USE OF AQUATIC PLANTS *PISTIA STRATIOTES, EICHHORNIA CRASSIPES AND SALVINIA MOLESTA* AS ORGANIC FERTILIZER IN SUSTAINABLE AGRICULTURE – REVIEW

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Keywords: aquatic plants, fertilizer, agriculture, environmental

ABSTRACT

The intensive application of pesticides and chemical fertilizers, in the context of the continuous development of agriculture, has led to a high level of environmental pollution and a serious deterioration in soil fertility. In an attempt to reduce all these negative effects, classical agriculture is moving towards sustainable agriculture. An ecological alternative to the use of chemicals is the application of organic fertilizers. One of the ecological sources is aquatic plants. Often considered invasive due to their rapid development, aquatic plants have a real potential in sustainable agriculture. This review presents the use of aquatic plants pistia stratiotes, eichhornia crassipes and salvinia molesta as organic fertilizer in sustainable agriculture.

INTRODUCTION

The continuous evolution of the human population and the increase of consumption lead implicitly to the increase (increase) of the demand for agricultural products. To meet all these requirements, classical agriculture uses numerous tillage operations and considerable amounts of water, pesticides, fertilizers.

Agriculture interacts with the environment through the use of resources and the production of waste, which can contain high levels of organic matter, nutrients and microorganisms with the potential to pollute water, soil and air [2]. From the point of view of crop production, soil and environmental health is important [12]. Also the quality of any agricultural crop is determined by the factors that act from the moment of sowing to harvest [18].

To meet these challenges, future crops should meet the characteristics of sustainable agriculture: maximum net production and minimum effects on the environment [24]. It is therefore vital to develop environmentally friendly agro-industrial and biotechnology strategies to reduce the application of chemical fertilizers that have negative effects on ecosystems and human health [13].

Organic farming is a production system, which largely manages to avoid or exclude the use of chemical fertilizers and pesticides [21]. An ecological alternative to chemicals are macrophytes due to the biological importance of these plants. Macrophytes are fast-growing aquatic plants and respond to a wide variety of environmental conditions [13].

Pistia stratiotes, eichhornia crassipes and salvinia molesta are aquatic plants that have a real potential as organic fertilizer in sustainable agriculture.

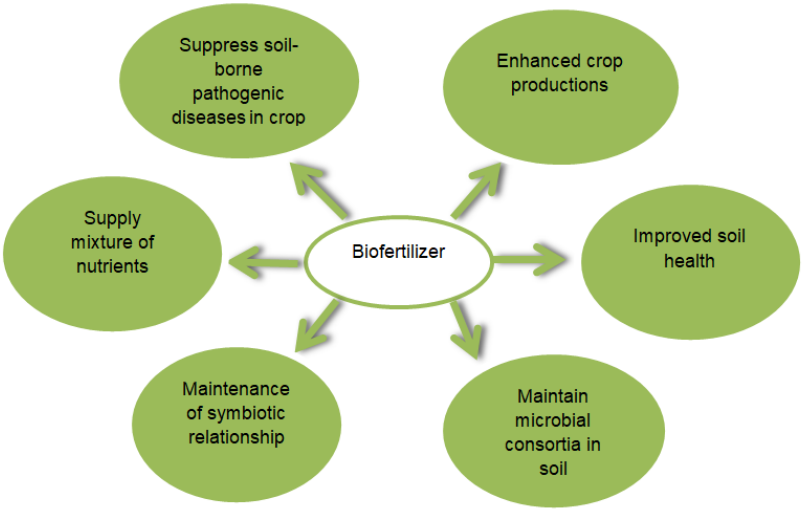


Fig.1. Multifunctional areas in which biofertilizer is used extensively and they expand organic farming [1].

Pistia stratiotes

Pistia stratiotes (water lettuce) is a floating macrophyte with rapid development and a rich content of nutrients, which gives it potential in the production of biofertilizers. The chemical properties of Pistia stratiotes are shown in table 1.

Table. 1. Nutrient contents of P. Stratiotes (nutrient concentratio: g kg^{-1}) [25].

Nutrient source	N	P	K	Ca	Mg	Na
P. stratiotes	127,16	87,62	214,34	101,59	23,95	12,37

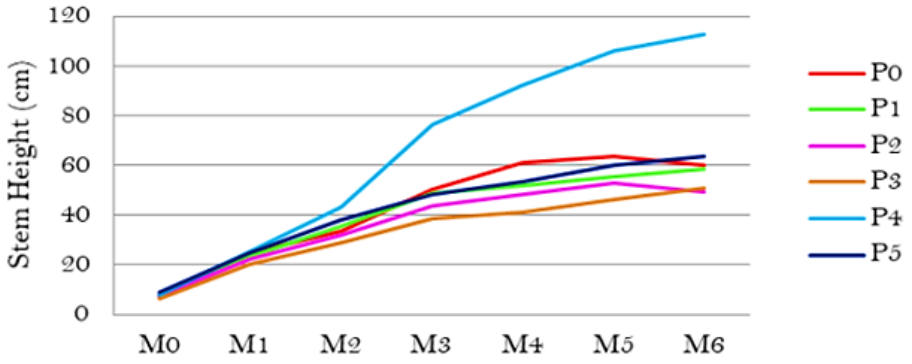
The aquatic plant *Pistia stratiotes* was analyzed by researchers to determine the effect of this macrophyte on the development of cempedak seedlings (fruit). After administration of the biofertilizer Pistia stratiotes, beneficial effects were observed in the development of the respective cempedak seedling at 30, 60 and 90 days after planting (DAP) compared to the control plant as shown in figure 2 [9].

24 DAP 30 DAP 60 DAP 90 DAP

Fig. 2. Phase growth and development of seedling cempedak.

This shows that the treatment of organic fertilizers from Pistia stratiotes in the planting environment can improve soil fertility, can meet nutritional needs, especially for the growth and development of cempedak leaves. After applying the treatment resulted in a higher growth of seedlings, better than the control plant [9].

Another study conducted in Indonesia looked at the potential of liquid organic fertilizer from Pistia stratiotes in growing Ipomoea reptans Poir. This fertilizer has been used because it contains compounds that provide nutrients such as nitrogen, carbon, potassium and phosphorus. At the end of the fermentation process of the fertilizer Pistia stastiotes results in a brownish-yellow fertilizing material. The results obtained after applying this organic treatment to Ipomoea reptans Poir strains are described in figure 3 [20].



Plant Age (MST)

Fig. 3. Average height of ground water spinach stems. P0: Control (without fertilizer) P1: Concentration 4%; P2: Concentration 8% P3: Concentration 12%; P4: Concentration 16% P5: Concentration 20%; M: Week [20].

It is well known that manure is a valuable source of nutrients and also improves the physical structure of the soil [23].

In Thailand, the effect of foliar application of *Pistia stratiotes*, manure and wood vinegar (pyroligneous acid) on the growth of rain rice was analyzed. The incorporation of Pista stratiotes combined with cattle manure and wood vinegar could not provide enough N (nitrogen) for the rice crop, but it is recommended for K (potassium) and P (phosphorus). The results obtained show that the incorporation of *Pistia Stratiotes* in the soil led to a significant increase in cereal production compared to the plots not treated with *Pistia stratiotes* [19].

Water lettuce

Due to the presence of inorganic compounds such as nitrogen (N) and phosphorus (P), composting remains among the most effective methods of obtaining biofertilizers from hyacinths. As a result, composting can help reduce the use of chemical fertilizers on crops, thus leading to organic farming [16].

Table. 2. Nutrient content of C-organic, Nitrogen, C/N, P, K, and Ca in biofertilizer with different doses of water hyacinth (*Eichhornia crassipes) [22].*

***W. H.*doses**	**C-organic (%)**	**Nitrogen (%)**	**C/N**	**P_2O_5 (%)**	**K_2O (%)**	**Ca (%)**
W.H. 25%	3,61	0,166	21,75	0,347	1,422	0,140
W.H. 50%	3,75	0,175	21,43	0,528	1,553	0,218
W.H. 75%	3,78	0,243	15,56	0,729	1,786	0,259
W.H. 100%	3,92	0,278	14,10	0,627	2,090	0,164

The compost is the best mulch and its use helps to fertilize the soil and increase crop yields [11]. According to the results obtained by the researchers, the biomass of the water hyacinth has a high content of energy and protein and can be used for various applications, such as compost, fertilizers and animal feed [17].

Figure 4 shows the benefits of using water hyacinth in sustainable agriculture [5].

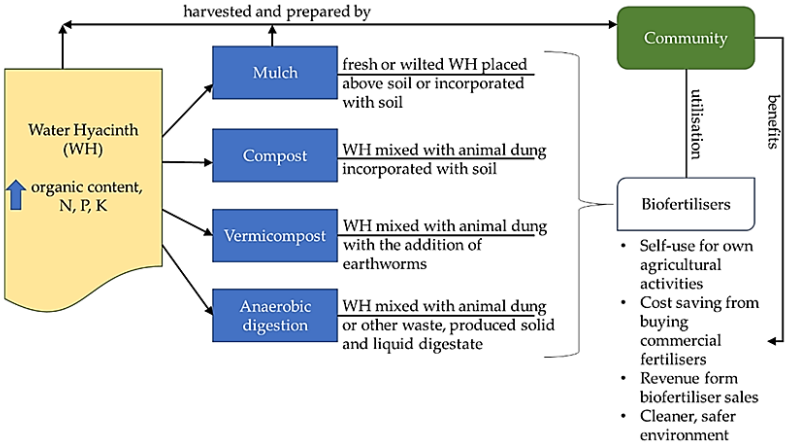


Fig. 4. Water hyacinth valorisation to biofertilisers and the role and benefits of the community [5].

The isolation of cellulolytic filamentous fungi involved in the decomposition of water hyacinths to produce organic fertilizers has been studied. The results obtained from the use of N.S8 isolate (Aspergillus oryzae) show an organic fertilizer with a high nutrient content as detailed in table 3 [14].

Table 3. Analysis results of total N, P, K contents in organic fertilizer sample [14].

	Before incubation		After incubation	
Content (%)	Control	Experimental treatment (Supplement with 5% *A. oryzae* "N.S8")	Control	Experimental treatment (Supplement with 5% *A. Oryzae* "N.S8")
Total N	1.42	1.42	1.53	3.35
Total P	0.16	0.16	0.19	0.43
Total K	0.36	0.36	0.38	0.74

Compost is obtained through a biological, aerobic process of controlled decomposition of organic substances using microorganisms, being extremely useful for horticulture and agriculture [15]. In India, compost consisting of water hyacinths, cow dung and sawdust in a ratio of 6: 3: 1, led to an increase in all nutrients (P, N, Na, Ca and K) tested and optimized the stability of the compost, indicating that water hyacinth is a good raw material for compost production [16].

Eichhornia. crassipes can be applied as a substrate for the production of compost or biogas, and its by-product can be used as a fertilizer, because biogas sludge contains almost all the nutrients of the substrate. The use of water hyacinth compost on different crops has led to increased yields. The rapid development and high concentrations of nutrients give E. crassipes great potential as a fertilizer. In addition, its high protein content makes it possible to use it as animal feed [10].

Salvinia molesta

Salvinia molesta also called giant salvinia is a floating aquatic plant spread all over the world and has various uses such as animal feed, compost and mulch.

The composition of the dry matter of Salvinia molesta is described in the literature as follows: 132g kg-1 of crude protein, 130g kg-1 of ash, 42 g kg-1 of ether extract and 135g kg-1 of lignin [10].

The vermicompost from salvinia molesta was studied to find out its potential in increasing the resistance of the lady finger plant (Abelmoschus esculentus) against pests and diseases. Applying vermicompost from salvinia on the soil where ladies finger was grown has led to increased plant productivity. Likewise, the nutrient content experienced a significant development compared to that of plants grown on untreated soil. Increasing

the concentration of vermicompost also caused a reduction in the incidence of plant diseases [6].

The growth rate of germination and seedlings grown on a soil supplemented with vermicompost from Salvinia molesta was analyzed. The plants analyzed were the lady's finger (Abelmoschus esculentus), the cucumber (Cucumis sativus) and the green gram (Vigna radiata). The influence of Salvinia vermicompost on the biological and physico-chemical characteristics of the soil was also studied. The research results show that the vermicompost increased seed germination as shown in figure 5 [7], and led to the morphological growth and biochemical content of the studied plant species. It also gave the soil physical-chemical and biological attributes beneficial to plants, thus becoming an ideal fertilizer for organic farming.

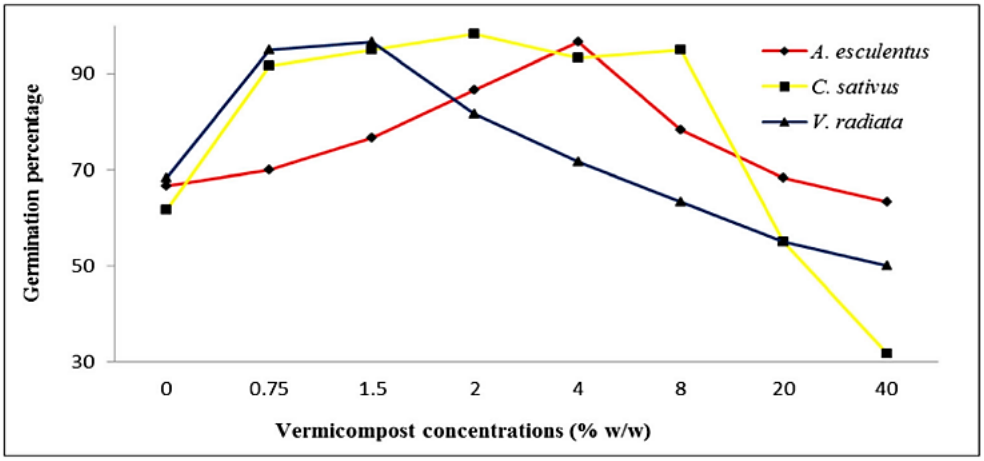


Fig. 5 Germination success of seeds as a function of the concentration of S. molesta vermicompost [7].

The researchers studied the benefits of transforming the aquatic plant Salvinia molesta into a vermicompost made of E. fetida earthworm. The results showed that the chemicals responsible for Salvinia's allelopathy are destroyed, turning it into a formidable organic fertilizer [8].

In Indonesia, a research project was carried out to discover new methods of growing two varieties of melon Action 434 and Amanta. One of the methods found is the cultivation of melons on floating swamp beds, namely ambul technology. Ambul is a growing medium of decomposed floating aquatic plants, built with bamboo or wood as a frame, which allows it to float on water. As a main factor, three aquatic plants were applied, namely Eichornia crassipes, Salvinia molesta, Eleocharis palustris. The results showed that the use of the Salvinia molesta floating environment had the best yield for the cultivation of the two watermelon varieties Action 434 and Amanta. The cultivation of watermelon on a floating bed is shown in figure 6 [3].

Fig. 6. Melon on swamp floating bed [3].

The potential of using the aquatic plants Eichornia Crassipes, Pistia Stratiotes and Salvinia Molesta in the production of a biofertilizer with the ability to maintain soil fertility, improved germination rate and seedling development and thus increased crop productivity was studied. The biomass of the three aquatic plants was subjected to an aerobic composting process under controlled conditions (by monitoring pH, temperature and humidity) for 77 days. After applying the biofertilizer on the seeds of habanero peppers (Capsicum chinense) and lentils (Lens esculenta), it was concluded that it has a real potential in soil fertilization and crop development [4].

CONCLUSIONS

The growing demand for agricultural products implicitly leads to an acute need to develop new technologies that will lead traditional agriculture to sustainable agriculture. Classical agriculture uses significant amounts of water, pesticides and insecticides. By adopting the principles of sustainable agriculture, the quantities of chemicals applied are considerably reduced, thus reducing the negative effects on the environment. The results obtained by researchers show that aquatic plants have a real potential in sustainable agriculture. This category also includes *pistia stratiotes, eichhornia crassipes* and *salvinia molesta*, which have a special contribution in obtaining biofertilizers in agriculture. All the studied positive effects of the three aquatic plants, in sustainable agriculture, encourage new research to discover other possible applications of *pistia stratiotes, eichhornia crassipes* and *salvinia molesta.*

ACKNOWLEDGEMENT:

This work was supported by the Romanian Research and Innovation Ministry, through NUCLEU Programme, Project “PN 19 10 02 03: "RESEARCH ON THE INTENSIVE GROWTH OF FISH IN THE POLYCULTURE SYSTEM AND THE COMPLEX VALORIFICATION OF THE BIORESOURCES (PLANTS) OF AQUATIC”, contract no. 5N / 07.02.2019.

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