USE OF MICROBIAL FERTILIZERS IN MULBERRY AND IMPACT ON SILKWORM (*B. MORI* L.) PRODUCTIVITY – A REVIEW

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CONTEXT

Mulberry (*Morus* sp.) is a perennial cultivated tree, and its leaves are used to feed *B. mori* silkworm. The mulberry leaves yield depends on agro-environmental conditions, and affects the silkworm development, productivity and silk quality (Samami et al., 2019).
Since the cost of mulberry leaf production represents over 60% of the total cost of silkworm cocoon production, efforts are being made to develop new varieties and agronomic practices to boost leaf productivity in order to sustain sericulture profitability (Nithya et al., 2011). Therefore, an essential role in mulberry culture productivity is played by soil fertility management (Baqual, 2013).
The growing interest in research studies concerning biofertilizers as low-cost and environmentally friendly alternatives to chemical substances to increase the productivity and sustainability of both moriculture and sericulture suggests the importance of this research topic.

OBJECTIVE

This review highlighted:
i). the microbial ways to improve nutrients absorption in soil-plant systems;
ii). productivity response of silkworm fed mulberry leaves with application of biofertilizers.

Biofertilizers...?

- ..."*substances containing live microorganisms which, when applied to plant surfaces, seeds or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of essential nutrients to the host plant*" (Vessey, 2003; Mącik et al., 2020).

Mode of action and advantages

- Soil: colonize the rhizosphere and increase the uptake of plant nutrients, improving soil fertility and crop yields (i.e., nitrogen fixation, potassium and phosphorus solubilization).
- Plants: increase the plant growth and yield by enhancing nutrients uptake, protection against plant pathogens.
- Environment: reduce the use of chemical fertilizers and pollution. (Itelima et al., 2018; Mącik et al., 2020; Demir et al., 2023).

Example of biofertilizers

- Bacteria: *Azotobacter*, *Azospirillum*, *Pseudomonas*, and *Bacillus* spp.
- Fungi: *Aspergillus* spp.
- Symbiotic fungi: Arbuscular Mycorrhizal Fungi (AMF) from *Gigaspora* and *Scutellospora* spp. or Vesicular-Arbuscular Mycorrhizal (VAM) fungi from *Glomus*, *Entrophospora*, *Acaulospora*, and *Sclerocystis* spp.

RESULTS AND DISCUSSIONS

EFFECTS OF USING BIOFERTILIZERS IN MULBERRY ON PLANTS-SILKWORM PARAMETERS

References	Mulberry varieties	Treatments	Main results
Ram Rao et al., 2007	S-13	T1: Control (100 % NPK = 300:120:120 kg/ha/year) T2: VAM* (50% reduction in P fertilizer) *VAM fungi *Glomus mosseae* T3: BBF** (50% reduction in N fertilizer) **Biofertilizer (BBF) bacterial *Azotobacter chrococcum* T4: VAM and BBF (50% reduction in both N and P fertilizers)	Reduction with 50% of chemical fertilizers doses in experimental treatments did not affect the leaf quality traits or cocoon parameters. This may be due to the effect of microbial inoculants in these treatments, which efficiently regulated the normal growth, metabolism and physiological activity in plants. Among the three biofertilizer treatments, leaf quality, silkworm growth and cocoon parameters were found to improve in T4 and were similar with control. The authors concluded that dual inoculation (T4) proved economical and beneficial with regard to saving 50 % cost of chemical fertilizers and improvement in soil fertility, leaf quality and cocoon parameters, and recommended this technology to sericulture farmers of semi-arid conditions.
Waktole and Bhaskar, 2012	M5	T1: Standard: R. NPK (100:50:50kg/ha/yr) + FYM (farm yard manure, 12 MT/ha/year) T2: 75% NP by chemical fertilizers + 25% NP by *Aspergillus awamori* and *Azotobacter* sp.+ FYM + K (50kg/ha/yr) T3: 50% NP by chemical fertilizers + 50% NP by *A. awamori* and *Azotobacter* sp. + FYM + K T4: 75% NP by chemical fertilizers + 25% NP by *A. awamori* , *Azotobacter* sp. and *Trichoderma harzianum* + FYM + K T5: 50% NP by chemical fertilizers + 50% NP by *A. awamori*, *Azotobacter* sp. and *T. harzianum* + FYM + K T6: NPK only by FYM T7: NPK only by chemical fertilizers T8: Control (No fertilizer)	The quantitative and qualitative larval growth performance and cocoon traits were not affected by the reduction with 25% of chemical fertilizers (NP) application to mulberry plant and supplemented with bio-inoculants (*Azotobacter* sp., *Aspergillus awamori* and *Trichoderma harzianum* at 20, 25 and 20 kg/ha/year, respectively). The use of these microbial bio-inoculants in sericulture to maintain the productivity of mulberry plantations, thereby silk cocoons, represent a viable option with the current increase in the price of chemical fertilizers and environmental concerns about the negative impact of such chemical fertilizers.
Barna and Manab, 2015	S1	T1: Control (FYM +NPK) T2: Weed compost +AZB + 50% N +40% P +100% K T3: Silkworm rearing waste compost + AZB + 50% N +40% P +100% K T4: Poultry manure + AZB + 50% N + 40% P +100% K T5: Pig manure+ AZB + 50% N +40% P +100% K	The use of organic manures, especially poultry manure, combined with *Azotobacter* biofertilizers, followed by reduced doses of inorganic fertilizers, significantly affected the growth and leaf quality of mulberry plants. The 50% reduction of inorganic nitrogen and a 60% reduction of phosphorus application do not adversely affect mulberry plant growth and foliar constituents when supplemented with the above bio-organic sources of amendments. The use of organic manures along with biofertilizer and reduced doses of chemical fertilizer is an eco-friendly technology beneficial for mulberry cultivation.
Moorthi et al., 2016	MR2	Biofertilizer *Azotobacter chroococcumon*	The application of *Azotobacter* increased the growth of the mulberry plants, enhanced the growth of silkworm larvae, and increased the cocoon weight, shell weight, shell ratio, effective rate of rearing and silk filament length.
Beevi et al., 2018	V-1 MR2	T0: Control / No inoculation T1: Full dose of fertilizer (300: 120: 120 Kg NPK/ha/yr) as standard control T2: *Azospirillum* + (75% N +full dose of P&K /ha/yr) +EM T3: *Azotobacter* + (50% N+ full dose of P&K/ha/yr) +EM T4: Phosphate solubilizing bacteria + (75% P + full dose of N&K/ha/yr) +EM T5: Vesicular Arbuscular Mycorrhiza VAM+ (50% P + full dose of N&K/ha/yr) +EM T6: *Azospirillum* + PSB + (75% N&P + full dose of K/ha/yr) +EM T7: *Azospirillum* + VAM + (75% N + 50% P + Full dose of K/ha/yr) +EM T8: *Azotobacter* +PSB + (50% N +75% P + full dose of K /ha/yr) +EM T9: *Azotobacter* + VAM+ (50% N +50% P + full dose of K /ha/yr) +EM T10: *Azospirillum* +PSB+VAM + (75% N+25% P + full dose of K /ha/yr) +EM T11: *Azotobacter* +PSB+VAM + (50% N+25% P + full dose of K/ha/yr) +EM	A significant beneficial effect was recorded on mulberry leaf yield of both varieties V-1 and MR-2 due to inoculation with microbial consortium containing nitrogen-fixing bacteria *Azotobacter* and *Azospirillum*, phosphate solubilizing and mobilizing microorganisms besides EMs even after curtailing nitrogenous and phosphatic chemical fertilizers to the extent of 25-75% of the recommended dose. The rearing performance with the variety V-1 exhibited highest matured larval weight in the treatment T10 compared to T1. Highest effective rate of rearing, higher cocoon and shell weight were recorded in the treatment T6, T10 and T2. The treatment T7 recorded the highest shell ratio. The rearing performance with the variety MR-2 exhibited highest matured larval weight, effective rate of rearing by number and weight in the treatment T10. The single cocoon weight and single shell weight were found to be the highest in the treatment T6 followed by T10, whereas higher shell ratio was observed in the treatment T8. Significant improvement in various cocoon characters of mulberry silkworm was observed as a result of feeding leaf from microorganisms inoculated plots over the plot receiving full dose of inorganic fertilizers and no inoculation.
Diniță et al., 2023	Ken Mochi Kokuso 21 Ucraina 107 Ichinose China 32 Olteni	V0: Control – unfertilized V1: Chemical fertilization (NPK), dose: N240:P120:K120 kg a.s./ha V2: Biofertilizer VAM (Endorize SOL), dose: 25 mg/plant	The fertilization with Endorize SOL bioproduct did not affects the agro-productive parameters in mature mulberry plants, compared to chemical fertilization. Additionally, that positively influences the sericultural economic results by reducing the production costs related to fertilization, having beneficial effects of ecological protection on soil. The use of biofertilizer Endorize SOL had a positive effect on technological parameters of the silk cocoons and on silkworms health status. The mycorrhizae technology has a great potential of application to improve the productivity and to reduce the environmental problems associated with the excessive use of chemical fertilizers.

CONCLUSIONS

- Biofertilizers promotes growth and yield of plants by supplying nutrients in available form, enhances the quality of mulberry leaf finally helps in production of good quality raw silk.
- The use of biofertilizers in mulberry cultivation reduces the demand for chemical fertilizers (about 50%), representing a sustainable, eco-friendly and economic strategy.

SELECTIVE REFERENCES

- Baqual, M. F. Economics of using biofertilisers and their influence on certain quantitative traits of mulberry. African Journal of Agricultural Research. 2013, 8(27), 3628-3631.
- Demir, H.; Sönmez, ˙I.; Uçan, U.; Akgün, ˙I.H. Biofertilizers improve the plant growth, yield, and mineral concentration of lettuce and broccoli. Agronomy 2023, 13, 2031. https://doi.org/10.3390/agronomy13082031.
- Itelima, J.U.; Bang, W.J.; Sila, M.D.; Onyimba, I.A.; Egbere, O.J. A review: Biofertilizer—A key player in enhancing soil fertility and crop productivity. Microbiol. Biotechnol. Rep. 2018, 2, 22–28.
- Mazid, M.; Khan, T.A. Future of bio-fertilizers in Indian agriculture: An overview. Int. J. Agric. Food Res. 2015, 3, 10–23.
- Samami, R., Seidavi, A., Eila, N., Moarefi, M., Ziaja, D. J., Lis, J. A., and Cappai, M. G. Production performance and economic traits of silkworms (*Bombyx mori* L., 1758) fed with mulberry tree leaves (*Morus alba*, var. Ichinose) significantly differ according to hybrid lines' Livestock Science, 2019, 226, 133-137.
- Vessey, J.K. Plant growth promoting Rhizobacteria as biofertilizers. Plant Soil 2003, 255, 571–586.
- Beevi, N.D, Devamani, M., and Qadri, S.M.H. Effect of co-inoculation of microbial consortium on mulberry leaf yield and silkworm cocoon production Int. J. of Sci., Env. and Tech. 2018, 7(6)1875-85.