Microbial Biogels: Tool for Pest Management in Pulse Crops

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The Biogel formulation was developed to overcome the limitations of existing microbial bio-agent formulations. The primary objective of this novel formulation was to enable easy application of beneficial bacteria and fungi for biocontrol and plant growth promoting (PGP) activities along with their easy and efficient mass multiplication for use over large crop areas at minimal input cost. A series of systematic experiments were conducted to optimize formulation, preservation and enhancement of shelf life of promising microbial bio-agents. As a result, a standardized process and protocol were successfully developed for formulating diverse microbial products in gel form, thus, collectively named Biogel.

This preservative-based, readily water-soluble formulation induces a dormant state inof microbial bio-agents, thereby ensuring their extended shelf life. To the best of our knowledge such formulation with these characteristics has neither been reported earlier nor is it currently available in the market. These biogels are concentrated preparations with

Figure 1: Demonstration on process of mass multiplication of microbial bio-agent on Institute foundation day

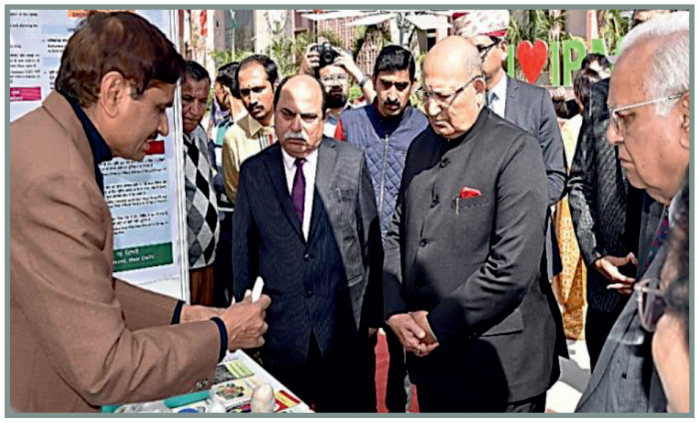


Figure 2: Showcasing of different Biogel and mass multiplication protocols

exceptionally high microbial loads (approximately 10^{18}–10^{20} CFU for bacteria and 10^{12}–10^{15} CFU for fungi). These formulations can be diluted as per requirement for seed treatment, soil application and foliar spray. Further, these can also be effectively utilized for on-farm mass multiplication of bio-agents. The technology is highly user-friendly and adaptable. Due to the extremely high CFU levels, biogels can be diluted up to 10,000 times and still remain superior to conventional liquid and talc-based formulations in terms of viable microbial count. The biogels require minimal storage space and can be conveniently stored under cold storage as well as ambient conditions. Comparative evaluations demonstrated that biogel based microbial formulations exhibited higher efficacy against target crop pests and significantly enhanced PGP activities.

Unlike talc-based formulations, where microbial cells are subjected to stress due to desiccation,and physical disturbance during storage and transportation, microbes in biogels remain embedded in a protective matrix with minimal friction and movement. Consequently, microbial viability and efficacy are maintained for longer durations. Because of their longer shelf life, high CFU content, ease of application, reduced storage requirements and superior performance, biogel-based microbial formulations possess strong commercial potential. Overall, Biogel technology represents a promising and sustainable tool for plant protection and crop productivity enhancement across diverse cropping systems.

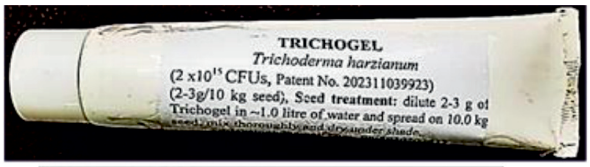
Shelf life assay of Biogels

The shelf life of microbial bio-agents was determined based on the survival of colony-forming units (CFUs) per unit volume of the formulation. The formulations were prepared separately following the newly developed protocol. Biogel formulations of *Bacillus thuringiensis* and *Trichoderma asperellum* were stored under ambient conditions in plastic collapsible tubes (50 g capacity). The viable CFU counts of all microbial formulations were recorded at monthly intervals. Shelf-life evaluation was conducted using the direct plate count method from March 2019 to Oct. 2020 (20 months) for *Trichoderma asperellum* and *Bacillus thuringiensis*.

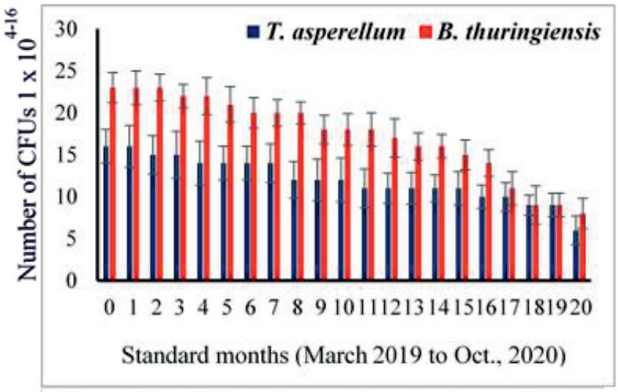
During the first month (March 2019), the initial CFU counts of bacteria (*Bacillus thuringiensis*) in gel formulation were recorded as 1×10^{20} CFUs/g (Fig. 4). The CFU levels in bacterial biogels remained stable for the first three months. A gradual decline in CFU counts was observed from the 4^{th} month onwards. However, the populations stabilized within the range of 10^{15} to 10^{18} CFU g^{-1} up to 9^{th} month. During the 17^{th} to 20^{th} month of storage, the CFU counts in bacterial biogel ranged between 1×10^{8} to 1×10^{10} CFU g^{-1} .

In contrast, the CFU counts of fungal biogel remained constant during the first three months (March–May 2019), recording approximately 1×10^{15}, in *Trichoderma asperellum*. During the 4^{th} month, a slight reduction in CFU counts was observed which declined to approximately 1×10^{14} CFUs g^{-1}. and a similar trend continued up to the 7^{th} month of storage. Subsequently, stable CFUs of *T. asperellum* were remained up to 10^{th} month *viz*., 1×10^{12} g^{-1} Overall, a gradual decline in CFU counts was recorded over the storage period. Based on these observations, it was concluded that the shelf life of *T. asperellum* in biogel formulations could be extended up to 20 months (Fig. 4).

Validation of efficacy of Biogel



Trichogel filled collapsible plastic



Shelf-life of *T. asperellum* reduction in CFUs/g

The validation of gel based products of *T. asperellum* and *B. thuringiensis* under the IPM programme was conducted in the Bundelkhand region (U.P.) in chickpea during rabi 2018-19 to 2020-21. Selected villages were Ragauli, Rura addu and Kukargaon under KVK Jalaun (BUAT) and Chokari, Tejpura and Bilati with KVK Jhansi, for the implementation of IPM strategies. During the 2018–19 cropping season, the IPM programme was validated over an area of 135 ha which was subsequently expanded to 710 ha for large-scale promotion and dissemination of IPM strategies.

The disease complexes in chickpea mainly includes collar rot (*Sclerotium rolfsii*), *Fusarium* wilt (*Fusarium oxysporum*), and dry root rot (*Rhizoctonia bataticola*/ *Macrophomina phaseolina*) can cause yield losses of up to 100%. Whereas, pod borer (*Helicoverpa armigera*) was the major insect pest that may reduce yields by up to 24.8%. Chickpea growers in the region had limited awareness of scientific pest management practices and mainly depended on chemical pesticides. Therefore, the programme was aimed to disseminate biological pest management strategies among farmers in the Jalaun and Jhansi districts with the collaboration of KVK Jalaun and KVK Jhansi under Banda University of Agriculture and Technology, Banda (Uttar Pradesh). Emphasizing on biological control initiatives, 1300 tubes Tricho-gel and 1700 tubes of Btgel were distributed among farmers for seed treatment (@) and foliar application (@) against soil borne disease and pod borer management in chickpea crop.

Application of Trichogel as seed treatment of chickpea

The formulation of T. *asperellum* (Tricho-gel, CFUs ~10^{15}/g) was applied as seed treatments (0.5g/ kg seed) in chickpea for soil borne disease management in a total 52 villages covering a large area under IPM programmes for three consecutive years. Farmer field days (173) were conducted for training and demonstrations of the seed treatment with Tricho-gel for wilt complex and foliar spray of *Bt*-gel for pod borer management in chickpea. Results indicated reduction in incidence of wilt complex, which is a major challenging constraint in chickpea production that may deteriorate crop yield up to 70%. The adopted farmers could achieve successful disease management in chickpea.

Table 1: Insect pest and disease management in chickpea using Tricho-gel and Bt-gel in Bundelkhand region

Year	Wilt Disease complex (%)			Pod damage (%)			B:C ratio	
	IPM	FP	% reduction over FP	IPM	FP	% reduction over FP	IPM	FP
2018-19	7.7±2.5	27.7±4.6	72.2	10.7±3.3	23.0±4.4	53.5	4.45	2.96
2019-20	9.3±2.3	25.0±5.6	62.8	12.7±2.6	22.0±3.6	42.3	4.33	3.23
2020-21	6.7±1.8	22.0±4.3	69.5	8.7±3.0	24.7±4.3	64.8	4.26	3.18
Pooled	7.9±1.3	24.9±2.9	68.2	10.7±2.0	23.2±1.4	53.5	4.35	3.12

Impact on Pest reduction and Economics

Pooled data revealed that IPM recorded 68.2 % reduction in wilt disease complex and 53.5 % reduction pod damage due to *H. armigera* over FP. On an average 7.9% disease incidence of wilt complex was found in IPM fields in chickpea. Whereas, it was 24.9% in FP fields at both the KVKs during 2018-19. The pod damage was 10.7% in IPM and 23.2 % in FP fields.

Tricho-gel showed strong efficacy against wilt complex and Bt-gel against pod borer in chickpea, with high BC ratios (4.35 in IPM, 3.12 in FP). Their inclusion in IPM strategies can cut chemical pesticide use by nearly 80% in adopted fields.

A successful pest management could be achieved using the bio-agents in the form of gel formulation. Farmers could get a handsome return with the minimum input cost. Since then we have delivered several trainings and demonstrations for on-farm mass production.