Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2020; SP6: 387-391

**MV Manjunatha**
Professor of Agricultural Engineering, AC, Hanumanamatti, Karnataka, India

**BH Prasanna Kumar**
Research Associates, Water4Crops Project, University of Agricultural Sciences, Dharwad, Karnataka, India

**Sunil A Satyareddi**
Research Associates, Water4Crops Project, University of Agricultural Sciences, Dharwad, Karnataka, India

**Manjunatha Hebbar**
Professor of Soil Science & Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

**Correspondence**
**MV Manjunatha**
Professor of Agricultural Engineering, AC, Hanumanamatti, Karnataka, India

**International Web-Conference**
**On**
**New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development**
**(21-22 June, 2020)**

# Response of different sources of irrigation with graded levels of fertilizer on yield, water productivity and economics of French bean

**MV Manjunatha, BH Prasanna Kumar, Sunil A Satyareddi and Manjunatha Hebbar**

## Abstract
A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during kharif, 2016 to study the response of French bean to different source of irrigation water with graded levels of fertilizer on yield, water productivity and its economics. The study consisted of four different source of irrigation water ie., Domestic wastewater (DWW), Engineered constructed wetland treated wastewater (TWW), fresh water (FW) & Engineered constructed wetland treated wastewater altered with domestic wastewater (TWW-DWW) and five levels of fertilizer ie., no RDF, 25 %, 50 %, 75 % and 100 % RDF). Significantly higher yield (4261 kg/ha) of French bean was recorded with DWW irrigation as compared with other sources of irrigation. Application of 100 per cent and 75 per cent RDF resulted in higher yield of French bean (4240 kg/ha and 3965 kg/ha, respectively) over other fertilizer levels. Among the interaction effect, application of DWW with 100 per cent RDF recorded higher yield of French bean (5294 kg/ha) which was on par with DWW irrigation with 75 per cent RDF (4985 kg/ha). Higher water productivity (113.8 kg/ha.cm), net return (Rs. 87,084/ha) and net profit per cm of water used (Rs. 2,326/cm) was recorded with DWW irrigation as compared to other sources of irrigation. Similarly, application of 100 per cent RDF recorded higher water productivity (113.2 kg/ha.cm), net returns ((Rs. 83,854/ha) and net profit per cm of water used (Rs. 2,240/cm). However, it was on par with application of 75 per cent RDF. Interaction effect results indicated that application of DWW as source of irrigation with 75 per cent and 100 per cent RDF resulted in higher water productivity, net returns and net profit per cm of water used.

**Keywords:** domestic wastewater, engineered constructed wetland, graded level of fertilizer, crop performance, water productivity, economic feasibility.

## Introduction
The rapid growth in population increases urbanization and industrialization which results in scarcity of fresh water for irrigation. Larger amounts of freshwater are diverted to domestic, commercial, and industrial sectors, which generate greater volumes of wastewater (Qadir *et al.* 2007) [12]. In India, only 24% of wastewater generated by households and industry is treated before its use in agriculture or disposal to rivers (Minhas and Samra 2003) [10]. Wastewater treatment plants in most cities in developing countries are non-existent or function inadequately. Advantages associated with wastewater recycling include the supply of nutrients and trace minerals to plants, potentially leading to higher yields and a decrease in the demand for inorganic fertilizers (Val-Moraes *et al*., 2011 and Bichai *et al*., 2012) [15, 1]. Higher yields can be achieved by using pre- treated wastewater for irrigation to various crops under controlled environmental conditions (Zavadil, 2009) [18]. Therefore, wastewater in partially treated, diluted or untreated form is diverted and used by urban and peri-urban farmers to grow a range of crops (Ensink *et al.* 2007) [3].

Many studies have shown that microbiological contamination can be a major issue for the re-use of treated agricultural wastewater (Rubino and Lonigro, 2008; Patterson *et al*., 2011; Vivaldi *et al*., 2013) [13, 11, 16]. Constructed wetlands (CWs) for wastewater treatment are potentially a good solution for treating domestic and industrial wastewaters (Kivaisi, 2001) [6].

The advantages of the CW technology are the utilisation of natural processes, the high process stability and the cost-effectiveness. Furthermore, the systems are simple to construct and operate which is a benefit in many developing countries. Treatment of sewage using CWs is achieved by passing wastewater through shallow gravel-filled beds planted with emergent macrophytes. (Davison *et al.*, 2005 and Wallace & Knight, 2006) [2, 17]. Moreover, wetland plants are an integral part of the constructed wetland treatment system. They play important roles in CWs for their capability of degrading and removing nutrients and other pollutants. Keeping these in view the necessity of re-use of waste water for irrigation and the importance of treatment of waste water through Engineered constructed wet land [ECWL] technology, field experiments were conducted to study the response of different sources of irrigation water with graded levels of fertilizer on crop response, water productivity and economics of French bean.

## Materials and Methods

A field experiment was conducted during kharif, 2016 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The site was situated at a latitude of 15º26'N and longitude of 75º07'E with an altitude of 678 m above MSL and falls in the northern transitional zone of Karnataka. The soil of the experiment site was sandy clay loam with low organic carbon and soil available nitrogen and medium in available phosphorus and high in available potassium. Soil and water were analyzed using standard procedure indicated by Tandon (1998) [14]. Soil analysis of the experimental site before the conduct of the experiment is presented in table 1.

Engineered Constructed Wetland (ECWL) with capacity to treat 50 $m^3$ $day^{-1}$ was established under Water4crops project, Department of Biotechnology, Government of India to treat the domestic wastewater generated from the University campus. ECWL treated wastewater, domestic wastewater and bore well water available at campus were used as a source of irrigation in the experiment. Macrophtyes of *Typha latifolia* and *Bracharia mutica* were used in the ECWL filled with filter bed with gravels (< 40 mm) to a depth of 50 cm; fine sand to a depth of 25 cm and charcoal to a depth of 5 cm. The water quality parameters were analyzed at fortnightly interval and mean of the data for the growing season is presented in table 2.

The experiment was laid out in split plot design with three replications. The study consisted of four different source of irrigation water as a main treatment [ie., Domestic wastewater (DWW), ECWL treated wastewater (TWW), fresh water (FW) & ECWL treated wastewater with domestic wastewater (TWW-DWW)] and five levels of fertilizer as a sub-treatments [ ie., no RDF, 25 %, 50 %, 75 % and 100 % RDF].

French bean (cv Seville) was sown on 30/08/2016 during kharif, 2016 at a spacing of 45 cm x 15 cm following the recommended package of practices. The recommended dose of fertilizer for French bean is 63:100:75 kg N, $P_2O_5$, $K_2O$ / ha. Cumulative weight of the periodic harvest of French bean was accounted and presented as fruits per plant. Net plot yield of French bean as influenced by the treatment were arrived and expressed as kg/ha. Irrigation was scheduled at 50 per cent depletion of soil moisture. Volumetric method was used to measure the water applied to each plot. In all a total of eight irrigations were given with an average depth of 31.3 mm for each irrigation during the cropping period. Total amount of water applied during the entire cropping period was 374.4 mm which includes effective rainfall of 124.0 mm. Water productivity was calculated and expressed as kg/ha-cm. Economic feasibility was studied in monetary terms of net return (Rs/ha), B: C ratio and net profit per cm of water used. Statistical analyses of the observed biometric and yield parameters were also carried out as per Gomez and Gomez (1984) [4].

**Table 1:** Initial soil properties of the experimental site

| Properties | Values |
|---|---|
| pH | 7.10 |
| EC (dS $m^{-1}$) | 0.42 |
| Organic carbon (g $kg^{-1}$) | 4.4 |
| Available nitrogen (kg $ha^{-1}$) | 173.2 |
| Available Phosphorus (kg $ha^{-1}$) | 27.3 |
| Available Potassium (kg $ha^{-1}$) | 423.5 |
| Exch-Ca [cmol ($p^+$) $kg^{-1}$] | 18.5 |
| Exch-Mg [cmol ($p^+$) $kg^{-1}$] | 12.25 |
| Available zinc (mg/kg) | 1.4 |
| Available iron (mg/kg) | 5.3 |
| Bulk density (Mg $m^{-3}$) | 1.42 |
| Water soluble aggregates (%) | 39.50 |

**Table 2:** Chemical properties of the different source of irrigation water during the cropping period

| Parameters | Fresh water /bore well water | Domestic wastewater | ECWL treated water |
|---|---|---|---|
| pH | 7.68 | 7.51 | 7.48 |
| EC (dS $m^{-1}$) | 0.79 | 1.37 | 1.21 |
| Total N (mg/l) | 0.65 | 20.8 | 11.5 |
| $NH^+_4$ – N (mg/l) | 0.35 | 12.0 | 5.8 |
| $NO^-_3$- N (mg/l) | 0.2 | 5.2 | 2.7 |
| Phosphate (ppm) | 0.3 | 10.1 | 5.6 |
| Ca + Mg (me/l) | 4.2 | 10.8 | 7.4 |
| Sodium (ppm) | 3.2 | 8.1 | 5.6 |
| Potassium (ppm) | 5.1 | 5.4 | 3.8 |
| Chloride (ppm) | 2.1 | 7.2 | 4.8 |
| Bicarbonate (me/l) | 2.5 | 10.3 | 4.9 |

## Results and Discussion

### Vegetative growth and yield parameters

Application of domestic wastewater recorded significantly higher plant height (44.0 cm) at 45 days over other sources of irrigation (Table 3). However it was on par with application of domestic wastewater alternated with ECWL treated wastewater (42.3 cm). Among the fertilizer doses application of 75 and 100 per cent of RDF recorded higher plant height (43.7 cm and 45.7 cm, respectively) over other fertilizer levels.

Application of domestic wastewater resulted in significantly higher fruits/plant (8.8). Similarly among the different fertilizer levels, application of 100 per cent RDF resulted in higher fruits/plant (8.6) which was on par with application of 75 per cent RDF (8.4). Among the interactions, application of 75 and 100 per cent RDF with domestic wastewater as source of irrigation resulted in significantly higher fruits/plant (9.7 and 9.8, respectively).

Higher fruit weight per plant was observed in domestic wastewater irrigated plots (41.0 g) followed by domestic wastewater alternated with ECWL treated wastewater (35.7 g). Application of the fresh water as source of irrigation resulted in lower fruit weight per plant (31.8 g). Application of 100 per cent RDF resulted in significantly higher fruit weight per plant (40.6 g). Interaction effect on fruit weight/plant recorded significant difference (Table 3). Application of 100 per cent RDF with domestic wastewater as source of irrigation resulted in higher fruit weight /plant (47.7 g) which was on par with same source of irrigation with 75 per cent RDF application (45.9 g). Gujjar *et.al* (2018) and Manjunatha *et.al* (2017a, 2017b, 2019) [5, 7, 8, 9] reported higher productivity of tuberose with waste water irrigation.

Domestic wastewater as source of irrigation resulted in higher yield (4261 kg/ha) over other sources of irrigation (Table 3). Application of 75 per cent RDF (3965 kg/ha) and 100 per cent RDF (4240 kg/ha) resulted in higher yield over other fertilizer levels. Correspondingly, among the interaction effect application of domestic wastewater with application of 100 per cent RDF recorded higher yield of French bean (5294 kg/ha) which was on par with domestic wastewater as irrigation source and application of 75 per cent RDF (4985 kg/ha). Manjunatha *et.al* (2017a, 2017b, 2019) [7, 8, 9] reported that higher yields of brinjal, chilli and cluster bean were recorded with domestic waste water irrigation as compared to irrigation with good quality water. Higher yields due to supply of additional nutrients by way of using waste water as a source of irrigation is also reported by Val-Moraes *et al*., (2011), Bichai *et al*., (2012) and (Zavadil, 2009) [15, 1, 18].

**Table 3:** Influence of the source of irrigation and fertilizer level on growth and yield of French bean

| Treatment | Plant height @ 45 DAS (cm) | Fruits per plant (No.) | Fruit weight per plant (g) | Yield (kg/ha) |
|---|---|---|---|---|
| I1 | 44.0 | 8.8 | 41.0 | 4261 |
| I2 | 38.8 | 7.4 | 33.7 | 3166 |
| I3 | 33.8 | 7.2 | 31.8 | 2825 |
| I4 | 42.3 | 7.7 | 35.7 | 3418 |
| SEm+ | 1.1 | 0.1 | 0.7 | 103 |
| CD (p=0.05) | 3.9 | 0.5 | 2.4 | 355 |
| F1 | 32.9 | 6.8 | 29.8 | 2535 |
| F2 | 35.4 | 7.2 | 32.3 | 2885 |
| F3 | 41.0 | 7.8 | 35.8 | 3464 |
| F4 | 43.7 | 8.4 | 39.3 | 3965 |
| F5 | 45.7 | 8.6 | 40.6 | 4240 |
| SEm+ | 1.4 | 0.1 | 0.7 | 108 |
| CD (p=0.05) | 3.9 | 0.4 | 2.0 | 312 |
| I1F1 | 37.3 | 7.5 | 33.2 | 3108 |
| I1F2 | 41.1 | 8.1 | 36.3 | 3545 |
| I1F3 | 44.6 | 9.0 | 42.1 | 4375 |
| I1F4 | 47.8 | 9.8 | 45.9 | 4985 |
| I1F5 | 49.3 | 9.7 | 47.7 | 5294 |
| I2F1 | 31.5 | 6.4 | 28.5 | 2386 |
| I2F2 | 33.1 | 6.9 | 30.6 | 2645 |
| I2F3 | 39.6 | 7.5 | 33.5 | 3123 |
| I2F4 | 43.7 | 8.0 | 37.1 | 3692 |
| I2F5 | 46.1 | 8.4 | 38.8 | 3986 |
| I3F1 | 28.6 | 6.6 | 27.8 | 2194 |
| I3F2 | 29.8 | 6.7 | 29.7 | 2439 |
| I3F3 | 34.3 | 7.0 | 31.7 | 2838 |
| I3F4 | 36.8 | 7.6 | 34.2 | 3155 |
| I3F5 | 39.5 | 7.9 | 35.6 | 3498 |
| I4F1 | 34.1 | 6.7 | 29.5 | 2454 |
| I4F2 | 37.6 | 7.3 | 32.5 | 2911 |
| I4F3 | 45.4 | 7.9 | 36.2 | 3519 |
| I4F4 | 46.4 | 8.4 | 40.1 | 4026 |
| I4F5 | 47.9 | 8.3 | 40.4 | 4180 |
| SEm+ | 2.7 | 0.2 | 1.4 | 217 |
| CD (p=0.05) | NS | 0.7 | 4.1 | 625 |

| Main plot: Irrigation sources | Sub plot: Fertilizer levels |
|---|---|
| $I_1$: Domestic wastewater (DWW) | $F_1$: Control (no RDF) |
| $I_2$: Engineered constructed wetland treated wastewater (TWW) | $F_2$: 25 % RDF |
| $I_3$: Freshwater (FW) | $F_3$: 50 % RDF |
| $I_4$: Engineered constructed wetland treated wastewater alternated with domestic wastewater (TWW-DWW) | $F_4$: 75 % RDF |
| | $F_5$: 100 % RDF |

### Water productivity and economic analysis

Application of domestic wastewater as source of irrigation resulted in significantly higher water productivity (113.8 kg/ha.cm) as compared to other sources of irrigation (Table 4). Similarly application of 100 per cent RDF recorded higher water productivity of 113.2 kg/ha.cm. However it was on par with application of 75 per cent RDF (105.9 kg/ha.cm). Interaction effect results indicated application of domestic wastewater as source of irrigation with 100 per cent RDF recorded higher water productivity (141.4 kg/ha.cm) and it was on par with 75 per cent RDF fertilizer applied with domestic wastewater as source of irrigation (133.2 kg/ha.cm).

Higher gross return (Rs. 1,70,454/ha) and net return (Rs. 87,084/ha) were observed with application of domestic wastewater as source of irrigation over other sources followed by domestic wastewater alternated with ECWL treated wastewater irrigation (Rs 1,36,722/ha and Rs. 53,587/ha, respectively). Application of the fresh water resulted in lower gross income (Rs. 1, 12,982/ha) and net returns (Rs. 29,612/ha). Among the fertilizer applications, 100 per cent

RDF resulted in higher gross income (Rs. 1, 69,580/ha) and net returns (Rs. 83,854/ha) which were on par with 75 per cent RDF (Rs. 1,58,588/ha and Rs. 74,334/ha). Interaction effect on the economics was significant (Table 4). Domestic wastewater irrigation with 100 per cent RDF (Rs. 2,11,753/ha and Rs. 1,26,027/ha, respectively) and domestic wastewater irrigation with 75 per cent (Rs. 199411/ha and Rs.114863/ha, respectively) recorded higher and on par gross returns and net returns, respectively over other combinations. Lower gross returns and net returns were recorded with fresh water combined with no fertilizer application (Rs. 87,740/ha and Rs. 6,726/ha, respectively). Influence of the source of irrigation and fertilizer levels on B:C ratio followed similar trend of Net returns (Table 4). Irrigation with domestic wastewater as source of irrigation resulted in higher BC ratio (2.04) followed by application of domestic wastewater alternated with ECWL treated wastewater (1.64). Among the fertilizer levels, application of 75 and 100 per cent RDF resulted in higher and comparable BC ratio over other levels. Interaction effect on BC ratio was also significant with higher BC ratio observed in domestic wastewater irrigation with application of 100 per cent RDF (2.47). However it was on par with application of domestic wastewater as irrigation source with application of 75 per cent RDF (2.36).

Application of domestic wastewater as source of irrigation resulted in significantly higher net profit per cm of water used (Rs. 2,326/cm). Similarly application of 100 per cent RDF recorded higher net return of Rs. 2,240 per cm of water used. However, it was on par with application of 75 per cent RDF with net return per cm of water used of Rs. 1,985/cm (Table 4). Interaction effect results indicated application of domestic wastewater as source of irrigation with 100 per cent RDF recorded higher net returns per cm used (Rs. 3,366/ha) and it was on par with 75 per cent RDF fertilizer applied with domestic wastewater as source of irrigation (Rs. 3,068/cm). Higher water productivity, net profit, B:C ratio and net profit per cm of water used was achieved with domestic waste water irrigation in different vegetables (Manjunatha *et.al* (2017a, 2017b, 2019) [7, 8, 9]. Beneficial effect of usage of waste water in agriculture is also reported by Val-Moraes *et al*., (2011), Bichai *et al*., (2012) and (Zavadil, 2009) [15, 1, 18].

**Table 4:** Influence of the source of irrigation and fertilizer level on water productivity and economics of French bean

| Treatment | Water Productivity kg/ha-cm) | Gross return (Rs/ha) | Net return (Rs/ha) | B: C ratio | Net return per cm of water used (Rs/cm) |
|---|---|---|---|---|---|
| I1 | 113.8 | 170454 | 87084 | 2.04 | 2326 |
| I2 | 84.6 | 126654 | 43284 | 1.51 | 1156 |
| I3 | 75.4 | 112982 | 29612 | 1.35 | 791 |
| I4 | 91.3 | 136722 | 53587 | 1.64 | 1431 |
| SEm+ | 2.7 | 4100 | 4100 | 0.05 | 108 |
| CD (p=0.05) | 9.5 | 14189 | 14189 | 0.17 | 376 |
| F1 | 67.7 | 101408 | 20394 | 1.25 | 545 |
| F2 | 77.0 | 115386 | 33194 | 1.40 | 887 |
| F3 | 92.5 | 138554 | 55184 | 1.66 | 1474 |
| F4 | 105.9 | 158588 | 74334 | 1.88 | 1985 |
| F5 | 113.2 | 169580 | 83854 | 1.98 | 2240 |
| SEm+ | 2.9 | 4339 | 4339 | 0.05 | 114 |
| CD (p=0.05) | 8.3 | 12498 | 12498 | 0.15 | 330 |
| I1F1 | 83.0 | 124310 | 43296 | 1.53 | 1156 |
| I1F2 | 94.7 | 141783 | 59591 | 1.73 | 1592 |
| I1F3 | 116.9 | 175013 | 91643 | 2.10 | 2448 |
| I1F4 | 133.2 | 199411 | 114863 | 2.36 | 3068 |
| I1F5 | 141.4 | 211753 | 126027 | 2.47 | 3366 |
| I2F1 | 63.7 | 95435 | 14421 | 1.18 | 385 |
| I2F2 | 70.6 | 105795 | 23603 | 1.29 | 630 |
| I2F3 | 83.4 | 124921 | 41551 | 1.50 | 1110 |
| I2F4 | 98.6 | 147686 | 63138 | 1.75 | 1686 |
| I2F5 | 106.5 | 159435 | 73709 | 1.86 | 1969 |
| I3F1 | 58.6 | 87740 | 6726 | 1.08 | 180 |
| I3F2 | 65.1 | 97540 | 15348 | 1.19 | 410 |
| I3F3 | 75.8 | 113522 | 30152 | 1.36 | 805 |
| I3F4 | 84.3 | 126195 | 41647 | 1.49 | 1112 |
| I3F5 | 93.4 | 139916 | 54190 | 1.63 | 1447 |
| I4F1 | 65.5 | 98149 | 17135 | 1.21 | 458 |
| I4F2 | 77.7 | 116425 | 34233 | 1.42 | 914 |
| I4F3 | 94.0 | 140760 | 57390 | 1.69 | 1533 |
| I4F4 | 107.5 | 161059 | 77689 | 1.93 | 2075 |
| I4F5 | 111.7 | 167216 | 81490 | 1.95 | 2177 |
| SEm+ | 5.8 | 8677 | 8677 | 0.10 | 230 |
| CD (p=0.05) | 16.7 | 24996 | 24996 | 0.30 | 663 |

#French bean vegetable sold @ Rs 40/kg

| Main plot: Irrigation sources | Sub plot: Fertilizer levels |
|---|---|
| $I_1$: Domestic wastewater (DWW) | $F_1$: Control (no RDF) |
| $I_2$: Engineered constructed wetland treated wastewater (TWW) | $F_2$: 25 % RDF |
| $I_3$: Freshwater (FW) | $F_3$: 50 % RDF |
| $I_4$: Engineered constructed wetland treated wastewater alternated with domestic wastewater (TWW-DWW) | $F_4$: 75 % RDF |
| | $F_5$: 100 % RDF |

**Acknowledgment**
Authors wish to acknowledge the financial support given by the Department of Biotechnology, Government of India, New Delhi in conducting this work under *Water4crops* project - "Integrating bio-treated wastewater reuse with enhanced water use efficiency to support the green economy in EU and India (India Side)".

**References**

1. Bichai F, Polo-Lopez MI, Ibanez PF. Solar disinfection of wastewater to reduce contamination of lettuce crops by Escherichia coli in reclaimed water irrigation. Water Res. 2012; 46:6040-6050.
2. Davison L, Headley TR, Pratt K. Aspects of design, structure, performance and operation of reed beds - eight years' experience in northeastern New South Wales, Australia. Water Sci. Technol. 2005; 51(10):129-138.
3. Ensink J, Tariq M, Dalsgaard A. Wastewater-irrigated vegetables: market handling versus irrigation water quality. Tropical Medicine and International Health. 2007; 12:2-7.
4. Gomez KA, Gomez AA. Statistical procedure for agricultural research, John Willey and Sons, New York. India, 1984.
5. Gujjar DS, Kaur R, Singh KP. Impact of waste water irrigation on vegetative growth, flowering characteristics, keeping quality and productivity of tuberose (Polianthes tuberose). Indian Journal of Agricultural Sciences. 2018; 88(4):584-589.
6. Kivaisi AK. The potential for constructed wetlands for wastewater treatment and reuse in developing countries: a review. Ecol. Eng. 2001; 16(4):545-560.
7. Manjuntha MV, Manjunatha Hebbara, Prasannakumara BH, Sunil Satyareddi, Dasog GS. Effect of untreated and engineered constructed wetland treated wastewater on yield, water productivity and economics of brinjal. Green Farming. 2017a; 8(3):676-679.
8. Manjuntha, MV, Prasannakumara BH, Sunil Satyareddi, Manjunatha Hebbara. Yield, water productivity and economics of green chilli as influenced by engineered constructed wetland treated and untreated domestic sewage water Int. Journal of current microbiology and applied sciences. 2017b; 6(4):2125-2132.
9. Manjuntha MV, Prasannakumara BH, Sunil Satyareddi, Manjunatha Hebbara. Response of treated and untreated domestic waste water irrigation on yield, water productivity and economics of cluster bean. Int. Journal of current microbiology and applied sciences. 2019; 8(7):2483-2491
10. Minhas PS, Samra JS. Quality Assessment of Water Resources in Indo-Gangetic Basin Part in India, p 68. Central Soil Salinity Research Institute, Karnal, 2003.
11. Patterson SR, Ashbolt NJ, Sharma A. Microbial Risks from waste water irrigation of salad crops: a screening-level risk assessment. Water Environ. Res. 2011; 73(6):667-672.
12. Qadir M, Wichelns D, Raschid-Sall L, Minhas PS, Drechsel P, Bahri A *et al*. Agricultural use of marginal-quality water-opportunities and challenges. (In) Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. Molden D (Ed). Earthscan, London, UK, 2007.
13. Rubino P, Lonigro A. Municipal treated wastewater irrigation: microbiological risk evaluation. Ital. J Agron. 2008; 1(1):119-124.
14. Tandon HLS. Methods of analysis of soils, plants, water and fertilizers. Fertilizer development and consultation organization. New Delhi. 1998, 9-16.
15. Val-Moraes S, Marcondes J, Carareto Alves L, Lemos E. Impact of sewage sludge on the soil bacterial communities by DNA microarray analysis. World J. Microbiol. Biotechnol. 2011; 27:1997-2003.
16. Vivaldi GA, Camposeo S, Rubino P, Lonigro A. Microbial impact of different types of municipal wastewaters used to irrigate nectarines in Southern Italy. Agriculture. Ecosyst. Environ. 2013; 181:50-57.
17. Wallace SD, Knight RL. Small-scale Constructed Wetland Treatment Systems Feasibility, Design Criteria, and O&M Requirements, 1st ed. IWA Report. Water Environment Research Federation, USA, 2006, 304.
18. Zavadil J. The effect of municipal wastewater irrigation on the yield and quality of vegetables and crops. Soil Water Res. 2009; 4:91-103.