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Phytostimulatory Potentialsof Fish Wastederived Fertilizers mediated by Plant Growth Promoting Rhizobacteria

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Abstract:

This study was conducted to evaluate the potential effects of fish waste derived fertilizers, compost or extracts on the growth and development of plants. The effects of fish waste is studied in Fenugreek (Trigonellafoenum-graecum), Cucumber (Cucumissativus L.), Vigna radiate, on Ice lettuce (LactucasativaL.), White mustard (SinapisalbaL.),Groundnut, Strawberry (FragariaSp)and Tomato (Solanum lycopersicum L.) plants. There are more than a half to two and a half fold increase in plant growth promotion has been reported. This study showed that the fish waste acts as an excellent organic fertilizer, which continuously provide nutrient to the soil and it results in better growth and nutritional quality of the plants and also creates way of converting waste to wealth, which is eco-friendly and costeffective.

Key Words: Fish waste, PGPR, plant growth promoting, Rhizobacteria, Fish effluent.

1. Introduction:

Over the last decade, a significant research interest has been generated around fish waste mediated plant growth and development. In the last decade processing of fish generates large amount of wastes, which are of global concern. It has been estimated that the amount of fish consumed are almost same to the generation of fish waste, which is discarded by ocean dumping or land disposal (Ahuja *et al*., 2020). Fish wastemay include whole fish (dead or damaged fish), fish trimmings, and specific tissues, such as heads, intestines, tails and fins, skins, scales and bones etc. Moreover, fish waste as a by-product or the non-utilizable parts obtained from fish markets, fish processing industries can represent 30-70% of the original fish weight (Toppe*et al.,* 2018). Uses of fish waste has been carried out for pharmaceutical purposes, proteins, amino acids, peptides, collagen, oil, minerals, enzymes, flavours and other compounds (Eilertsen*et al.,* 2017, Ghaly*et al.,* 2013). Implementation of fish waste as a fertilizer has been gained attention over the last few years for generation of economy and ecological sustainability. Shellfish debris has been used to raise crops in several countries (Wyatt and McGourty, 1990).Moreover, large quantities of fish waste have not been utilized efficiently and the disposal of fish waste can have large negative impacts on local environments. Unutilized fish waste is often disposed of by landfill or incineration or by dumping into the sea. Therefore, there is an urgent need to find ecologically acceptable means for reutilizing fish waste. Composting has also been suggested as a viable solution to the problem of fish waste disposal (Liao *et al*., 1997).

Application of organic waste in soil is a suitable method for the maintenance of soil organic matter, improve soil fertility and supply nutrients needed by plants (Davarinrjad*et al.,* 2004). Nearly 75% of the total weight of the fish was generated as solid waste in the form of gut, head, skin, bones, fins and frames after processing. The fish wastes rich in nitrogen, potassium, phosphorus and trace minerals (Ghaly*et al.,* 2013) can serve as raw material for the production of many nutritive and non-nutritive products.Chemical fertilizers pollute water bodies and make soils biologically dead. However, fish waste manure can be an excellent source of essential nutrients for plants, including N, P and K, Which play key role for the plant growth and development. Fish waste can enhance soil structure, increasing its water holding capacity and more productive soils. Depending upon the method of processing, several terms are used to describe Fish waste products, including fish solubles/fish emulsion, fish soluble nutrients, hydrolysed waste/fish hydrolysate (also called fish silage) fish meal.

However, some studies reported that plants fertilized solely with fish wastewater, particularly in a system called aquaponics, showed mineral deficiency symptoms, which could be due to either inadequate nutrient availability or inability to recover nutrients efficiently (Madende and Maria 2020). Hence, the use of beneficial microbes has been considered as a safe, efficient and practical agent to enhance plant growth.

Plant Growth Promoting Rhizobacteria (PGPR) are commonly used as inoculants for improving the growth and yield of agricultural crops. They can act as biostimulants through phytohormone production, mineral solubilisation, improving nutrient uptake efficiencies (Mishra *et al.*, 2012). Phytostimulatory effects mainly include stimulation of root morphological development, which could facilitate efficient absorption of water and nutrients leading to improved plant growth. One of the most studied plant-associative genera of PGPR is *Azospirillum*. Inoculation with *Azospirillum* spp. has been demonstrated to improve plant growth and yield via improving mineral and water uptake of colonized roots. While the mechanisms by which *Azospirillum* promote plant growth are not clear, it has been proposed to include phytohormone production, biological nitrogen fixation, solubilization of nutrients, and enhancement of water and nutrient uptake (Madende and Maria 2020).Fish protein hydrolysates are also used as biostimulants and are ordinarily derived from fish skins and other by-products such as heads, muscle, viscera, bone, frames and roe (Chalamaiah*et al.,* 2012).

Application of fish waste can reduce the dependencies on hazardous and costlier chemical fertilizer that can reduce the environmental impact of disposal methods such as landfilling and incineration. Incorporation of fish waste into agricultural practices promotes sustainability by closing the loop on waste generation and turning it into a valuable resources. However, the mechanisms underlying the fish waste mediated plant growth and development are still not clear enough. Implementation of fish waste in agricultural farm, kitchen garden, pot garden offer significant promise and are worthy of further exploration in attempts to enhance the growth and development of crops or plants. Fish waste can be an alternate of chemical fertilizers. Altogether, in this review, we present an overview of knowledge that will be useful for increasing the utilization of fish waste as organic fertilizers.

2. Effect on *cucumissativus L*(Cucurbit).

Literature survey reveals that the application of fish waste extract in different formulations increase the growth and yield of cucurbit. More than two fold increase in vine length and number of leaves, leaf area,stomatal conductance,total soluble solid content,number of flower and root lengthof cucurbit and pumpkin leaf has been reported (Buang*et al*., 2018). The applied fish waste increased the activity of microorganism present in the soil and plant growth regulators that increase the vegetative growth of flowering and fruiting plants (Oladimeji*et al*., 2018; Khandaker*et al*., (2013). According to Moneruzzaman*et al*., (2013) fish waste extract contains the growth regulators that play a significant role in the development of the flower bud. They also reported that localized application of gibberellin increased the number of flower of wax apple plants. Moreover, chlorophyll content and stomatal conductance in fish waste treated red chilli plant has also been reported (Khandaker*et al*., (2017). It has been reported that application of organic fertilizer increased the Total Solid Sediment (TSS) content of seedless Grapevines (Shaheen*et al*., 2012).Vine length increase probably due to the effect on early cell division and cell expansion (Saifuddin*et al.*, 2009).Significant increase in leaf fluorescence, chlorophyll content, carotene content in leaves, fruit weight and number of fruitsin fish wastetreated cucurbit plantsunder *in vivo* conditions has been reported (Khandaker*et al*., 2017; 2018). Moreover, increase in chlorophyll content and number of fruits was also observed in fish waste treated red chilli plant under *in vitro* conditions (Khandaker*et al*., 2017). In another similar experiment chlorophyll fluorescence and photosynthetic yield in fish waste treated watermelon plants under field condition has also been reported. Where soil enrichment with organic matter and bio-stimulants plays a significant role (Dalorima*et al*.,2018).Furthermore, carotene content in fish waste treated lettuce leaves has also been reported (Cruz*et al*.,2012). It was suggested that the cultural practice including use of fertilizers and plant growth regulators significantly alter the plant physiological activities, flowering and fruit formation (Moneruzzaman*et al*., 2013; Mahmoud *et al*., 2009).

3. **Effect on fenugreek (*Trigonellafoenum-granecum*) plant**:

In this experiment fish waste fertilizer was prepared by mixing jaggery, water and banana together and fermented up to 15 days. Fermented fish waste fertilizer sprayed on the experimental plant for upto 10 days except the control plants. Significant growth was reported on the germination of the plant, shoot length, root length, leaf length, nutritional quality and the time taken for growth. The effect of fermented fish waste product on fenugreek plant revealed that 10-15% increase in the height of plant. Furthermore, 20% germination of seeds after the treatment of fish waste product as compared to control within 2-3 days (Susitha&Thiripurasundari, 2023).

4. **Effect of fermented fish waste on *Vigna radiate (mung bean)***

In this cup assay study the seeds of *Vigna radiate* were soaked in fermented fish waste product for 24hbefore sowing. After 7 days of growth one and a half fold increase in % of seed germination, root length, shoot length, number of hairy roots, number of leaves has been reported. Fermentation of the fish waste produces significant amount of organic acids like lactic acid and acetic acid (Antoun*et al*., 2001), which activates mineral phosphate solubilization and P solubilizer PGPR like *Rhizobium* (Halder*et al*., 1991) and *Bacillus* (Yuming*et al*., 2003). Besides increasing the soil P level, P solubilizers also increase the nitrogen fixation, Trace elements and phytohormones (Gyaneshwar*et al*., 1998). Thus fermented fish waste could be used as a valuable organic liquid fertilizer for better yield from crops at lesser cost and also without the harmful effects of chemical fertilizers(Suganthi and Sujatha 2015).

5. **Effect on Ice lettuce (*Lactucasativa*L.) and White mustard (*Sinapisalba*L.)**

The effect of fermented fish waste compost on ice lettuce and white mustard, it was observed that increase in fresh and dry matter yield of leaves of both the plants by the Radziemska*et al.,* 2019.The chemical composition of fish waste compost in dry matter components as in (g/Kg) Total organic C is 382.6; total Nitrogen is 11.4; C/N ratio is33.4;phosphorus is 2.61;potassium is 3.07;Mg is 0.60;Na is 0.31;Ca is 3.75;Cu is 19.3;Cd is 1.52;Chromium is 5.40;Lead is 18.5;Nickel is 9.91 and Zinc is 159.9 (Radziemska*et al.,* 2019).(Radziemska*et al.,* 2019).

6. **Effect of *Azospirillum*on fish waste recycling on tomato seedlings:**

PGPR play vital role in maintainingsustainable agriculture either by fixingatmospheric dinitrogen or mobilizing fixedmacro and micronutrients or by converting insolubleP present in the soil into plant assessable forms, or by releasing phytohormones like IAA, Gibberalic acids, iron chelatingsiderophore and there by increases the efficiency and availability. Fish waste contains large number of micro and macro nutrients, like Ca, P, K, Na,Mg Mg Zn, Mn and Cu, which is essential for the growth of plants (Ghaly*et al*., 2013).Study has been made on the effect of African sharptooth catfish (*Clariasgariepinus*) and Nile tilapia (*Oreochromisniloticus*) effluents on the growth, yield parameters, and yield of tomatoes. Results showed that irrigation with *C.gariepinus* effluent increased the stem diameter by 21%, the number of flowers by 88%, the fruit number by 50%, the fruit diameter by 24%, the mean fruit weight by 34%, and total fruit weight of tomato by 96% compared to NPK treatments (Diatta*et al.,* 2023).

This study evaluated the effects of three *Azospirillumbrasilense* strains on tomato seedlings fertilized with effluent from freshwater fish aquaculture. Seeds were inoculated with *A. brasilense* strains Sp7, Sp7-S and Sp245 before sowing and after transplanting. Seedlings were raised under controlled greenhouse conditions with natural light. Inoculated seedlings produced longer roots (67%), bigger leaves (22%), higher seedling biomass (>33%), and greater protein (15%) and endogenous plant IAA (94%) contents. Inoculation with Sp7 and Sp245 increased the number of leaves and stem diameter by 8 and 10%, respectively. Seedling height was also increased by inoculation, but only with Sp7. In addition, seedlings inoculated with strains Sp7-S and Sp245 had higher total phosphorus content, while inoculation with Sp245 increased the activity of the enzyme peroxidase, which suggests that plant defence responses had been triggered (Mangmang*et al.,* 2015).

7. Effect on Groundnut:

Balkhande 2021 studied the effect of organic fertilizer prepared from fish waste on the germination and morphological characteristics of four different varieties of groundnut. 92-100% seed germination was recorded as compared to control after 7 days of sowing. Moreover, they revealed that more than one and a half fold increase in Total Plant height, Color of flowers, color of leaves, leaf length, leaf width, pod size and pod per plant of the groundnut in fish compost treated bed.It was found that because of NPK and other micronutrients in fish waste manure may be responsible for higher growth.On the other hand application of organic manure with recommended fertilizers significantly enhance the growth parameters of groundnut (Lourduraj, 2000).Increase in Groundnut growth parameters in presence of various organic manure (FYM, Poultry and Vermicompost has been well documented (Mohanty*et al.*, 2005). It was found that besides N, P and K organic fertilizers significantly influence the soil condition, root proliferations that might be due to the enhancement of uptake of nutrients (Gopalakrishnan (2007).Significant enhancement of plant height and number of pods/plant, no. of branches/ plant of groundnut and wheat in presence of organic compost with *Azatobacter /Rhizobium*, as PGPR has been reported (Kulkarni *et.al.*, 2018; Balkhande 2021).

8. Effect of Strawberry Flowering (*Fragaria* Sp.)

Literature survey revealed that one and a half fold increase in plant height and number of leaves was reported in fish waste water treated strawberry seeds as compared to control after 9 weeks of growth. On the other hand lowering of flowering age by 15-20 days was also observed in fish waste water treated strawberry seeds (Rosadi& Catharina 2022).

9. Effect on*Amaranthusdubius* (Amaranthus) and *Trigonellafoenum-graecum* (coriander):

In this study fish waste fertilizer sprayed (foliar spray) on the experimental plants after the interval of 7 days and up to 35 days of experimental period. Reports revealed that the growth and yield such as plant height (cm), shoot length (cm), number of leaves (cm), number of branches (cm), leaf length (cm), length of internodes (cm), root length (cm) and stem diameter (cm) was highly increased (Thankachan and Chitra 2021).Ndubuisi (2019) studied response of fish pond effluent as organic fertilizer on the growth of cucumber (*Cucumissativus*) and soil chemical properties. Ahuja *et al.*, (2020) conducted a study about the production and uses of fertilizers from fish and fish waste that may be applicable for certified organic farming, with a focus on crop and horticultural plants. Da *et al.,* (2020) assessed fish waste based fertilizer on the cucumber (*Cucumissativus*L.) vegetable growth and yield. Devi et al., (2020) conducted an experiment to assess the influence of foliar application of organic liquid manures prepared on the growth, yield and quality of amaranthus.

10. **Discussion:**

Research has shown that most nutrients needed for plant growth can be found in fish feed. Studies have shown that multiple species such as tomatoes, lettuces (*Lactucasativa* L.), bean (*Phaseolus vulgaris*) plants, potato (*Solanum tuberosum* L.), soybean (*Glycine max* L.) Merr.) and onion (*Allium cepa* L.), fava bean (*Viciafaba* L.), lupine (*Lupinusperennis* L.), soybean, and sunflower (*Helianthus annus* L.) can be grown throughout the year using fish effluents(Diatta*et al.,* 2023). The resilience of farming system has increased when cultivated crops are irrigated with fish effluents. Fish effluents can enhance soil chemical properties, such as nitrogen, available phosphorus, water-soluble potassium, calcium, and magnesium.

Previous studies have demonstrated that crop irrigation with fish effluents increased water use efficiency and soil fertility, which resulted in enhanced plant growth and overall productivity.Studiesshowedthatnetincomebenefitsofupto60%canbe achieved when fish is integrated with rice (*Oryzasativa* L.) and some vegetables as a result of both savings in fertilizers and increased plant productivity (Day *et al.,* 2006).Soil fertilization with fish waste compost increased contents of macro-elements in lettuce leaves by 78.6% in the case of nitrogen, by 61.8% in the case of phosphorus, by 56.3% in the case of potassium, by 44.4% in the case of sodium, and by 38.5% in the case of calcium and magnesium. On the other hand fish hydrolysates are proven to improve the utilization of nutrients by the plants and root associated beneficial microbes that induce morphological changes in root architecture (Du Jardin*et al*., 2015, Chalamaiah*et al*., 2012). The biological eff ects of these mechanisms of action are better root growth and development, increased root and leaf growth, induction of flowering and improved fruit setting and reduced fruit drop (Yakhin*et al.,* 2017).The biological conversion of fish waste into nutrient mediated by the PGPR for the phytostimulation is a sustainable and eco-friendly solution to global issues like waste management, soil fertility enhancement, improvement of soils health and reducing the environmental impact of waste disposal by harnessing the nutrients and organic compounds present in fish waste and reduction uses of synthetic fertilizers.

11. Conclusion:

Making manure from fish waste offers a promising and practical approach to achieving sustainable agricultural practices. With proper management and adherence to best practices, this innovative solution has the potential to play a significant role in building a more sustainable future for agriculture. The authors hypothesized that FW compost might be a suitable for agricultural use.

References

Ahuja, A.,Dauksas, E.D.Fremme, J.,Richardsen, R. and Loes, A.K. (2020). Fish and fish waste fertilizers in organic farming with status in Norway. **Waste Management**.115, 95-112.

Antoun, H.and Kloepper, J.W.(2001) Encyclopedia of Genetics, **Academic Press, New York**, 1477-1480.

Balkhand, J.V.(2021). Effect of organic fertilizer prepared from fish waste on germination and morphological characteristics of groundnut.**Agricultural Research Journal**. 58(5), 888-891.

Buang, E.A., Nornasuha,Y.Nashriyah, M. and Khandaker, M.M. (2018) Effects of Fish Waste Effluent on the Growth, Yield and Quality of *Cucumissativus* L. **Journal of Agrobiotechnology.** 9(1S), 258-267.

Chalamaiah, M., Rao, G.N., Rao, D.G. Jyothirmayi, T. (2010), Protein hydrolysates from meriga (*Cirrhinusmrigala*) egg and evaluation of their functional properties. **Food Chem**. 120, 652-657.

Chalamaiah, M. Kumar, D.B.Hemalatha, R.,Jyothirmayi, T. (2012), Fish protein hydrolysates: Proximate composition, amino acid composition, antioxidant activities and applications: A review. **Food Chemistry.**135,3020-3038.

Cruz, R.,Baptista, P., Cunha, S., Pereira, A.J.and Casal, S. (2012), Carotenoids of Lettuce (*Lactucasativa*L.) Grown on Soil Enriched with Spent Coffee Grounds. **Molecules**.17,1535-1547.

Da, C.T., Tu, P.A.,Livsey, J., Tang, V.T., Berg, H. and Manzoni, S.(2020), Improving Productivity in Integrated Fish-Vegetable Farming Systems with Recycled Fish Pond Sediments. **Agronomy.**10(7), 1025. 6.

Devi, A., Priya, S.M., Monika, N.P., Yazhini, N., Switha andNivedha, R. (2020), Effect of Organic Spray on Growth and Yield of *Amaranthusdubius* var. Co-1.**International Journal of Current Microbiology and Applied Sciences.**9(6), 1227-1233.

Dalorima, T., Khandaker, M.M., Zakaria, A.J., and Hasbullah, M. (2018) Impact of Organic Fertilizations in Improving Bris Soil Conditions and Growth of Watermelon (*Citrulluslanatus*). **Bulgarian Journal of Agricultural Science**.24(1), 112-118.

Davarinrjad, G., Haghnia, G. and Lakzian, A. (2004), Effect of enrichment manure and compost on wheat yield. **Agricultural Industrial Science Journal.** 18, 75-83.

Dey, M.M., Kambewa, P., Prein, M., Jamu, D., Paraguas, F.J., Pemsl, D.E. Briones, R.M. Waibel, H.,Zilberman, D. (2006), International Research on Natural Resource Management. Rome: FAO and Cambridge: **CAB International**. WorldFish Center. Impact of the development and dissemination of integrated aquaculture technologies in Malawi. 118–140.

Dey, M., Prein, M. (2004) Increasing and Sustaining the Productivity of Fish and Rice in the Flood-Prone Ecosystems in South and Southeast Asia; **Final Report to IFAD;** WorldFish Center: Penang, Malaysia.1-94.

Dey, M.M., Prein, M., Mahfuzul, H.A., Sultana, P., Cong, D.N., Van, H.N. (2005), Economic feasibility of community-based fish culture in seasonally flooded rice fields in Bangladesh and Vietnam.**Aquacultural Economics.** 9, 65-88.

Diatta, A.A., Manga, A.G.B., Bassène, C., Mbow, C., Battaglia, M., Sambou, M., Babur, E., Uslu, Ö.S. (2023) Sustainable Production of Tomato Using Fish Effluents Improved Plant Growth, Yield Components, and Yield in Northern Senegal. **Agronomy**. 13, 2696.

Du Jardin P. (2015) Plant Biostimulants: Definition, concept, main categories and regulation. **Science Horticulture.**196, 3-14.

Buang, E.A., Nornasuha, Y., Nashriyah, M. and Khandaker, M.M. (2018), Effects of Fish Waste Effluent on the Growth, Yield and Quality of *Cucumissativus*L. **Journal of Agrobiotechnology.** 9 (1S), 258-267.

Ghaly, AE, Ramakrishnan VV, Brooks MS, Budge SM, Dave D. (2013)Fish processing wastes as a potential source of proteins, amino acids and oils: A critical review. **Journal of Microbiologyand BiochemistryTechnology**. 5, 107-129.

Gopalakrishnan TR. (2007) Vegetable Crops. **Horticulture Science Series**. 4, 32-33.

Gyaneshwar P, Kumar N, and Parekh LJ. (1998) Cost effectiveness of converting fish waste into liquid fertilizer. **Journal of Microbiology Biotechnology**.14, 669 -673.

Halder GC, Mazid MA, Haque MKI, Huda MS and Ahmed KK. (1991) A review on the fisheries fauna of the Kaptai reservoir.**Bangladesh Journal of Fish**. 14,127-135.

Ahuja I, Dauksas E, Remme JF, Richardsen R, loesAK.(2020) Fish and fish waste-based fertilizers in organic farming-With status in Norway.**Waste Management.**115, 95-112.

Balkhande JV.(2021) Effect of organic fertilizer prepared from fish waste on germination and morphological characteristics of groundnut.**Agriculture Research Journal**. 58 (5), 888-891.

Mangmang JS, Deaker R, and Rogers G. (2015)*Azospirillumbrasilense*. Enhances Recycling of Fish Effluent to Support Growth of Tomato Seedlings. **Horticulturae.**1, 14-26.

Khandaker MM, Rohani F, Dalorima T,Mat N.(2017) Effects of Different Organic Fertilizers on Growth, Yield and Quality of *Capsicum Annuum*L. Var. Kulai (Red Chilli Kulai). **Biosciences Biotechnology Research Asia.**14(1), 185-192.

Khandaker MM, Faruq G, Motior MR, Azirun SM,Boyce AN. (2013) The Influence of 1-Triacontanol on the Growth, Flowering and Quality of Potted Bougainvillea Plants (*Bougainvillea glabra* var. Elizabeth angus) Under Natural Conditions. **The Scientific World Journal**, Article ID 308651.

Kulkarni MV, Patel KC, Patil DD, Pathak M.(2018) Effect of organic and inorganic fertilizers on yield and yield attributes of groundnut and wheat. **International Journal of Chemical Studies**.6 (2), 87-90.

Liao PH, Jones L, Lau AK, Walkemeyer S, Egan B, and Holbek N. (1997) Composting of fish wastes in a fullscale in-vessel system. **Bioresource Technology**.59, 163-168.

Lourduraj AC. (2000) Effect of irrigation manure application on the growth and yield of groundnut. **Acta-agronomic Hungarica.**43 (1), 83-88.

Thankachan M, Chitra G,(2021). The potential effect of fish waste fertilizer on the growth and yield of *Amaranthusdubius* and *Trigonellafoenum-graecum*. **International Journal of Advance Research**. 9(04), 406-411.

Mishra VK, Kumar A (2012) Plant growth promoting and phytostimulatory potential of *Bacillus Subtilis*and*Bacillus Amyloliquefaciens*.**ARPN Journal of Agricultural and Biological Science.**7(7).

Mahmoud E, Nasser AE, Paul R, Nouraya AC,Lamyaa AER (2009). Effects of Different Organic and Inorganic Fertilizers on Cucumber Yield and Some Soil Properties. **World Journal of Agricultural Science**.5 (4), 408-414.

Radziemska M, Vaverková MD, Adamcová D, Brtnický M, Mazur Z, (2019) Valorization of Fish Waste Compost as a Fertilizer for Agricultural Use; Waste and Biomass. **Valorization.** 10, 2537-2545.

Mangmang JS, Deaker R, Rogers G.(2015) Maximizing fish effluent utilization for vegetable seedling production by *Azospirillumbrasilense*. **Procedia Environmental Sciences.**29, 179.

Mohanty S, Paikaray NK, Rajan AR. (2005) Uptake of major nutrients from organic manures in groundnut sequence. **Annual Agriculture Research** New series.26 (3), 3449-352.

Balkhand JV.(2021). Effect of organic fertilizer prepared from fish waste on germination and morphological characteristics of groundnut.**Agriculture Research Journal**.58 (5), 888-891.

Moneruzzaman KM, Hossain ABMS, Saifuddin M, Imdadul H, Normaniza O. Amru NB.(2013) Effects of sucrose and kinetin on the quality and vase life of Bougainvillea glabra Var. Elizabeth angus bracts at different temperature. **Australian Journal of Crop Science.**4(7), 474-479.

MadendeM, Hayes M.(2020) Fish By-Product Use as Biostimulants, An Overview of the Current State of the Art, Including Relevant Legislation and Regulations within the EU and USA. **Molecules**. 25, 1122,1-20.

Ndubuisi NL. (2019) Response of Fish Pond Effluent on Soil Chemical Properties and Growth of Cucumber (*Cucumissativus*) in Igbariam South Eastern, Nigeria. **International Journal of Current Microbiology and Applied Sciences**. 8 (02), 1-10.

Oladimeji AS, Olufeagba SO, Ayuba VO, Sololmon SG,Okomoda VT (2018) Effects of different growth media on water quality and plant yield in a catfish-pumpkin aquaponics system. **Journal of King Saud University-Science**. 1(10), 1-7.

Radziemska M, Vaverková MD, Adamcová D, Brtnický M, Mazur Z. (2018): Valorization of fish waste compost as a fertilizer for agricultural use. Waste and Biomass.**Valorization.** 10, 2537-2545.

Rosadi NA, Catharina TS.(2022) Effect of Fish Water Waste Liquid Organic Fertilizer on Strawberry Flowering (*Fragaria*Sp). **Journal PenelitianPendidikan.** 8, 96-100.

Suganthi S, Sujatha J. (2015) Studies on evaluation of plant growth promoting effect of fermented fish waste on *Vigna radiate***.Life Science Archives.**1(3),192-195.

Saifuddin M, Hossain ABMS, Normaniza O, Nasrulhaq BA, Moneruzzaman KM. 2009(a)The Effects of Naphthalene Acetic Acid and Gibberellic Acid in Prolonging Bract Longevity and Delaying Discoloration of *Bougainvillea spectabilis*. **Biotechnology**. 8(3),343-350.

Shaheen MG, Abdel WSM, Hassan EA, AbdelAMRA. (2012) Vegetative Growth and Quality of Crimson Seedless Grapevines. **Journal of Horticultural Science & Ornamental Plants.** 4(3), 260-266.

Susitha D,Thiripurasundari B, (2023) The Effect of Amendment of Fish Waste Fertilizer to Soil and its Impact on the Growth and Nutritional Status of *Trigonellafoenum-graecum*, **InternationalJournal of Innovative Science and Research Technology**. 8 (6).

Toppe J, Olsen RL, Peñarubia OR, James DG. (2018) Production and utilization of fish silage: A manual on how to turn fish waste into profit and a valuable feed ingredient or fertilizer. **FAO**. Rome. http://www.fao.org/3/I9606EN/i9606en.pdf.

Wyatt B, McGourty G. (1990) Use of Marine By-products on Agricultural Crops. In the Proceedings of the International Conference on Fish By-products. Anchorage, Alaska. Edited by Sue Keller.187-195.

Yakhin, OI, Lubyanov AA, Yakhin IA, Brown PH. (2017) Biostimulants in plant science: A global perspective. Front. **Plant Science**. 7, 2049.

Yuming B, Xiaomin Z, Smith DL. (2003) Composting of fish wastes in a full-scale in-vessel system. **Crop Science.** 43, 1774-1778.