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# SEWAGE WATER AND ORGANIC MANURE INFLUENCE ON GRAIN AND FODDER MAIZE PRODUCTION: A REVIEW

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**SUMMARY**

Maize (*Zea mays* L.), due to its higher yield potential among other members of *Poaceae* family; known as "queen of cereals". Maize is India's third most important crop after rice and wheat. Following India's green revolution, intensive agriculture practices have resulted in a variety of issues, including environmental pollution, decline in soil fertility, productivity and organic matter content. Adding organic source of nutrients is critical for plant and field growth, yield and quality as they are good source of both macro and micro nutrients in available form to the plants; in addition, it improves soil health, microbial count and water holding capacity of soil. In this review, most of research findings reviewed indicates that organic manure application improved sustainable productivity, nutrient content and soil nutrient status. Use of treated sewage water has been found promising in replacing the conventional irrigation water. Keeping these points in view, the literature pertaining to organic manure and treated sewage water use in maize and other crop to obtain higher production and good quality has been reviewed.

**Key words :** Maize, sewage water, organic manure, quality, production and fertility

In India, Rice-wheat is the main cropping system in Indo-Gangetic plains, which has resulted in number of issues such as soil degradation, weed problems and over-exploitation of under-ground water. Maize can be replaced in this system because of its wider adaptability and it can be well fitted for intercropping too *i.e.* compatibility (Byjesh *et al.,* 2010). Maize is a multi-purpose crop used as food, feed, fodder, biofuel etc. The maize grain is a major feed and a standard component of livestock diets where it is used as a source of energy. Many by-products of maize processing for flour (hominy feed, bran, germs, oil meal), starch (corn gluten feed, corn gluten meal) and biofuel industries (distillers' dried grains and solubles) can be fed to animals (Anonymous, 2022). Besides this, it is an important *kharif* and summer forage crop grown throughout the country which provides very palatable, highly succulent and nutritionally rich fodder to livestock. As green forage, particularly when it contains the leaves and ears, stalks; it is an energy-rich source of feed for ruminant livestock, while maize forage is usually ensiled in cooler regions, year-round maize production in the tropics may allow the continuous harvesting of green forage, making ensiling unnecessary (Brewbaker, 2003). It is quick growing, high yielding and supplies essential nutrients, which can be fed at any stage of growth without any risk to animals; as it is free from anti-metabolites (Kumar *et al.,* 2020). India is home to 536 m livestock (Anonymous, 2019) and the deficit in fodder components is to the tune of 35.6, 11.0 and 44.0 per cent for green fodder, dry crop residues and concentrate feed ingredients, respectively; which hampers the productivity potential of the livestock in terms of milk and meat. Green fodder is a rich and cheapest source of protein, vitamins, carbohydrates and minerals for livestock (Anonymous, 2013). Being a cereal crop, the nutrient requirement of maize is high. However, in some regions, the overuse of high-analysis chemical fertilizers such as N, P and K has resulted in fertility imbalances and micronutrient deficiencies. If the imbalanced fertilizer dose is not managed, the yield can stagnate or decrease. Water resources in arid and semi-arid regions have been steadily declining for decades due to over-exploitation of ground water (Kumar *et al.,* 2018). In most Indian

cities, a sewage system is used, in which human excreta is flushed with a large amount of water and its outlet is connected to the sewage system (Chandana and Rao, 2022). Therefore, treated sewage water can be a valuable alternative source of irrigation for feeding a population with limited water resources. The advantage of organic manure has been proved superior to use of each component separately. This review aimed to study the role of organic manure and sewage water on maize performance and their resultant effect on soil properties.

## 1 Effect of sewage water

### 1.1 Growth and development

Alawsy *et al*. (2018) revealed that biomass (g/plant), plant height (cm) and dry weight (g/plant) of the maize seedlings treated with sewage water (50%) showed a significant increase over control. Chandrikapure *et al*. (2017) reported that five irrigations with treated sewage water treatment ($T_7$) recorded higher growth and yield attributing characters *viz*., plant height (180.01 cm), number of leaves per plant (10.87), dry matter accumulation per plant (164.57 g), leaf area per plant (74.24 $dm^2$). Tavassoli *et al*., 2010 found that the use of waste water in comparison to well water irrigation resulted in the increase of fresh and dry forage corn yield (8.25% and 23.14%). Gwenzi *et al*. (2016) showed that maize growth was increased by 53% by sewage sludge application compared to the untreated control. Maize growth, biomass production and nutrient uptake were significantly improved in biochar and sewage sludge amendments compared to the unamended control.

Khanmohammadi *et al*. (2016) obtained highest shoot dry matter in the sewage sludge treatment. Mousavi and Shahsavari (2014) concluded that irrigation with treated municipal waste water (TMWW) lead to significant effect in all the characters than control. The highest stem height and diameter were observed in irrigation with 25% well water + 75% TMWW, which was statistically higher than other treatments, also similar results were obtained in other growth parameters such as: flag leaf length, flag leaf width, ear diameter and ear length.

Alkhamisi *et al*. (2011) reported that plants irrigated with the reclaimed water had higher plant height than those irrigated with fresh water. Reclaimed water had shorter time for 50% male and female flowering of forage maize plants, indicating earlier maturity. Plants irrigated with reclaimed water had higher chlorophyll content. Mousavi *et al*. (2013) found that irrigation with primary-treated municipal waste water had a significant positive impact on all characters compared with the control.

### 1.2 Yield and its attributes

Chandrikapure *et al*. (2017) at Nagpur recorded maximum grain yield and fodder yield (4404 kg/ha and 6693 kg/ha, respectively) in five irrigations with treated sewage water ($T_7$) followed by recommended irrigations with normal water ($T_1$) which had grain yield and fodder yield (4169 kg/ha and 6295 kg/ha, respectively). Somasundaram *et al*. (2016) showed that increased rate of sewage sludge (SS) increased the green and dry fodder yield of forage maize. Almasi (2014) showed that number of irrigation with waste water had significant effect on ear diameter, cob weight, total weight of grain and cob in corn. Mohammad and Ayadi, 2005 studied that wastewater irrigation increased the forage maize yield over potable water irrigation. Mok *et al*., 2014 studied that wastewater can be viably used as agricultural irrigation water with no significant yield loss in silage maize. Nahhal *et al*. (2013) found that biomass of Chinese cabbage and corn grown in plots irrigated with treated waste water was higher than those grown in plots irrigated with fresh water.

Mousavi and Shahsavari (2014) revealed that number of grains per ear and number of rows per ear in maize significantly increased with use of waste water. Maximum 1000 seed weight was 303.8 g that obtained with use of 75% wastewater. Maximum yield was obtained in 75% TMWW that was 25% more than control. Yaryan (2000) concluded that the yield of sunflower and corn was higher under treated waste water treatment compared to well water treatment.

### 1.3 Quality parameters

Tejada *et al*. (2016) found that biofertilizer obtained from sewage sludge (SS) when applied through foliar fertilization resulted in increase in grain protein content significantly by 30% and the yield increased by about 17% compared with the control treatment (SS not applied).Treated waste water had significantly increased the crude protein, ash percentage and macro nutrients (N, P and K) content in maize forage (Tavassoili *et al*., 2010). Mohammad and Ayadi, 2005 reported that nitrogen uptake by forage

maize was significantly increased by wastewater irrigation over potable water. Latef and Sallam (2015) reported that increase in protein content and growth (shoot, fresh and dry weight) of maize than the control. This increase was generally higher in shoot than root. Mousavi *et al*. (2013) revealed that irrigation with primary-treated municipal wastewater (TMWW) increased seed oil to 5.85%, which was 29.2% more than that of control in maize. Maximum zinc concentration (15.93 mg/kg) was obtained in irrigation with 25% clean water and 75% TMWW in maize.

### 1.4 Soil properties

Mhaske *et al*. (2018) revealed that use of treated domestic waste water has showed improvement in yields in maize and the nutrient status was also better as compared to well water. NPK were 268.4, 16.99 and 440.1 kg/ha, respectively in treated domestic waste water; while 266.5, 16.36 and 434.0 kg/ha, respectively in well water. Khaskhoussy *et al*. (2013) found that the irrigation with treated wastewater significantly increased the fertilizer elements as N, P and K and decreased significantly the soil pH. The results on corn plants showed that irrigation with treated wastewater led to significant increase of these elements in different organs of corn.

Kharche *et al*. (2011) reported that use of sewage irrigation in vegetables recorded certain improvement in soil physical properties like bulk density, water retention, hydraulic conductivity, organic carbon and build-up of soil N, P, K, micronutrients and microbial count providing the proper aerated conditions. Rattan *et al*. (2005) indicated that there was an increase in organic carbon content ranging from 38 to 79 per cent in sewage-irrigated soils (content varied from 0.14 to 3.71 % with an average of 0.65%). Yerasi *et al*. (2013) revealed that sewage-irrigated soils had high amount of organic carbon and build-up of soil available N, P, K and micronutrient status, thus improved the soil fertility to certain extent. Mojiri and Amirossadat (2011) revealed that the urban waste water increased the DTPA- extractable iron, manganese in soil and corn in comparison to irrigation with water. Soni *et al*. (2016) revealed that highest protein content of 9.76% in first cut was observed with irrigation using sewage water in sorghum. Abdelrahman *et al*. (2011) concluded that maize plants irrigated with the treated wastewater contained greater nitrogen concentrations at all levels of water quantities than those irrigated with fresh water.

## 2 Effect of organic manure

### 2.1 Growth and development

Chaudhari *et al*. (2017) at Anand showed that highest plant height of 71.93 and 98.33 cm of maize was obtained in FYM application at 1% ($F_1$) as compared to treatment having no application of FYM ($F_0$) at 30 DAS and at harvest, respectively. Application of 20 t/ha FYM had depressed the availability of cadmium concentration and increased the dry matter yield of fodder maize (Khurana and Bansal, 2014). Nagavani and Subbian (2014) at Coimbatore found significant increase in plant height and leaf area index of hybrid maize with the application of 50% RDF through poultry manure + 50% RDF through inorganic fertilizers followed by 50% RDF through vermicompost + 50% RDF through inorganic fertilizers.The highest plant height, number of leaves and stem girth of fodder maize Cv. African Tall was recorded under the treatment FYM @ 30 t/ha+ Azotobacter + PSB (Bhat *et al*., 2021). Prasad *et al*. (2018) revealed that the application of pressmud @ 7.5 t/ha being at par with vermicompost @ 7.5 t/ha recorded highest value of growth over no organic manure in spring maize.

Mohsin *et al*. (2012) reported that plant height at maturity was tallest (211.3 cm) in treatment in which N source was 100% through urea but was statistically similar to the application of 50% N from urea + 50% N from FYM (207.4 cm). Habib *et al*. (2012) revealed that organic sources including FYM produced significant effects on maximum leaf area, leaf area duration, crop growth rate and net assimilation rate over control. Naveena *et al*., 2021 concluded that application of 50% RDN through FYM and remaining 50% RDN through poultry manure as top dress at 30 DAS resulted in higher dry matter yield (117.13 q/ha) of fodder maize. Majumder *et al*. (2016) found that application FYM in all treatments along with different irrigation scheduling resulted into higher water use efficiency as compared to the no FYM application treatment. Shinde *et al*. (2014) revealed that a significant increase in dry matter production and plant height was observed with the application of 100% RDF + 10 ton FYM per hectare over other treatments and was statistically at par with the treatment having application of 100% RDF + 5 t FYM/ha.

By conducting field experiment at Punjab Agricultural University, Ludhiana on maize crop, Gajri *et al*. (1994) found that farm yard manure @ 15 t/ha improved root growth and the crop extracted soil water

more efficiently. Rao *et al*. (2017) found that the application of FYM @ 10 t/ha and vermicompost @ 5t/ha increased the SPAD meter reading compared to the control (without any fertilizer) in maize. Imran (2018) studied that phenological and morphological trait responses of maize was positive to organic matter incorporation. Pre and post-harvest soil analysis of the maize showed that soil health was significantly boosted with organic matter addition. Better growth in terms of plant height, leaf area index and dry matter accumulation was observed with the application of farmyard manure @ 10 t/ha (Balyan *et al*., 2006) and 20 t/ha (Verma *et al*., 2006) as compared to control.

Deepak *et al*. (2018) reported that treatment $T_3$ – 50% of RDN as FYM + 50% vermicompost (VC) recorded significantly higher plant height (169.49 cm) of maize over all other treatments. The maximum chlorophyll content, leaf area index of maize was observed under $T_3$ – 50% of RDN as FYM + 50% VC. In maize application of 20 t/ha FYM resulted in significantly higher number of leaves as well as dry matter production over control (Joshi and Chilwal, 2018). Higher plant height, leaf area index and dry matter accumulation was achieved with the application of vermicompost @ 2 t/ha which was statistically at par with farm yard manure (FYM) @ 10 t/ha and significantly higher than no organic manure. Highest leaf area index, dry matter production, number of effective cobs per plant and tallest plant in both the years were recorded in the treatment 75% recommended dose of fertilizer + vermicompost @ 2 t/ha, as reported by Haque *et al*. (2012).

**2.2 Yield and its attributes**

Chaudhari *et al*. (2017) revealed that green forage yield of maize (206.39 g/pot) increased due to FYM @ 1% ($F_1$) and it was 25.15 per cent higher over control ($F_0$). The dry weight of leaves, stem and roots of maize was 36.79, 4.49 and 4.38 g/pot respectively, which increased to 43.10, 49.17 and 36.02 per cent due to application of FYM @ 1% ($F_1$) over control ($F_0$), respectively. Prasad *et al*. (2018) found that the application of pressmud @ 7.5 t/ha being at par with vermicompost @ 7.5 t/ha recorded highest value of yield attributing characters *viz*. plant height, leaf area index, cob length, test weight and grain yield over no organic manure in spring maize. The leaf yield and yield components were higher in manure fertilized fodder maize as compared to fertilization with NPK (Fasae *et al*., 2019). Shah and Wani (2017) revealed that combined application of vermicompost @ 5.5 t/ha + FYM @ 5.5 t/ha was statistically at par with the 100% RDF (60:60:30 kg/ha) but it was significantly higher than control in relation to cobs/$m^2$, cob length (cm), number of grains per cob and grain yield of maize.

Mohsin *et al*. (2012) revealed that application of 50% N through urea and 50% from FYM produced longer cobs (18.57 cm), maximum cob weight (216.4 g), maximum 1000-grain weight (279.1 g), higher grain yield (5793 kg/ha) and maximum biological yield (14880 kg/ha) in spring maize. Ramasamy *et al*. (2011) concluded that the maximum kernel number of 598.55/corn and highest length of 1.71 cm/kernel were noticed in the plants cultivated on 75% vermicompost whereas the maximum kernel breadth of all kernels (232.43 gm/corn) were noticed in the plants grown on 50% vermicompost concentration.The highest forage yield of 360.26 q/ha and 358.48 q/ha of maize during first and second year of investigation was recorded with the application of 30 t/ha of FYM (Bhat *et al*., 2021). Geng *et al*. (2019) revealed that compared with chemical fertilizer treatments, equal amounts of substitutions with cow manure increased production and the substitution not only provides enough nutrients but also improves the soil environment and leads to increased yields. Tanwar *et al*. (2016) at Shivamogga, India revealed that plots that received organic manures + chemical fertilizers recorded a significantly higher grain and stover yield over plots that received N through chemical fertilizer alone. Kumar and Pitchai (2010) at Madurai, reported that the highest grain yield (4402 kg/ha) of irrigated maize was recorded in treatment that received vermicompost @ 5 t/ha with 75 per cent RDF and it was found superior to over other treatments. Zaremanesh *et al*. (2017) showed that application of vermicompost had significant impact on corn yield.

Puri and Tiwana (2008) studied the effect of organic and inorganic sources of nitrogen in forage maize and observed that dry matter and green fodder yields were increased significantly by addition of FYM. The increment in green fodder yield (375.5 q/ha) by 10% and dry matter yield (99.6 q/ha) by 11.3% was observed when FYM was applied @ 25 t/ha over no FYM.The application of 50% RDN through FYM + 50% RDN though bio-compost recorded higher green forage yield (352 q/ha) of maize, as reported by Shekara *et al*., 2020. Paradkar (2008) concluded that highest maize grain yield of 6.19 t/ha was observed with the application of FYM @ 6 t/ha which was

significantly higher than the control. Among various organic manure applications *viz*. vermicompost, FYM and poultry manure, the application of FYM @ 7.5 t/ ha gave higher maize yield which was at par with vermicompost @ 2.5 t/ha, while significantly higher than poultry manure, as concluded by Lingaraju *et al*. (2010).

**2.3 Quality parameters**

Nagavani and Subbian (2014) at TNAU, Coimbatore recorded higher phenol content (0.0190%) in maize grain with the application of 100 per cent RDF through vermicompost. Application of FYM @ 30 t/ha+ Azotobacter + PSB recorded higher crude protein and crude fiber in fodder maize Cv. African Tall (Bhat *et al*., 2021). Naikwade *et al*. (2012) revealed that crude protein, water-soluble reducing sugar in leaves and stem was higher in the treatment containing vermicompost at nutrient source in fodder maize over other treatments. Choudhary and Kumar (2013) reported that the uptake of nitrogen, phosphorous and potassium was higher at application of vermicompost in maize.

Higher nitrogen (217.03 kg/ha), phosphorous (21.17 kg/ha) and potassium (208.14 kg/ha) uptake at harvest was recorded in fodder maize under application of 50% RDN through FYM and remaining 50% RDN through poultry manure as top dress at 30 DAS (Naveena *et al*., 2021). Mahesh *et al*. (2010) revealed that combined application of FYM 10 t/ha + RDF of NPK (150:75:40 kg/ha) recorded higher nitrogen, phosphorous and potassium uptake (160.8, 41.9 and 77.8 kg/ha, respectively). Bunker *et al*. (2013) from Gujarat reported that higher protein content of 10.43% was achieved under application of 100% NPK + FYM @ 5 t/ha which was significantly higher over control. Higher protein content in maize was recorded with the application of vermicompost @ 1.5 t/ha over vermicompost @ 1.0 t/ha and vermicompost @ 0.5 t/ ha and control, as concluded by Meena *et al*. (2007).

**2.4 Soil properties**

Janwal (2006) reported that application of farmyard manure increased significantly the available N, P and K status of the soil after maize harvest. The available P status of soil also increased significantly due to the residual effects of FYM and fertility levels. Choudhary and Kumar (2013) reported that the physical parameters like porosity, maximum water holding capacity, field capacity, permanent wilting point and bulk density were recorded higher when the crop was supplied with FYM. Similarly, chemical parameters like pH, soil organic carbon, available nitrogen (N), phosphorous (P) and potassium (K) were recorded better under vermicompost. Shilpashree *et al*. (2012) reported that the available nitrogen was recorded lower under chemical fertilizers than the organic matter (FYM and vermicompost) application.

Rao *et al*. (2017) at Rajendranagar revealed that with the application of FYM and vermicompost there was significant increase in the porosity as compared to the control. Chaudhary *et al*. (2019) reported that application of FYM @ 10 t/ha recorded significantly higher N content at 30 DAS and at harvest than no FYM. Application of FYM @ 10 t/ha recorded significantly the highest uptake of N, P, K, S, Fe, Mn, Zn and Cu by crop at harvest. Sheikh and Dwivedi (2017) at Ujjain revealed that pH (7.14), electric conductivity (1.84 ds/m), organic carbon (198.53 g/ kg), nitrogen (246.57 kg/ha), phosphorus (55.24 kg/ ha), potassium (438.52 kg/ha), zinc (320.13 ppm), copper (289.34 ppm), iron (239.34 ppm) and manganese (248.37 ppm) were found more in vermicompost followed by farmyard manure application.

**2.5 Economics**

Shah and Kumar (2014) reported that maximum mean net returns (Rs.87297.5/ha) and B:C ratio (1.6) with the application of NPK 50% RDF + FYM @ 15 tonnes/ha. Choudhary and Kumar (2013) studied that the gross and net return were higher with the application of vermicompost. Viswanath *et al.* (2019) reported that maximum net returns of 57333 Rs./ha and benefit: cost ratio value of 2.68 was obtained in treatment of 100% RDF + Vermicompost @ 05 t/ ha as compared to control. The higher net returns (Rs.53043/ha) and benefit cost ratio (2.67) in fodder maize was achieved with the application of 50% RDN through FYM and remaining 50% RDN through poultry manure as top dress at 30 DAS (Naveena *et al*., 2021). Mahato *et al*. (2020) reported that application of vermicompost @ 2 t/ha along with 75% RDF and 0.5% foliar application of $ZnSO_4$ ($T_6$) exhibited maximum net returns (Rs. 77112/ha), BCR (2.33) over application of 100% of RDF in maize.

Makwana *et al*. (2016) at Gujrat revealed that the maximum net realization of 37187 Rs./ha and benefit: cost ratio of 1.37 was obtained under treatment 100% RDF + FYM @ 10t/ha. Combined application of 100% NPK (150:75:40 kg/ha) + FYM 10 t/ha

recorded the highest gross returns of Rs. 44,375/ha and benefit-cost ratio of 2.62. Lowest gross returns (Rs. 31,970/ha) and B: C ratio (1.99) was achieved in 100% RDF. Significantly higher B: C ratio of 2.78 and 2.84 and net return of Rs. 54,888/ha and Rs. 56,840/ ha were achieved with application of 100% RDF + vermicompost @ 5 t/ha over 100% RDF + goat manure @ 5 t/ha during both the years, as reported by Maruthupandi and Jayanthi (2017).

## FUTURE PROSPECTS

There are numerous short-term studies on the positive impact of sewage water irrigation in maize crop; however, its long-term effects have not been studied yet. Sewage water contains a high amount of organic matter, nutrients and certain heavy metals. The sewage water may increase salts concentration in soil resulting in degradation of soil and loss of its productivity. Consistent application of sewage water may result in crossing the critical limit of heavy metals in soil. Accumulation of higher amount of heavy metal in maize further raises human and animal health related risks. The sewage water can have pathogenic microbes in it, which may lead to unpredictable disease outbreak. So, there is a need for long-term studies for the impact of sewage water irrigation on field, plant, human and animal health.

As in this contemporary era, the researchers focus more on the high yielding varieties to feed the ever-growing population, the need of nutrients for these varieties cannot be fulfilled only by the organic manures, however enrichment of organic manures by the application of nutrient like phosphorous during their preparation can cope up with this issue. The main challenge in organic manure is they have high ammonia content which leads to odour emission after composting. Composting and vermicomposting process are a source of secondary pollution through the emission of greenhouse gases. This shortcoming can be overcome by fortifying waste with carbon bulking agents and mature compost.

## CONCLUSION

Organic manures are rich source of nutrients and they help in nutrient availability through production of organic acid, ligand formation and chelation. Organic manures were found to enhance macro and micro nutrient content in soil, in plant parts like leaf, stem and cob. Organic manures also enhanced microorganism activity because microorganism uses carbohydrates as raw material. Organic manures were found to improve the soil physico-chemical properties like porosity, pH, aggregation,water holding capacity and organic carbon (labile and non-labile pools). Due to higher availability of nutrients and favourable conditions provided by the organic manure, the maize plant has found to have higher nutritional concentration, yield and grain quality. However, nutritional solubility is not possible without optimum moisture in soil. The composition of water generally used for irrigation have no or minimal nutrients. Sewage water have significantly higher level of nitrogen, phosphorous and micronutrients like iron, manganese, zinc and copper than normal water used for irrigation, but it have imbalanced salt ratio in it. Though, the salt and heavy metal concentration in soil were found within limit. The irrigation of maize with sewage water resulted in enhanced growth, increased yield and higher nutrient uptake and protein content. However, the careful attention should be kept towards soil and environment continuously.

## REFERENCES

Anomymous, 2019 : 20th Livestock Census, 2019. Department of Animal Husbandry, Dairying and Fisheries, Government of India. http:// dahd.nic.in/dahd/WriteReadData/Livestock.pdf.

Abdelrahman, H. A., S. A. Alkhamisi, M. Ahmed, and H. Ali, 2011 : Effects of treated wastewater irrigation on element concentrations in soil and maize plants. *Communication in soil science and plant analysis*, **42** : 2046-2063.

Alawsy, W. S. A., L. A. S. Alabadi, and H. M. Khaeim,2018 : Effect of sewage water irrigation on growth performance, biomass and nutrient accumulation in maize and barley. *International Journal of Agricultural and Statistical Sciences*,**14**(2) : 519-524.

Alkhamisi, S.A., H. A. Abdelrahman, M. Ahmed, and M. F. A. Goosen, 2011 : Assessment of reclaimed water irrigation on growth, yield and water use efficiency of forage crops. *Appl. Water Sci.,***1**: 57-65.

Almasi, B. A.,2014 : Influence of irrigation with wastewater of leaven factory on grain and ear characteristics of corn. *International Journal of Bioscience*, **4**(10): 159-163.

Anonymous 2022 :http://www.nordfeed.com/corn-maize-grain.html.

Balyan, J. K., P. Singh, L. K. Jain, and M. L. Jat, 2006 : Maize (*Zea mays* L.) productivity in response to integrated nutrient management in southern

Rajasthan. *Current Agriculture*., **30**(1/2): 63-65.

Bhat, R. A., F. Ahmad, T.A. Ahngar, T. A. Shiekh, Z. Rashid, W. Raja, L. Ahmad, S. A. Hakeem, M. U. Kousar, R. Nissar, and Z. A. Dar, 2021 : Evaluation of fodder maize (*Zea mays* L.) Cv. African Tall and its response to different rates of FYM and biofertilizers under cold arid conditions of Kargil. *International Journal of Plant & Soil Science*, **33**(24): 458-465.

Brewbaker, J. L., 2003: Corn production in the tropics: the Hawaii experience. Honolulu (HI): University of Hawaii. pp 76.

Bunker, M. C., A. M. Patel, M. K. Man, and S. Ali, 2013 : Influence of integrated nutrient management on productivity and quality of single cross hybrid maize (*Zea mays* L.) cv. HQPM-1. *Advance Research Journal of Crop Improvement*, **4**(1): 54-58.

Byjesh, K., S. N. Kumar,andP. K. Aggarwal,2010 : Simulating impacts, potential adaptation and vulnerability of maize to climate change in India. *Mitigation and adaptation strategies for global change,***15**(5): 413-431.

Chandana, N., and B. Rao,2022: A critical review on sludge management from onsite sanitation systems: A knowledge to be revised in the current situation. *Environmental Research*, **203**: 111812.

Chandrikapure, V. M., V. S. Khawale, U. N. Gajnhiye, and K. N. Uikey,2017 : Effect of sewage water treatments on growth and yield of maize. *Trends in Biosciences*.,**10** (33) : 7143-7145.

Chaudhari, B. H., J. K. Parmar, R. H. Mali, and N. H. Bumbadiya, 2017 : Effect of Co level and FYM on growth and yield of fodder maize. *International Journal of Chemical Studies,* **5**(1): 327-329.

Chaudhary, K. V., J. K. Parmar, and V. N. Patel,2019 :Influence of phosphorous, sulphur and FYM on chemical composition of forage maize (*Zea mays* L.) grown on loamy sand soil. *International Journal of Chemical Studies*, **7**(2): 948-956.

Choudhary, V. K., and P. S. Kumar, 2013 :Maize production, economics and soil productivity under different organic source of nutrients in eastern Himalayan region, India. *International J. of Plant Prod.,***2**: 167-186.

Deepak, R. N. Meena, J. P. Singh, A. Shori, R. Meena, and M. Bhoi,2018 : Effect of different organic sources on growth, yield and quality of rainfed maize (*Zea mays* L.) + guava (*Psidium guajava* L.) based agri-horti system. *J. Pharmacognosy and Phytochemistry*, **7**(4): 2125-2129.

Fasae, O. A., M. M. Abiola,T. O. Fabunmi,A. O. Yusuf, R. Y. Aderinboye, and E. O. Fakoya, 2019 :Yield and nutrient composition of fertilized maize as fodder for ruminant production. *Nigerian Journal of Animal Production*, **46**(2): 219-227.

Gajri, P. R., V. K. Arora, and M. R. Chaudhary, 1994 : Maize growth responses to deep tillage, straw mulching and farmyard manure in coarse textured soils of N.W. India. *Soil Use and Management*, **10** : 15-20.

Geng, Y., G. Cao, L. Wang, and S. Wang, 2019 : Effects of equal chemical fertilizer substitutions with organic manure on yield, dry matter and nitrogen uptake of spring maize and soil nitrogen distribution. *PLoS ONE*, **14**(7): e0219512.

Gwenzi, W., M. Muzava, F. Mapanda, and T. P. Tauro, 2016 : Comparative short-term effects of sewage sludge and its biochar on soil properties, maize growth and uptake of nutrients on a tropical clay soil in Zimbabwe. *Journal of Intensive Agriculture*, **15**(6): 1395-1406.

Habib, M. D., M. Asif, M. Aziz, A. Ali, M. Ashraf, A. Mahmood, and M. M. Javaid, 2012 : Growth performance of spring maize and soil fertility status as influenced by nutrient sources. *Int. J. Agric. Appl. Sci.,***4**(1).

Haque, S., P. Sarathi, and A. Saha, 2012 : Growth attributes, cob yield and economics of maize cultivars as affected by integrated nutrient management under Terai region of West Bengal. *Indian Journal of Agricultural Research,* **46**(1): 42-47.

Imran., 2018 : Organic matter amendments improve soil health, productivity and profitability of maize and soybean. *Annals of Reviews and Research*, **1**(3): ARR.MS.ID.555564.

Janwal, J. S., 2006 : Effect of integrated nutrient management in maize on succeeding winter crops under rainfed conditions. *Indian J. of Agron*., **51**(1): 14-16.

Joshi, G., and A. Chilwal,2018 : Effect of integrated nutrient management on growth parameters of baby corn (*Zea mays* L.). *International Journal of Advances in Agricultural Science and Technology*., **5**(7): 216-225.

Khanmohammadi, Z., M. Afyuni, and M.R. Mosaddeghi, 2016 : Effect of sewage sludge and its biochar on chemical properties of two calcareous soils and maize shoot yield. *Archives of Agronomy and Soil Sci*., **63** (2) : 198-212.

Kharche, V. K., V. N. Desai, and A. L. Pharande, 2011 : Effect of sewage irrigation on soil properties, essential nutrient and pollutant element status of soils and plants in a vegetable growing area around Ahmednagar city in Maharashtra. *J. Ind. Soc. Soil Sci*., **59**(2): 177-184.

Khaskhoussy, K., M. Hachicha, B. Kahlaoui, B. Messoudi-Nefzi, A. Rejeb, O. Jouzdan, and A. Arselan, 2013 : Effect of treated wastewater on soil and corn crop in the Tunisian area. *Journal of Applied Sciences Res.,* **9**(1): 132-140.

Khurana, M. P. S., and B. D.Kansal, 2014 : Effect of farm yard manure on chemical fractionation of cadmium and its bio-availability to maize crop grown on sewage irrigated coarse textured soil. *Journal of Environmental Biology*, **35**(2): 431-437.

Kumar, N., Satpal, S. Kumar, U. Devi, J. M. Sutaliya and Shweta, 2020 : Maize fodder production under changing climatic scenario for nutritional security of livestock– A review. *Forage Res*., **46**(1): 10-21.

Kumar, R., U. Vaid, and S. Mittal, 2018: Water crisis: issues and challenges in Punjab. *Water resources management*., 93-103.

Kumar, V. S. and G. J. Pitchai, 2010 : Effect of various sources of organic manure on yield and yield attributes of irrigated maize (*Zea mays* L.) Super 900M. *An Asian Journal of Soil Sci*., **5**(2): 199-401.

Latef, A. A. H. A., and M. M. Sallam,2015 : Changes in Growth and Some Biochemical Parameters of Maize Plants Irrigated with Sewage Water. *Austin Journal of Plant Biology*,**1**(1) : 1004.

Lingaraju, B. S., K. G. Parameshwarappa,, U. K. Hulihalli, and B. Basavaraja,2010 : Effect of organics on productivity and economic feasibility in maize-bengal gram cropping system. *Indian Journal of Agricultural Res*., **44**(3): 211-215.

Mahato, M., S. Biswas, and D. Dutta, 2020 : Effect of integrated nutrient management on growth, yield and economics of hybrid maize (*Zea mays* L.). *Current Journal of Applied Science and Tech*., **39**(3): 78-86.

Mahesh, L. C., K. N. Kalyanmurthy, Y. M. Ramesha, K. M. Shivakumar, H. Yogeeshappa and Siddaram, 2010 : Effect of integrated nutrient management on nutrient uptake and economics of maize. *International J. of Agriculture Sci*., **6** : 327-329.

Majumder D., P. K. Kingra, and S. S. Kukal, 2016 : Water productivity of spring maize under modified soil microenvironment. *J. Agrometeorology,***18**(1): 134-136.

Makwana, N. D., J. D. Thanki, P. B. Der, and J. K. Nandaniya, 2016 : Grain yield, nutrient uptake and economics of *Rabi* maize under different fertilizer levels and organic sources in south Gujrat condition. *Advances in Life Sci*., **5**(5): 1661-1664.

Maruthupandi, K. and C. Jayanthi, 2017 : Integrated nutrient management for yield and economics of maize (*Zea mays* L.) in-rice-gingelly-maize cropping system through integrated farming system. *International Journal of Current Microbiology and Applied Sci*., **6**(11) : 2745-2750.

Meena, O., H. R. Khafi, M. A. Shekh,, A. C. Mehta, and B. K. Davda, 2007 : Effect of vermicompost and nitrogen on content, uptake and yield of *rabi* maize (*Zea mays* L.). *Crop Research*, **33**(1/3): 53-54.

Mhaske, A. R., S. M. Taley, and R. N. Katkar, 2018 : Impact of Treated Domestic Sewage Water Irrigation on Soil Properties, Maize Yield and Plant Uptake: A Case Study from Nagpur City, Central India. *Sustainable Management of Land Resources*, Chapter **24** : 601-621.

Mohammad, M. J., and M. Ayadi, 2005 :Forage yield and nutrient uptake as influenced by secondary treated wastewater. *J. Plant Nutrition*., **27**(2): 351-365.

Mohsin, A. U., J. Ahmad, A. U. H. Ahmad, R. M. Ikram, and K. Mubeen, 2012 : Effect of Nitrogen application through different combinations of urea and farm yard manure on the performance of spring maize (*Zea mays* L.). *The J. Animal & Plant Sci*., **22**(1): 195-198.

Mojiri, A., and Z. Amirossadat, 2011 : Effects of urban wastewater on accumulation of heavy metals in soil and corn (*Zea mays* L.) with sprinkler irrigation method. *Asian J. Plant Sci.,***10**(3): 233-237.

Mok, H. F., K. B. Dassanayake, G. Hepworth, and A. J. Hamilton, 2014 : Field comparison and crop production modeling of sweet cornand silage maize (*Zea mays* L.) with treated urban wastewaterand freshwater. *Irrig Sci.,* **32** : 351-368.

Mousavi, S. R., and M. Shahsavari, 2014 : Effects of treated municipal wasterwater on growth and yield of Maize (*Zea mays)*. *Biological Forum – An International Jour*., **6**(2) : 228-233.

Mousavi, S. R., M. Galavi, and H. Eskandari, 2013 : Effects of treated municipal wastewater on fluctuation trend of leaf area index and quality of maize (*Zea mays*). *Water Science and Tech*., **67**(4): 797-802.

Nagavani, A. V., and P. Subbian, 2014 : Effect of poultry manure on quality of hybrid maize grain. *Current biotica*.,**7** (4): 332-335.

Naikwade, P. V., S. T. Sankpal, and B. B. Jadhav, 2012 : Management of waste by composting, vermicomposting and it's use for improvement of growth, yield and quality of fodder maize. *ARPN Journal of Science and Technology*, **2**(5): 184-194.

Nahhal, Y. E., K. Tubail, M. Safi and J. Safi, 2013 : Effect of treated waste water irrigation on plant growth and soil properties in Gaza Strip, Palestine. *American J. Plant Sci.,* **4** : 1736-1743.

Naveena, H., B. G. Shekara, K. N. Manoj, and N. M. Chikkarugh, 2021 : Effect of different organic sources of nutrients on green fodder yield, nutrient uptake and economics of fodder maize and succeeding fodder cowpea under maize-

cowpea cropping system. *Forage Research*, **47**(1): 130-134.

Paradkar, V. K., 2008 : Influence of fertilizer management on productivity of quality protein maize (*Zea mays*). *National Symposium on "New Paradigms in Agronomic Research*", Nov., 19-21, Navsari, Gujarat, pp. 71-72.

Prasad, G., R. S. Rinwa, and P. Kumar, 2018 : Growth and yield response in maize (*Zea mays* L.) to organic and inorganic nutrient sources under Haryana Conditions. *International Journal of Pure and Applied Bioscience*, **6**(6): 259-265.

Puri, K. P. and U. S. Tiwana, 2008 : Effect of organic and inorganic source of nitrogen in forage maize. *Forage Res.*,**34**(1): 62-63.

Ramasamy, P. K., K. Baskar, and S. Ignacimuthu, 2011: Influence of vermicompost on kernel yield of maize (*Zea mays* L.). *Elixir Agri*., **36** : 3119-3121.

Rao, P. L., G. Jayasree, G. Pratibha, and T. R. Prakash, 2017 : Effect of soil amendments on texture, porosity of soil and chlorophyll content in maize. *J. Pharmacognosy and Phytochemistry.,* **6**(3): 435-437.

Rattan, R. K., S. P. Datta, P. K. Chhonkar, K. Suribabu, and A. K. Singh, 2005 : Long-term impact of irrigation with sewage effluents on heavy metal contents in soils, crops and groundwater-a case study. *Agriculture, Ecosystems and Environ*., **109** : 310-322.

Shah, R. A., and B. A. Wani, 2017 : Yield, nutrient uptake and soil fertility of maize (*Zea mays* L.) as influenced by varying nutrient management practices under temperate conditions of Kashmir valley, India. *Plant Archives*, **17**(1): 75-78.

Sheikh, M. A., and P. Dwivedi,2017 : Physico-chemical parameters of organic manure, soil and impact of organic manure and NPK fertilizer on seed germination of soybean and wheat. *International Journal of Engineering Technologies and Management Res*., **4**(12): 118-130.

Shekara, B. G., P. Mahadevu, N. M. Chikkarugi, and N. Manasa, 2020 : Enhancing productivity and quality of fodder through organic source of nutrients in fodder cowpea - maize cropping system. *International Journal of Current Microbiology and Applied Sciences*, **11**: 914-930.

Shilpashree, V. M., H. M. Chidanandappa, R Jayaprakash, and B. C. Punitha, 2012 : Effect of integrated nutrient management practice on distribution of nitrogen fraction by maize crop in soil. *Indian J. of Fundamental and Applied Life Sci*., **2**(1): 38-44.

Shinde, S. A., M. J. Patange, and S. J. Dhage,2014 : Influence of irrigation schedules and integrated nutrient management on growth, yield and quality of *rabi* maize (*Zea mays* L.). *International Journal of Current Microbiology and Applied* Sci.,**3**(12): 828-832.

Shah, R. A., and S. Kumar, 2014: Direct and residual effect of integrated nutrient management and economics in hybrid rice wheat cropping system. *American-Eurasian J. Agriculture and Environmental Science*, **14**(5): 455-8.

Somasundaram, J., R. Krishnasamy, P. Savithri, M. V. Coumar, V. A. Kumar, B. S. Kumar, R. Indirani, S. Maragatham, S. Mahimairaja, T. Chitdeswari, and K. Sivasubramanium,2016 : Effect of sewage sludge–coir pith pellets on dry matter yield and trace metal concentration in various plant parts of forage maize. *Journal of Plant Nutrition*, **39**(11) : 1556-1569.

Soni, P. G., R. K. Yadav, G. Kumar, R. K. T. Yadav, K. Paul, G. Kumar, and G. Makarana, 2016 : Effect of irrigation schedules of domestic wastewater on fodder sorghum yield and quality. Extended Summaries Vol. 1: 4th International Agronomy Congress, Nov. 22-26, 2016, New Delhi, India.

Tanwar, V. S., Y. V. Shetty, B. C. Dhananjaya, M. D. Kumar, and T. S. Vageesh, 2016 : Effects of different organic manures and nitrogen fertilizers on the nutrient uptake and yield of maize. *Sri Lanka J. Food and Agriculture*, **2**(2): 51-54.

Tavassoli, A., A. Ghanbari, E. Amiri and Y. Paygozar, 2010 : Effect of municipal wastewater with manure and fertilizer on yield and quality characteristics of forage in corn. *African J. Biotechnology*, **9**(17): 2515-2520.

Tejada, M., B. R. Morgado, I. Gomez, L. F. Andreu, C. Benitez, and J. Parrado,2016 : Use of biofertilizers obtained from sewage sludges on maize yield. *European Journal of Agronomy*, **78** : 13-19.

Verma, A., V. Nepalia and P. C. Kanthaliya, 2006 : Effect of integrated nutrient supply on growth, yield and nutrient uptake by maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agron*., **51**(1): 3-6.

Viswanath, K., R. K. Sharma, and G. Mallikarjuna, 2019 : Effect of organic and inorganic manures on n, p and k content in grain and straw at harvest of maize. *Journal of Pharmacognosy and Phytochemistry*, **8**(4): 2475-2478.

Yaryan, K.M., 2000 : The effect of treated wastewater and irrigation systems on yield of some field crops. *M.Sc. Thesis*. Isfahan University Technology College of Agriculture Iran.

Yerasi, P. K. R., Y. S. K. Reddy, G. K.Reddy, and M. R. Prasad, 2013 : Sewage irrigation can sustain the soil health: A review. *Int. J. Agricultural Sci*., **3**(4): 470-472.

Zaremanesh, H., B. Nasiri, and A. Amiri, 2017 : The effect of vermicompost biological fertilizer on corn yield. *J. Mater. Environ. Sci*., **8**(1): 154-159.