

cient and popular that children will cheerfully and of their own accord come to them, and will not willingly leave them. It is through children that education hopes to reach the parents and society, and it must be remembered that every child who leaves the school unwillingly is a missionary for education, and everyone who leaves it in a contrary

frame of mind is a dangerous force on the other side.

We cannot enter here into all the general and special aspects of educational reform, but can only indicate its general principles and the future policy of its control and management. If we think of education in all its bearings and its nature, as lifelong, as interpenetrating all

occupations, as teaching every man and woman of doing their work in a better and more intelligent way, as co-extensive with the entire field of social activities, then education should be autonomous in its own territory. This reform being effected, all else will follow.

## SCIENTIFIC CORRESPONDENCE

### Use of the fungus *Beauveria bassiana* (Bals.) Vuill (Moniliales: Deuteromycetes) for controlling termites

Entomopathogenic fungi such as *Beauveria bassiana* (Bals.) Vuill (Order Moniliales: Deuteromycetes) have the potentiality to infect insects, resulting in their mortality. It is a beneficial fungus infecting a wide range of insects of the order Lepidoptera, Coleoptera and Hymenoptera, most of which are agricultural pests. The biocontrol potentiality of this fungus has been exploited, making use of the local isolates collected from either soil or from dead insect hosts prevailing in different geographic areas. Control of termites using entomopathogenic fungi has been documented earlier<sup>1-3</sup>. *Metarhizium anisopliae* conidia have been formulated and the product named 'BioBlast'<sup>4</sup> has been used to control termites. The mode of treatment of the pest was in the form of fungal baits<sup>5</sup> or pure cultures of the entomopathogen<sup>6</sup>. Workers of the termite colony were targeted more than the soldiers<sup>5</sup>. Dry conidial sprays or mixing the entomopathogen in the soil at  $10^8$  conidia g<sup>-1</sup> of soil can be used to control termites for up to a period of 3 months to 3 years under cool, dry, humid conditions<sup>7</sup>; with 100% mortality after 10 days of application in the field and 48 h after application in the laboratory<sup>8</sup>.

Most of the work on termites has been done using laboratory bioassays, by disturbing the termites from their natural environment and allowing them to crawl/feed on baits containing the entomopathogen<sup>9</sup>. Direct field trials by treating the colonies in their natural

environment are meagre. Evaluation of relative pathogenicity of the fungal isolates by classical bioassays is beset with problems, in view of the difficulty to rear on artificial diet and through movement of the termites after application of the inoculum deep into the soil and into the surrounding areas. Collection of data on mortality from different mounds also become unrealistic in view of inadequacy of information on the pest load before treatment, due to their confinement to mounds. In the present study, an attempt has been made to overcome these problems by selecting the uplifted mounds of termites so as to cause least disturbance to their natural habitat and at the same time facilitating collection of mortality data after treatment with local isolates of *B. bassiana*. The ultimate objective of the study is to select a virulent isolate of *B. bassiana* for deployment in the development of eco-friendly bioinsecticide for termite control.

Six strains of *B. bassiana* isolated from the dead insect larvae collected from the farmers' fields of Andhra Pradesh were maintained as pure cultures on Sabaraud's dextrose yeast agar medium. The fungus was mass multiplied on sorghum, bran and husk for a period of 10–15 days for treating the mounds containing white ants.

The intact mounds were collected by using flat crowbars from underneath and brought in intact condition to the laboratory. They were maintained in proper humid conditions by keeping

them in plastic trays of 12 cm depth throughout the experimental period. Treatment with the fungal isolates was conducted by thoroughly sprinkling the mass multiplied inoculum on the mounds along with the natural medium, which promoted growth of the fungus. Mortality was recorded from the second day onwards and the data for workers and soldiers were separately noted. The dead termites were removed everyday and kept in humid chambers for overgrowth of the fungus on the cadavers. Later, these were surface sterilized and the fungus was reisolated from the dead termites. Six isolates of *B. bassiana* were used for understanding relative pathogenicity against termite populations (Table 1). The mounds serving as controls were treated with only the natural medium used for mass multiplying the fungus. The mass-multiplied inoculum along with the natural medium was mixed with 1% sucrose and placed around the mound in the tray for serving as diet. Three replicates were maintained for each isolate along with the control sets.

Effect of the biocontrol agent studied in terms of mortality recorded from the second day onwards indicated that the worker community of the termites was more susceptible. Some of the dead insects were collected everyday and kept in humid chambers for fungal overgrowth on the surface of the insects. Prior to death, the insects showed symptoms of fungal infection in the form of sluggishness. The isolates 4–23

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**Table 1.** Evaluation of *Beauveria bassiana* isolates for virulence against worker and soldier communities of termites

Isolate number	Mortality values after treatment**									
	Second day		Third day		Fourth day		Fifth day		Pest load leftover on the sixth day	
	Worker*	Soldier*	Worker	Soldier	Worker	Soldier	Worker	Soldier	Worker	Soldier
Control	–	–	11 (2.2%)	–	5 (5.0%)	1 (1.0%)	27 (10.6%)	4 (4.0%)	447 (89.4%)	96 (96.0%)
4-6	29 (6.4%)	–	42 (15.7%)	2 (2.0%)	46 (26.0%)	10 (10.0%)	47 (36.4%)	12 (12.0%)	286 (63.5%)	88 (88.0%)
4-15	25 (5.5%)	–	13 (8.4%)	–	91 (28.6%)	3 (3.0%)	57 (41.3)	8 (8.0%)	264 (58.6%)	92 (92.0%)
4-16	20 (4.4%)	–	29 (10.8%)	4 (4.0%)	27 (16.8%)	5 (5.0%)	27 (22.8%)	10 (10.0%)	347 (77.1%)	90 (90.0%)
4-17	43 (8.6%)	–	32 (15.0%)	6 (6.0%)	22 (19.4%)	7 (7.0%)	71 (33.6%)	12 (12.0%)	332 (66.4%)	88 (88.0%)
4-10 <sup>+</sup>	92 (20.4%)	–	46 (30.6%)	5 (5.0%)	24 (36.0%)	12 (12.0%)	74 (52.4%)	14 (14.0%)	209 (46.4%)	86 (86.0%)
4-23	128 (25.6%)	–	36 (32.8%)	13 (13.0%)	83 (49.4%)	11 (11.0%)	87 (66.8%)	15 (15.0%)	166 (33.2%)	85 (85.0%)
Control	–	–	23 (5.0%)	–	22 (10.0%)	–	18 (14.0%)	2 (2.0%)	387 (86.0%)	98 (98.0%)
4-10 <sup>++</sup>	83 (18.4%)	5 (5.0%)	32 (25.5%)	7 (7.0%)	49 (36.4%)	9 (9.0%)	53 (48.2%)	12 (12%)	233 (51.7%)	88 (88.0%)
4-23	102 (22.6%)	3 (3.0%)	39 (31.3%)	5 (5.0%)	49 (42.2%)	8 (8.05)	49 (53.1%)	10 (10%)	211 (46.5%)	90 (90.0%)

\*About 500 workers and 100 soldiers per mound; \*\*Mean values from three replicates; <sup>+</sup>Data of August '99 experiment; <sup>++</sup>Data of September '99 experiment.

**Table 2.** LT 50 values of worker community of termites after treatment with *B. bassiana* isolates

Strain	LT 50 (in days)	Regression equation	Fiducial limits (95% confidence limit)
4-6	6.5590 ± 0.3788	y = 2.5339 + 3.0189x	5.8572 to 7.3450
4-15	5.7961 ± 0.2193	y = 2.0423 + 3.8756x	5.3820 to 6.2421
4-16	9.6493 ± 1.1429	y = 2.5036 + 2.5356x	7.6509 to 12.1697
4-17	7.4530 ± 0.5504	y = 2.7434 + 2.5868x	6.4490 to 8.6133
4-10	5.2755 ± 0.2946	y = 3.4791 + 2.1055x	4.7288 to 5.8854
4-23	3.8504 ± 0.1005	y = 3.3790 + 2.7684x	3.6583 to 4.0526
4-10	5.5871 ± 0.3269	y = 3.3600 + 2.1947x	4.9820 to 6.2657
4-23	4.8300 ± 0.2321	y = 3.5405 + 2.1338x	4.3959 to 5.3069

and 4–10 of *B. bassiana* showed 20–25% mortality of workers on the second day and LT 50 (time taken for killing 50% of the pest) was recorded on the third and fifth days after application. The mounds were cleared and scrutinized for the number of live and dead termites, for the purpose of arriving at LT 50 values on the 5th day. The data were subjected to probit analysis<sup>10</sup> and the LT 50 values showed good fit, well within the fiducial limits, at 95% confidence limit (Table 2). The LT 50 values were calculated from the regression

equation  $y = a + bx$  by using the log of per cent values of mortality recorded. 4-15, 4-16, 4-6 and 4-17 strains showed mortality rates of 5–40% from the second to the fifth day and a range of 5–9 days of LT 50 values. The experiment was repeated with 4-10 and 4-23 strains in order to ascertain their virulence based on LT 50 values. Nearly 500 workers and 100 soldiers were present in each mound before treatment, excluding the nymphal stages. Mortality of the soldiers on the other hand, was only 10–15% even on fifth day (Table 2).

Delate *et al.*<sup>9</sup> studied the effect of fungal pathogens against termites in the form of fungal baits using *B. bassiana*. Insecticidal baits<sup>11</sup> and insect pathogens such as *B. bassiana* and *M. anisopliae*<sup>5,12</sup>, were studied as alternatives to conventional soil insecticides for remedial termite control. Since termites prefer to stay in the mounds, the method of treatment by dusting may not prove good enough, as the inoculum may not reach the target to cause infection. Some diseases may spread through oral infection based on the nature of groom-

ing that is seen in these insects<sup>7</sup>. As the insects were fed with sucrose mixed with mass-multiplied fungus on the natural medium, there is every chance for the spore to be carried inside the insect body by ingestion. Spread of infection might be via proctodeal trophallaxis and faeces to other members of the population<sup>13</sup>. Twenty-four hours after treatment, the spores were found to invade the haemocoel and the fungus was re-isolated from the hindgut<sup>6</sup>. The mechanism for killing the termites in the present study, appears to be initiated by cuticular infection and further spread of inoculum by ingestion. The isolates used in the present study were collected from the agricultural fields of different districts in Andhra Pradesh during the  $35 \pm 2^\circ\text{C}$  temperature periods. Mass production on cheap agricultural wastes can easily be undertaken by the enthusiastic farmers themselves, if they are provided with inoculum. Fungal pathogens offer great promise for biological control of soil-inhabiting insects<sup>14</sup>, because desiccation of fungal spore and their destruction by UV irradiation and temperature extremes are mitigated in the soil matrix. Mortality rate of 65% and 52% recorded in 4-23 and 4-10 isolates of *B. bassiana* respectively, is

an emphatic indication for their effective use as bioinsecticide in a termite control programme. The warm, humid and densely populated termite nests are ideal for growth and persistence of the biocontrol agent for a longer time after application.

1. Khan, H. K., Jayaraj, S. and Gopalan, M., *Insect-Science and its Application*, 1993, vol. 14, pp. 529-535.
2. Jones, W. E., Grace, J. K. and Tamashiro, M., *Environ. Entomol.*, 1996, **25**, 481-487.
3. Almeida, J. E. M., Alves, S. B., Moino, A. Jr. and Lopes, R. B., *An. Soc. Entomol. Bras.*, 1998, **27**, 639-644.
4. Rath, A., *Pest Control*, February 1995, 42-43.
5. Zoberi, M. H. and Grace, J. K., *Sociobiology*, 1990, **16**, 289-296.
6. Kramm, K. R. and West, D. F., 1982, **40**, 7-11.
7. Milner Richard, J. and Staples Judith, A., *Biocontrol Sci. Technol.*, 1996, **6**, 3-9.
8. Fernandes, P. M. and Alves, S. B., *An. Soc. Entomol. Bras.*, 1992, **21**, 319-328.
9. Delate, K. M., Grace, J. K. and Tome, C. H. M., *J. Appl. Entomol.*, 1995, **119**, 429-433.
10. Finney, D. J., *Probit Analysis: A Statistical Treatment of the Sigmoid Response Curve*, University Press, Cambridge, 1964.

11. Grace, J. K. and Zoberi, M. H., *Sociobiology*, 1992, **20**, 23-28.
12. Grace, J. K. and Wildey, K. B. and Robinson, W. H. (eds), *Proceedings of the 1st International Conference on Insect Pests in the Urban Environment*, 1993, p. 474.
13. Keast, D. and Walsh, L. W., *Appl. Environ. Microbiol.*, 1979, **37**, 661-664.
14. Storey, G. K. and McCoy, C. W., *Fla. Entomol.*, 1992, **75**, 533-539.

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## Monsoon onset-2000 monitored using multi-frequency microwave radiometer on-board Oceansat-1

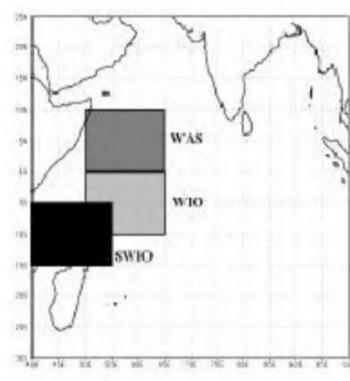
The south-west monsoon is an important atmospheric circulation which affects the Indian subcontinent. The ocean interacts with the atmosphere through exchange of moisture, momentum and heat, which in turn drives the ocean current and modifies the atmospheric circulation. These exchanges play an important role in the organization of various tropical systems like depressions, cyclones, etc. and their precise knowledge in tropical areas is an extremely important input to ocean and atmospheric models. The atmospheric water vapour profile is the most significant manifestation of these exchanges.

In the past, several studies have been made to explain different aspects of

monsoon circulation. The observational<sup>1</sup> and theoretical attempts<sup>2,3</sup> to understand the advancement of monsoon from the equatorial Indian Ocean to the main continent, deserve special mention.

The onset of monsoon in meteorological parlance has been associated with the heralding of monsoonal rains over the Kerala coast of the Indian mainland<sup>4</sup>. The onset dates varied from 11 May in 1918 to 18 June in 1972. The average onset date is 1 June, with a standard deviation of eight days. Monsoon affects not only rainfall but also tropospheric wind, humidity and temperature fields. Satellite images also show signatures of monsoon onset. There have been earlier attempts to correlate the onset date with antecedent

upper air circulation<sup>5</sup> and thermal features<sup>6</sup>.



**Figure 1.** Various segments over the Indian Ocean – Monsoon onset.