Economic Affairs, Vol. 64, No. 3, pp. 563-569, September 2019
DOI: 10.30954/0424-2513.3.2019.12

Economic Appraisal of Bio-Priming Mediated Stress Moderation in Crop Plants

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Received: 12-04-2019 **Revised:** 14-07-2019 **Accepted:** 23-08-2019

ABSTRACT

The primary restraint in crop production and food security worldwide is exposure of crop to stress conditions *viz.*, abiotic and biotic which has driven the attention of scientists. Stress conditions induce changes in plant internal functions leads to reduction in plant growth and yield. The adverse economic losses due to abiotic stresses can be mitigated by application of chemicals such as anti-transpirants, nutrients and plant growth regulators, while the biotic stresses by application of pesticides and fungicides. Another way to resist stress conditions is adoption of modern breeding technologies and biotechnological strategies to produce climate resilient crops. Promotion of chemicals and biotechnology tools negatively impacts soil health, environment as well as socio-economic status of the farmer. Though the use of agro-chemicals is unavoidable in modern agriculture, indiscriminate use of chemicals would cause imbalance in environment and reduction in benefit to cost ratio (B: C) of farmer. In this context to make the crop production profitable, the review has outlined different economic considerations associated with biopriming mediation for stress moderation in different crop plants.

Highlights

- Multiple stress due to climate change during crop production can be mitigated through the invention of seed bio-priming.
- Bio-priming intervention can supplement a part of inputs needed for crop production thus reduce the investment.
- Bio-priming can improve both quality and quantity of produce and enhance B : C ratio as compared with solely RDF.

Keywords: Biotic stress, abiotic stress, bio-priming, B : C ratio

Importance of bio-priming in the present perspective of changing climate

Climate change is a shift in pattern of regional or global climate which is predominantly caused by anthropogenic activities. Global warming is phenomenon of climate change leads to raise in average temperature of the earth and is directly related to green house gas emissions, fossil fuels, deforestation, intensive farming etc. (Fig. 1.)

As agriculture is highly dependent on climatic conditions, it is interconnected with climate change. Climate change alters agriculture in numerous manners including increase in temperature, change in rainfall and extreme weather conditions.

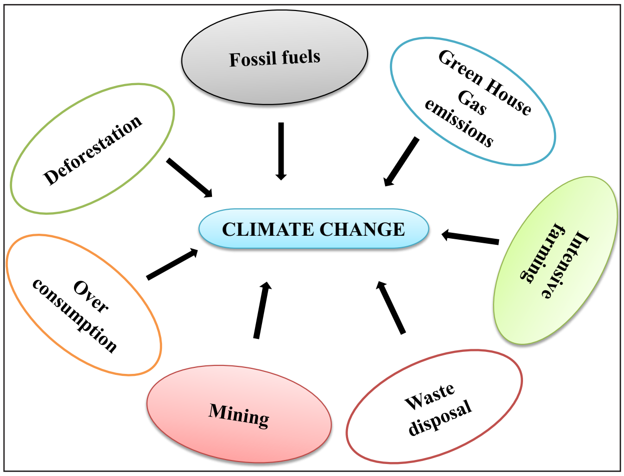

Fig. 1: Causes for climate change

These weather situations leaves the crop under stress, favours the attack of pest and diseases and also degrades the quality of the produce. In this scenario, to mitigate the effects of climate change and to ensure food security, well suited technique is conventional breeding and genetic engineering approaches which is not economical and practically feasible. The alternative method which is eco friendly, low cost intensive for secured yield even under adverse climatic conditions is bio-priming.

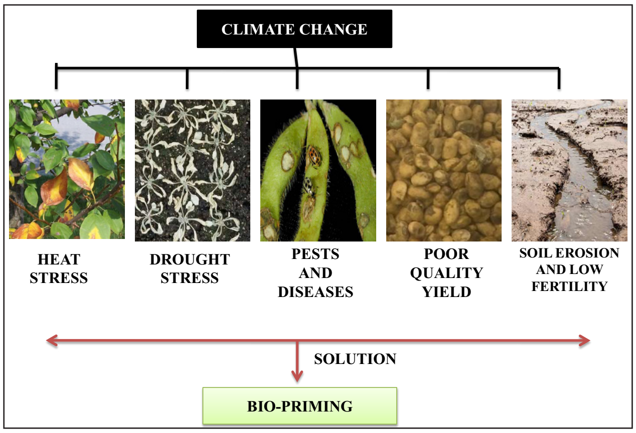

Fig. 2: Effect of climate change in agriculture

Bio-priming is a process of biological seed treatment that refers combination of seed hydration (physiological aspect of disease control) and inoculation (biological aspect of disease control) of seed with beneficial organism to protect seed (Rakshit *et al*. 2014). Bio-priming improves germination rate, uniformity in plant population, increases water and nutrient use efficiency, eliminates seed borne pathogens, controls pests and diseases. Besides these advantages, bio-priming reduces the hazardous effects on humans caused by the use of fungicides, bactericides and pesticides by supplementing a part of chemical usase (Fig. 3).

Bio-priming with Trichoderma in soybean enhanced both macro and micro nutrient use efficiency (Entesari *et al*. 2013; Santiago *et al*. 2012) and in mustard, the over all performance of the crop with reference to yield and buffering capacity of crop against abiotic stresses is improved (Karthika *et al*. 2012; Lalitha *et al*. 2012). Pseudomonas isolates controls soil-borne phyto pathogens (O'Callaghan *et al*. 2006), it controlled alternaria blight in sunflower and showed least disease indices i.e., 19.24, 28.86 and 37.74 % at 45, 60 and 75 DAS respectively (Rao, *et al.* 2009). Priming the sesame seed with *Trichoderma harzianum* successfully controlled the charcoal rot disease (*Macrophomina phaseolina*) (El-Fiki *et al.* 2004). Seed bio-priming defends the plants against several adverse conditions like pest and disease attack. Seed priming of cucumber seeds with bacteria *Bacillus gaemokensis* defended the plant against both pathogen viz., *Pseudomonas syringae* and herbivore viz., *Spodoptera litura* by producing jasmonic acid in leaves. This induced plant resistant was mainly due to the cyclo-dipepides (L- leu, P - pro) present in Bacillus and is a promising technique for protecting plant against biotic stress conditions (Song *et al.* 2017).

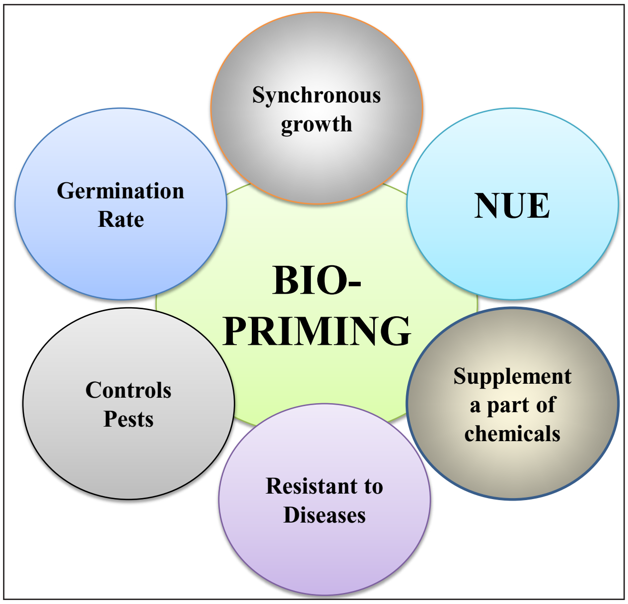

Fig. 3: Different facets of bio-priming

Priming ground nut seed with *Pseudomonas fluorescens* resist the crop against salt stress (Saravanakumar & Samiyappan, 2007). Tolerance to heat stress was observed in soybean by bio-priming seed with *Serratia proteamaculan* (Dimkpa *et al*. 2005). Inoculation of maize seed with *Azospirillum brasilense* recorded improved relative and absolute water content as compared to non primed plants and the results were more significant at 75 % reduction in water supply than 50 % reduction (Casanovas *et al*. 2002).

In course of time, along with change in climate plant have to pass through several adverse conditions such as abiotic and biotic stresses which affects crop performance. Over the past few years, priming, particularly seed priming has emerged as a promising strategy in modern stress (biotic and

Table 1: Economics of crop loosing at the farmers income

Sl. No.	Agroecology	Crops	Treatment	Impact	B : C	Reference
1	Arid to dry sub humid	Okra	RDF	Bio-priming with liquid formulation of Azospirillum brasilense @ 15% for 12 hours along with RDF recorded highest yield than other treatments.	1.05	Karthika *el al*. 2016
			RDF + Bio-priming with *Azospirillum brasilense*		1.14	
2	Dry sub humid	Green gram	RDF	Significantly higher yield was recorded in seed priming treatment at spacing 30 * 10. Quality of seed, protein content, nutrient content and uptake were recorded maximum in priming treatment at 30*10 spacing.	1.81	Gohil *et al*. 2017
			RDF + Bio-priming with *Rhizobium* and PSB		2.18	
3	Tropical savannah	Yellow sarson	RDF	Integrated application of chemical fertilizers along with poultry manure and bio fertilizers *viz*., PSB and *Azotobacter* recorded significantly higher dry matter accumulation, siliquae per plant, no. of seeds per siliquae, seed yield and oil quantity. Highest benefit cost ratio was also achieved.	1.5	Raj *et al*. 2017
			50% RDF + Poultry manure 2.5kg/ha + PSB + *Azotobacter*		2.1	
4	Humid subtropical	Baby corn	RDF	In an attempt to reduce chemical fertilizers, the treatment combination of T. viride + G. intraradices + 75 % RDF found very effective treatment for baby corn production which showed highest yield among all the treatments. Strong positive correlation was observed among crop yield, leaf area, root length, chlorophyll content and fresh and dry weights.	2.05	Yadav *et al*. 2018
			75% RDF + Bio-priming with *Trichoderma viride* + *Glomus intraradices*		2.75	
5	Humid subtropical	Okra	RDF	Treatment supplied with 90% RDF and seed priming not only reduced 10% chemical fertilizers but also produced almost similar yield as compared to RDF. Energy / unit produce production in bio-priming treatments were reduced upto 970-1670KJ which is cost effective and user friendly technique.	2.14	Pal *et al*. 2018
			90% RDF + seed bio-priming with *Trichoderma harzianum*		2.10	
6	Humid subtropical	Wheat	RDF	The highest yield was observed in RDF followed by 75% of RDN & RDF of P, K + seed bio-priming with *Trichoderma harzianum* and is comparable to RDF. Over all result showed that bio-priming with 75% RDN produced better yield and emerged as an alternative to full dose of RDF.	2.3	Meena *et al*. 2017
			75% of RDN & RDF of P, K + seed bio-priming with *Trichoderma harzianum*		2.0	
7	Humid subtropical	Yellow sarson	RDF	Marked improvement in yield, productivity and economics were observed due to integrated nutrient management and seed priming techniques. Among all the highest yield was observed in the treatment supplied with 75% RDF + FYM + *Azotobacter* + PSB.	1.15	Mookherjee *et al*. 2014
			75% RDF + FYM + *Azotobacter* + PSB		1.23	
8	Tropical wet and dry climate	Mung bean	RDF	All the growth parameters and yield were significantly influenced by the *Rhizobium* inoculation. All the parameters performed better including nodules / plant in case of *Bradyrhyzobium* inoculums	2.16	Uddin *et al*. 2009
			RDF + *Rhizobium* inoculation		2.39	

9	Warm and temperate	Field pea	RDF	Application of 100% RDF+ seed inoculation with *Rhizobium* + PSB + PGPR improved grains per pod, no. and weight of pods per plant which attributed to increase in yield. The yield increase was 11.93% higher with seed inoculation as compared to RDF.	1.92	Mishra *et al*. 2010
			RDF+ seed inoculation with *Rhizobium* + PSB + PGPR		2.14	
10	Tropical savannah	Mustard	RDF	Seed inoculation with microbial agents in the combination of 100% RDF gave highest yield among all the treatments. It significantly improved the yield by 11.18% than the 100% RDF.	1.91	Gudadhe *et al*. 2005
			RDF +seed inoculation with *Azotobacter* and PSB		2.07	
11	Humid subtropical	Tomato	RDF	The yield was significantly increased with the application of bio fertilizers in the combination of RDF. The yield improvement was nearly 25% more in the treatment supplied with RDF + *Azospirillum* than RDF	1.8	Singh *et al*. 2018
			RDF + *Azospirillum*		1.9	
12	Humid subtropical	Wheat	RDF	Bio fertilizer application with RDF increased both grain yield and straw yield than most of the treatments. RDF + *Azotobacter* + PSB enhanced yield significantly as compared to RDF.	2.35	Singh *et al*. 2016
			RDF + *Azotobacter* + PSB		2.5	
13	Tropical wet and dry climate	Sesame	RDN	Sesame is cultivated as summer rice fallow in which *Azospirillum* supplemented 50 % of the chemical fertilizer requirement and reduced the impact of chemicals on soil health	1.59	Paul and Savithri. 2003
			50 % RDN + *Azospirillum*		1.56	
14	Warm and temperate	Tomato	RDF	Supply of *Trichoderma* as a supplement of nitrogen fertilizer not only reduced the fertilizer requirement, but also boosted up the growth and yield significantly.	1.35	Haque *et al*. 2012
			50 % N + *Trichoderma*		2.13	
15	Warm and temperate	Mustard	RDF		1.47	
			50 % N + *Trichoderma*		1.42	
16	Tropical wet and dry	Groundnut + Pigeon pea	RDF	In groundnut pigeon pea relay intercropping system, RDF gave the highest productivity and benefits with the exception of enhanced cost of production. Integration with bio-fertilizers can alleviate this limitation which has given next best benefit cost ratio.	1.84	Poonia *et al*. 2014
			50% RDF + FYM @ 1 t/ha + *Rhizobium* + PSB		1.71	
17	Humid subtropical to tropical savannah	Wheat	RDF	Though the highest benefit was with RDF, application of bio-fertilizers along with half dose of RDF increased returns by 1.4 – 8.5% than sole application of 50% RDF.	2.80	Behera and Rautaray, 2010
			50% RDF + *Azospirillum*		2.50	
18	Warm and temperate	Maize	RDF	Application of recommended dose of fertilizer along with bio-fertilizer has given maximum yield followed by RDF application.	1.03	Meena *et al*. 2013
			RDF + *Azotobacter*		1.10	
19	Local steppe	Cowpea	RDF	In this filed experiment application of bio-agent with full dose of fertilizer enhanced the economics, profit of cowpea as compared to sole application of RDF	1.95	Meena *et al*. 2014
			RDF + *Rhizobium*		2.46	
20	Tropical	Safflower	100 % N	Seed inoculation with *Azotobacter* and *Azospirillum* along with 50% RDN enhanced the crop growth, yield attributing characters and yield than in RDN.	1.56	Sudhakar and Sudha Rani, 2008
			50 % N + *Azotobacter* + *Azospirillum*		1.68	

abiotic) management as it protects plants against pathogens and abiotic stresses without heavily affecting fitness (Van Hulten *et al.* 2006).

Cost of cultivation methodology

The secondary data used in this study were collected from several research evidences. Concepts used in the study:

(a) Benefit cost ratio (BCA): It is an approach to evaluate a project or investment by comparing economic benefits with economic costs. BCA is calculated as value of benefits divided by value of costs at the time of respective experiments conducted.

$$BCR = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}} \quad \text{(Shively, 2012)}$$

B_t is the benefit at time t and C_t is the measure of costs at time t.

(b) Conversion of yield/plant to yield/ha:

No. of plants = 10,000 m^2 / product of spacing in m^2. Simple statistical and arithmetic tools such as averages, percentages and ratios were worked out.

Economic appraisal of different crops under varied agro ecology

Agro ecology is the application of ecological concepts and principles to the design and management of sustainable agricultural systems (Gliessman, 1992). India is comprised of heterogeneous landforms with varying environmental situations resulted in variety of soils. Under these varying conditions, for getting assured production farmers are applying plenty amount of fertilizers, pesticides and herbicides, this choice overloaded the farmers economically. The economic impacts of stress conditions can be complex and may lead to less benefit to the farmers.

Rapidly expanding population puts ample burden on the natural assets, and hence it is necessary to adopt eco-friendly and efficient methods. By keeping all these in view, adopting microbial agents in agriculture can be suggested as an alternative to the varying environmental situations and for sustainable use of natural resources (Table 1).

CONCLUSION

Climate change is giving negative impact on agriculture and imposing an economic penalty. In agriculture dependent countries like India, sustainable production technologies to mitigate climate change is necessary and prerequisite. Climate change leads to exposure of plant to multiple stress conditions causes unpleasant changes in functioning of plant, ultimately leads to deleterious effect on quality and quantity of produce. To overcome this problem farmers are using plenty of agro-chemicals which over loaded the farmer economically and resulted in reduction in the benefit to cost ratio. To reduce the burden on the natural resources, input cost to farmers and for getting assured production, adoption of eco-centric and user friendly techniques like bio-priming is necessary. Bio-priming improves plant performance even under adverse environmental conditions by several means such as improving germination percentage, resist the plant against both biotic and abiotic stresses, supplements part of the chemical use. Besides these, bio-priming assures sustainability, yield and it also increases benefit to cost ratio compared to conventional practices.

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