | | NA | | NA | | 1.13 | 3.34 | | | NA | | NA | |
| Sub plot (S) | | NA | NA | | NA | | NA | | 1.52 | 4.50 | | | NA | | NA | |
| Interaction (MXS) | | NA | NA | | NA | | NA | | 2.54 | NS | | | NA | | NA | |

Main plot: Drip fertigation schedule (M) Sub plot: Sources of fertilizer (S)
M$_1$: Once in 5 days S$_1$: 100% water soluble fertilizer (WSF)
M$_1$: Once in 10 days S$_2$: 75% WSF + 25% normal fertilizer (NF)
M$_1$: Once in 15 days S$_3$: 50% WSF + 50% NF
S$_4$: 100% NF
*NA-Not analysed

**Table 6:** Bacterial population (cfu×10$^5$/g of soil) of soil after harvest of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources

| | 60 DAS | | | | 90 DAS | | | | At harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **M$_1$** | **M$_2$** | **M$_3$** | **Mean** | **M$_1$** | **M$_2$** | **M$_3$** | **Mean** | **M$_1$** | **M$_2$** | **M$_3$** | **Mean** |
| S$_1$ | 73.03 | 68.29 | 62.77 | 68.03 | 80.01 | 74.77 | 68.55 | 74.44 | 63.50 | 58.92 | 53.60 | 58.67 |
| S$_2$ | 71.44 | 65.52 | 60.16 | 65.71 | 78.30 | 71.65 | 66.10 | 72.02 | 61.85 | 56.24 | 51.20 | 56.43 |
| S$_3$ | 63.09 | 58.27 | 56.09 | 59.15 | 68.88 | 63.94 | 61.39 | 64.74 | 53.60 | 49.30 | 46.90 | 49.93 |
| S$_4$ | 57.90 | 52.53 | 50.25 | 53.56 | 63.50 | 57.42 | 54.87 | 58.60 | 48.70 | 43.70 | 41.60 | 44.67 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 66.36 | 61.15 | 57.32 | | 72.67 | 66.95 | 62.73 | | 56.91 | 52.04 | 48.33 | |

| | S.Em.± | CD (P=0.05) | S.Em.± | CD (P=0.05) | S.Em.± | CD (P=0.05) |
|---|---|---|---|---|---|---|
| Main plot (M) | 0.70 | 2.07 | 0.77 | 2.28 | 0.60 | 1.78 |
| Sub plot (S) | 0.95 | 2.81 | 1.04 | 3.08 | 0.81 | 2.39 |
| Interaction (MXS) | 1.58 | NS | 1.73 | NS | 1.35 | NS |

Main plot: Drip fertigation schedule (M) Sub plot: Sources of fertilizer (S)
$M_1$: Once in 5 days $S_1$: 100% water soluble fertilizer (WSF)
$M_1$: Once in 10 days $S_2$: 75% WSF + 25% normal fertilizer (NF)
$M_1$: Once in 15 days $S_3$: 50% WSF + 50% NF
$S_4$: 100% NF

**Table 7:** Fungal population (cfu×$10^4$/g of soil) of soil after harvest of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources

| | 60 DAS | | | | 90 DAS | | | | At harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$M_1$** | **$M_2$** | **$M_3$** | **Mean** | **$M_1$** | **$M_2$** | **$M_3$** | **Mean** | **$M_1$** | **$M_2$** | **$M_3$** | **Mean** |
| $S_1$ | 35.65 | 33.03 | 30.80 | 33.16 | 39.06 | 36.17 | 33.64 | 36.29 | 31.00 | 28.50 | 26.30 | 28.60 |
| $S_2$ | 34.91 | 31.80 | 29.26 | 31.99 | 38.23 | 34.78 | 32.15 | 35.05 | 30.20 | 27.30 | 24.90 | 27.47 |
| $S_3$ | 31.66 | 28.72 | 26.55 | 28.98 | 34.57 | 31.52 | 29.06 | 31.71 | 26.90 | 24.30 | 22.20 | 24.47 |
| $S_4$ | 27.94 | 25.36 | 22.71 | 25.34 | 30.64 | 27.73 | 24.80 | 27.72 | 23.50 | 21.10 | 18.80 | 21.13 |
| Mean | 32.54 | 29.73 | 27.33 | | 35.63 | 32.55 | 29.91 | | 27.90 | 25.30 | 23.05 | |

| | S.Em.± | CD (P=0.05) | S.Em.± | CD (P=0.05) | S.Em.± | CD (P=0.05) |
|---|---|---|---|---|---|---|
| Main plot (M) | 0.35 | 1.04 | 0.38 | 1.50 | 0.30 | 0.89 |
| Sub plot (S) | 0.46 | 1.36 | 0.50 | 1.49 | 0.39 | 1.16 |
| Interaction (MXS) | 0.77 | NS | 0.84 | NS | 0.66 | NS |

Main plot: Drip fertigation schedule (M) Sub plot: Sources of fertilizer (S)
$M_1$: Once in 5 days $S_1$: 100% water soluble fertilizer (WSF)
$M_1$: Once in 10 days $S_2$: 75% WSF + 25% normal fertilizer (NF)
$M_1$: Once in 15 days $S_3$: 50% WSF + 50% NF
$S_4$: 100% NF

**Table 8:** Actinomycetes population (cfu×$10^3$/g of soil) of soil after harvest of direct seeded rice as influenced by drip fertigation schedule and fertilizer sources

| | 60 DAS | | | | 90 DAS | | | | At harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$M_1$** | **$M_2$** | **$M_3$** | **Mean** | **$M_1$** | **$M_2$** | **$M_3$** | **Mean** | **$M_1$** | **$M_2$** | **$M_3$** | **Mean** |
| $S_1$ | 17.71 | 16.46 | 14.29 | 16.15 | 19.40 | 18.02 | 15.60 | 17.68 | 15.40 | 14.20 | 12.20 | 13.93 |
| $S_2$ | 17.46 | 15.84 | 13.63 | 15.64 | 19.12 | 17.33 | 14.98 | 17.14 | 15.10 | 13.60 | 11.60 | 13.43 |
| $S_3$ | 15.42 | 14.07 | 13.04 | 14.17 | 16.83 | 15.43 | 14.27 | 15.51 | 13.10 | 11.90 | 10.90 | 11.97 |
| $S_4$ | 14.20 | 13.03 | 12.01 | 13.08 | 15.57 | 14.24 | 13.11 | 14.31 | 11.94 | 10.84 | 9.94 | 10.91 |
| Mean | 16.20 | 14.85 | 13.24 | | 17.73 | 16.26 | 14.49 | | 13.89 | 12.64 | 11.16 | |

| | S.Em.± | CD (P=0.05) | S.Em.± | CD (P=0.05) | S.Em.± | CD (P=0.05) |
|---|---|---|---|---|---|---|
| Main plot (M) | 0.17 | 0.50 | 0.18 | 0.53 | 0.14 | 0.42 |
| Sub plot (S) | 0.22 | 0.67 | 0.25 | 0.73 | 0.19 | 0.57 |
| Interaction (MXS) | 0.38 | NS | 0.41 | NS | 0.32 | NS |

Main plot: Drip fertigation schedule (M) Sub plot: Sources of fertilizer (S)
$M_1$: Once in 5 days $S_1$: 100% water soluble fertilizer (WSF)
$M_1$: Once in 10 days $S_2$: 75% WSF + 25% normal fertilizer (NF)
$M_1$: Once in 15 days $S_3$: 50% WSF + 50% NF
$S_4$: 100% NF

## Conclusion

The study revealed that the plots which received the scheduling of fertigation once in five days with 100% WSF fertilizer recorded highest number of microbial population and highest water productivity. Whereas lowest water productivity and lowest microbial population count recorded in the plots where fertigation scheduled once in fifteen days and 100% NF applied plots.

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