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Bio-fertilizers for sustaining potato productivity in rainred hills

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ABSTRACT

Studies conducted on role of *Azotobacter* and phosphorus solubilizing bacteria (PSB) on N and P economy under rainfed conditions in mid hills of Shimla and its regional stations revealed significant response to nitrogen application as well as *Azotobacter* applied through seed tuber inoculation. However, combined application of N along with *Azotobacter* was found to be best as indicated by increase in number of medium and large sized tubers, total tuber yield and also the nutrients uptake by potato. Role of phosphorus (P) and phosphorus solubilizing bacteria (PSB) on P use efficiency by the potato crop revealed significant response to P application as well as PSB applied through seed tuber inoculation. Their combined application gave higher yields of medium sized tubers, total tuber yield and also nutrients uptake. Phosphorus recovery was also higher in combined application of PSB and P than that of application of P alone. Thus, seed inoculation with *Azotobacter and* phosphate solubilizing bacteria (PSB) reduced N and P requirement by 25%. The beneficial effect of PSB in soils in native P is attributed to the release of native P present in the soil by these P solubilizing bacteria which in turn make sufficient P in soil solution around root zone as indicated by the higher P recoveries in presence of lower P doses.

Keywords: Potato Productivity, *Azotobacter,* Phosphorus solubilizing bacteria, Rainfed conditions Recoveries

The use of chemical fertilizers have played a vital role in bringing green revolution in the country in late sixties. However, in the recent years their indiscriminate use has adversely affected soil productivity and its fertility resulting in decline in crop productivity. Moreover, the continuous mining of nutrients from soil reserves has led to depletion of essential nutrients. The increased dependence on fertilizer imports at a high international price necessitates the need to explore and exploit the potential alternative sources of plant nutrients. Of late, bio-fertilizers, which are cheaper, pollution free and based on renewable energy source and improve soil physical properties, tilth and soil health in the long run have shown a good promise and have emerged as an important component of integrated plant nutrients supply (IPNS).

The concept "symbiotic N fixation" was given by JB Boussingault in 1834. The bacteria responsible for N fixation were later identified and isolated from root nodule as *Rhizobium* in 1888 by Beijerinek. Later on, he discovered two other bacteria viz. *Azotobacter* and *Azospirillum*, in 1905 and 1925, respectively which were able to improve the N availability in the soil by non-symbiotic fixation. *Bacillus meqaterium, Pseudomonas striata*, *Aspergillus niger* and *Mycorrhizae* (VAM) are other examples of PSB and fungi, respectively. Their commercial use in India started with its commercial production in 1956 at New Delhi.

In potato, mainly non symbiotic N fixer, PSB and plant growth promoting bacteria have been found beneficial in the rainfed area, particularly in the hills where potato is cultivated during summer season and soils contain high organic matter. The acidic hill soils of north western and north eastern hills have P fixing problem due to insoluble compound of Al and Fe ions. Thus, it becomes imperative to adopt environment friendly approaches through integrated use of bio-fertilizers, chemical fertilizers and organic manures in right proportion for ensuring optimum potato yield. The present paper reviews the results of field experiments conducted at CPRI, Shimla in north western hills and at CPRS, Shillong in the north eastern hills.

MATERIALS AND METHODS

Field experiments were conducted at Central Potato Research Institute, Shimla and Central Potato Research Station, Shillong where soils are acidic in nature and have high organic carbon. Different manurial treatments combinations of NPK through inorganic fertilizer and bio-fertilizer (Azotobacter+PSB) have been tried at different locations at research farm and at farmer's field. Seed tubers were inoculated with bio-fertilizers culture mixed in sucrose solution for 10 minutes and dried under shade before planting. Likewise, the rest of seed tubers were treated in similar way but without bio-fertilizers. Nitrogen was applied in splits *i.e.* half at planting and rest at earthing up at 50 days after planting in the form of calcium ammonium nitrate. Basal application of P_2O_5 and K_2O through single super phosphate and muriate of potash respectively at the time of planting was done at all the locations.

RESULTS AND DISCUSSION

Effect of biofertilizers on potato in north western hills

Beneficial effects of non-symbiotic nitrogen fixers have been reported from north western hills. At Shimla, *Azotobacter* inoculation was found beneficial in increasing the potato yield under rainfed condition in absence of N. However, the effect of non symbiotic N fixer decreased with the increase in N doses and it became non significant at 180 kg N ha^{-1} (Anonymous. 2007 and 2008).

Azotobacter inoculation improved leaf N content, N use efficiency as well tuber yield, particularly at lower doses of N. Tuber inoculation with *Azotobacter* alone increased the leaf N probably due to increased N availability from soil to the plant at early stage of crop growth when plant needs are high. At harvest, it was found that the inoculation with *Azotobacter* alone or with N significantly increased number of medium and large sized tubers. Likewise, *Azotobacter* alone increased the tuber yields by 22 q ha^{-1} over control and enhanced N use efficiency significantly in presence of lower doses of N *i.e.* at 25% and 50% of recommended N dose. Thus, combined application of N along with tuber inoculation with *Azotobacter* proved more productive in terms of total tuber numbers, yield and recovery (Fig.1).

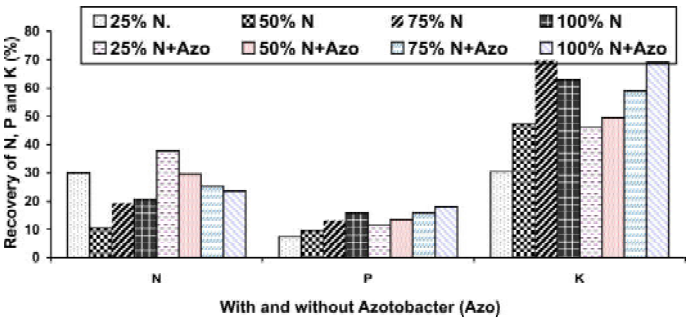

Fig. 1. Effect of N and *Azotobacter* on recovery of NPK

In another study at Shimla, application of P and phosphorus solubilizing bacteria (PSB) alone or in combination significantly increased tuber dry matter content with the highest increase obtained with PSB (Table 1). Maximum number of tubers were obtained with 100 kg P_2O_5 ha^{-1}, (the recommended dose of P for the region) and was statistically at par with PSB+25 or 50 kg P_2O_5 ha^{-1} (Sud and Jatav, 2007). Grade wise tuber yield showed that P application along with seed inoculation with PSB significantly increased the yield of medium sized tubers, whereas, it had no effect on yield of large sized tubers. Seed inoculation with PSB in conjunction with lower doses of P *i.e.* 50 kg P_2O_5 ha^{-1} not only gave higher yields but also led to better nutrient utilization of P from fertilizers and soils which was further reflected in higher nutrient recovery of P by potatoes with highest P recovery obtained with application of 25% recommended P dose along with seed inoculation with PSB (Fig. 2).

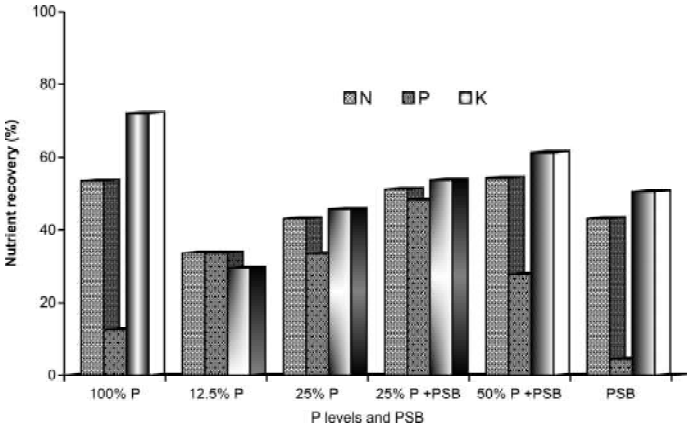

Fig. 2. Effect of P levels and PSB on nutrients recoveries by potato

Source: Sud and Jatav (2007)

Table 1. Effect of phosphorus and PSB on potato nutrition

P (% RDP*)	Dry matter (%)	Tuber No (000 ha^{-1})	Tuber yield (q ha^{-1})				Nutrient uptake (kg ha^{-1})		
			Small (<25 g)	Medium (25-75 g)	Large (>75 g)	Total	N	P	K
Control	15.46	445	42	100	140	282	43.24	4.39	56.31
12.5% P	16.80	407	32	110	168	300	83.62	6.23	79.89
25.0% P	16.11	467	25	104	191	320	95.01	8.07	92.91
100% P	16.02	548	35	124	185	344	107.40	9.91	113.97
25% P +PSB**	16.18	522	38	114	165	317	104.60	9.70	99.28
50% P +PSB**	16.20	523	36	144	159	339	108.29	10.50	105.33
PSB**	17.04	450	33	115	145	293	95.00	7.95	96.65
CD (P ?0.05)	0.33	32	NS	11	25	23	14.76	2.29	15.73

* RDP = recommended dose of P (100 kg P_2O_5)
**PSB applied through seed inoculation
Source: Sud and Jatav (2007)

In another field study at Shimla, the seed inoculation with PSB in conjunction with 50, 75 and 100% recommended dose of P application resulted not only in higher yields but also better nutrient utilization as was evident by its positive effect on nutrients uptake and reflected in higher nutrient recovery of NPK by potatoes. This might be due to beneficial effect of PSB in the acidic soils by the release of native P present in the soil which in turn makes sufficient P in soil solution around root zone as indicated by the higher NPK recoveries (Annonymous, 2008). The beneficial effect of phosphate solubilizing microorganisms attributes *to* the release of P from inorganic fractions of Al-P, Fe-P and Ca-P and reducing P fixing capacity of the acidic soil.

The plant growth promoting bacteria had great promise by better growth of crop, yield and showed nutrient economy (Sood and Sharma, 2001). Two cultures of plant growth promoting bacteria *viz*. *B. subtilus* and *B. cerus* were evaluated in potato crop. *B. cerus* was superior to *B. subtilus* at all levels of fertilizers. On yield basis, use of plant growth promoting bacteria *B. cerus* economized on NPK fertilizer dose by 25%. *Bacillus subtilis* and *Bacillus cereus* separately increased the tuber yield of potato. In acidic soils of Kufri in high hills of Shimla in north western Himalayas, a positive response to bio-fertilizers on potato growth parameters was observed by significant increase in plant height, number of leaves and stems plant^{-1} (Sood and Sharma, 2001). Application of 50% NPK along with tuber inoculation with bio-fertilizers produced 222 q ha^{-1} of tubers as compared to 101 q and 241 q ha^{-1}, under control and with 100% NPK dose, respectively. The nutrients uptake as well as fertilizer use efficiency was also higher in presence of bio-fertilizers.

Effect of biofertilizers on potato north eastern hills

Inoculation with phosphobacteria (*Pseudomonas striata*) significantly increased the tuber yield at Shillong (Meghalaya) during summer season of 1999 and 2000. However, its effect on plant stand was not significant compared with no inoculation (Singh, 2002a). Response to phosphorus increased when seed tubers were inoculated with *P. striata* (Fig. 3). The maximum net returns were obtained with the application of recommended dose of fertilizer with phosphobacteria.

At Shillong, application of phosphate solubilizing bacteria in combination with different phosphatic fertilizers at different levels, using potato cultivars, *Kufri Megha* and *Kufri Jyoti,* increased crop yield and tuber size. The net returns increased with increasing rates of P and were higher with the inoculation of phosphate solubilizing bacteria (Singh, 2002b). The interaction effects of P rate and phosphate solubilizing bacteria inoculation were significant (Table 2).

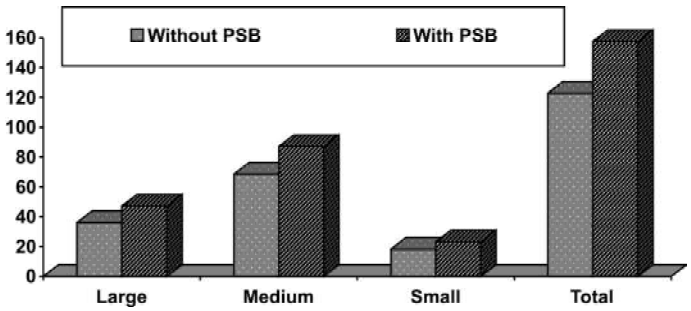

Fig. 3. Effect of phosphobacteria on potato tuber yield (q ha^{-1})

Source: Singh (2002a)

The PSB inoculant enhanced the tuber yield by 24.03% and net return by Rs 10325 ha^{-1}. The best combination was PSB +120 kg P_2O_5 ha^{-1} giving 18.81 t ha^{-1} tuber yield and Rs 34374 ha^{-1} net return.

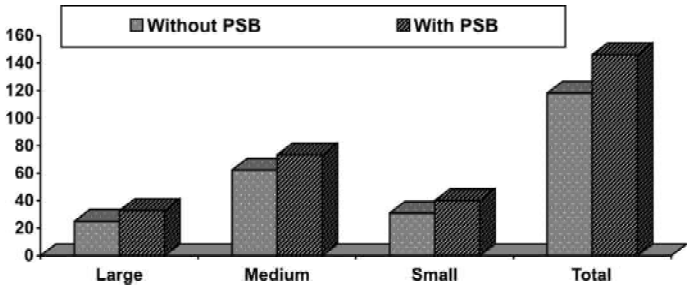

Fig. 4. Effect of different treatments on grade wise potato tuber yield

Source: Singh (2002b)

Table 2. Interaction effect of different treatments on tuber yield of potato

Levels of P_2O_5 (kg ha^{-1})	Without PSB			With PSB		
	Large size (>75 g)	Medium size (25-75 g)	Small size (<25 g)	Large size (>75 g)	Medium size (25-75 g)	Small size (<25 g)
0	13.8	44.7	25.4	18.5	51.8	32.5
60	22	58.5	29.2	23.8	63.7	37
120	29.2	68.5	32	49.8	93.3	45
180	35.1	77.6	36.9	39.3	84.5	45.7
CD (P=0.05)	4.6 for large, 8.0 for Medium and NS for small					

Source: Singh (2002b)

In field experiments at Shillong, during the summer season of 1996-98, the biofertilizers (*Azotobacter* and/or phospho-inoculant culture of *P. striata*) were evaluated in combination with N at 0, 50, 100 and 150 kg ha^{-1} on the yield of potato cv. *Kufri Jyoti*. The tuber yield, tuber number and tuber size increased with increasing rates of N. Inoculation with *Azotobacter* and *P. striata* resulted in the highest tuber production and tuber number regardless of N rates, although

differences in tuber production due to inoculation of different biofertilizers at 100 and 150 kg N ha^{-1} were not significant (Singh, 2002). Net returns increased with the increasing N rates and were highest with *Azotobacter* and *P. striata* inoculation (Table 3).

Table 3. Effect of biofertilizers at different levels of N on potato tuber yield (q ha^{-1})

Biofertilizers	N levels (kg ha^{-1})				Mean	Mean
	0	50	100	150		
Control	102	150	174	180	152	19948
Azotobacter	126	165	176	187	164	24548
P. striata	124	169	177	189	165	25048
Azotobacter + P. striata	138	179	191	199	177	29748
Mean	123	169	180	189		-
CD (P=0.05)	13	07	NS	NS		-

Source: Singh (2002)

Azotobacter and phosphobacteria inoculants applied separately increased the tuber yield (Singh, 2001). Combined inoculation of *Azotobacter* and phospho bacteria resulted in the highest growth attributes, yield of tubers, nutrient uptake and also the net return (Table 4 and fig. 5).

Table 4. Effect of biofertilizers on growth and potato tuber yield

Biofertilizers	Plant height (cm)	Stems/ sq. m	Compound leaves sq. m^{-1}	Tuber weight/ hill (g)	Tuber yield (q ha^{-1})	Net return (Rs ha^{-1})
Control	36.7	31.3	340.5	195.5	142	19948
Azotobacter	42.5	32.1	389.6	208.2	164	24548
Phosphobacteria	45.8	33.7	402.8	2.8.9	165	25048
Azotobacter+Phosphobacteria	47.3	34.2	429.3	225.3	177	29748
CD (P=0.05)	7.2	NS	31.2	21.6	13	

Source: Singh (2001)

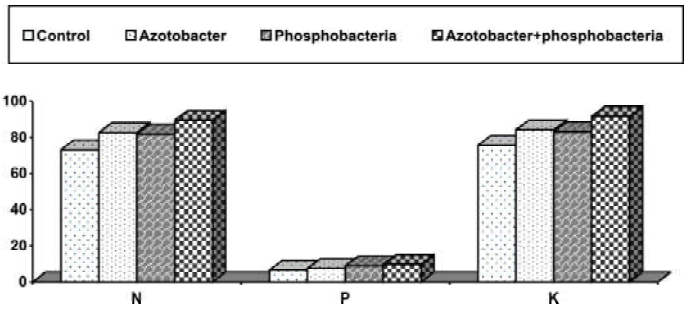

Fig. 5. Effect of biofertilizers on total nutrients uptake (kg ha^{-1})

Source: Singh (2001)

Results from Three years study in acidic soils of Shillong, showed that inoculation of seed tubers with biofertilizers *(Azotobacter*+phosphobacteria*)* was superior to application of *Azotobacter* or phosphobacteria alone through soil application as compared to control. Potato yield significantly increased with the application of *Azotobacter* (soil application), phosphobacteria (soil application), *Azotobacter* (tuber inoculation), phosphobacteria (tuber inoculation), *Azotobacter*+phosphobacteria (soil application) and *Azotobacter* + phosphobacteria (tuber inoculation) as compared to no bio-fertilizer application (Singh, 2000). Combined use of *Azotobacter*+ phosphobacteria gave higher tuber yield and net return compared to separate use of biofertilizer and control (Fig. 6 and Table 5).

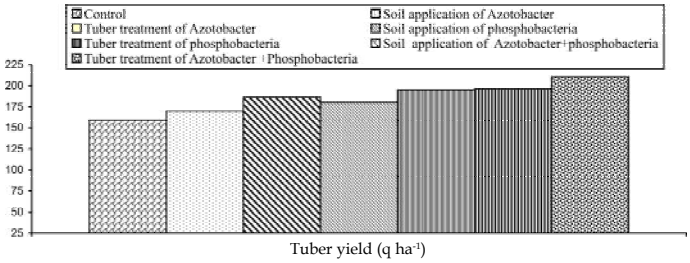

Fig.6. Effect of biofertilizers on emergence, tuber number and potato yield

Source: Singh (2000)

Table 5. Effect of biofertilizers on graded potato tuber yield and net return

Biofertilizers	Graded tuber yield (q ha^{-1})			Net return over control (Rs ha^{-1})
	Large	Medium	Small	
Control	22	99	38	
Soil application of *Azotobacter*	28	107	35	3900
Tuber treatment of *Azotobacter*	30	118	38	10200
Soil application of Phosphobacteria	32	114	34	7900
Tuber treatment of phosphobacteria	44	119	32	13800
Soil pplication of *Azotobacter* + phosphobacteria	35	130	34	14200
Tuber treatment of *Azotobacter* phosphobacteria	50	128	33	20000
CD (P=0.05)	13	15	NS	

Source: Singh (2000)

PSB play important role in solubilizing fixed P in soil particularly in acid soils and at Shilong in north eastern hill region, application of PSB inoculants culture had significant effect on potato yields. The increase due to PSB indicated that in soils with sufficient organic matter, the PSB inoculation are able to reduce the P fixation thus releasing P from the native soil P.

The application *Azotobacter* under rainfed conditions in north western and north eastern hills of Shimla and shillong improved number of medium and large sized tubers, total tuber yield and the nutrients uptake by potato. The combined application of phosphorus and phosphorus solubilizing bacteria improved P use efficiency. The seed inoculation with combined application of *Azotobacter and* phosphate solubilizing bacteria reduced N and P requirement and improved the yield of tubers and net return in north western and north eastern hills of India. It is thus concluded that the biofertilizers as cheaper source may be used in acid soils for sustainable agricultural specially in heavy feeder crops like potato.

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Effect of organic manures and biofertilizers on yield and economics of cabbage, *Brassica oleracea* var. *capitata*

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ABSTRACT

The field experiment laid out in randomized block design with six treatments and four replications during 2008-09 at experimental farm, Department of Horticulture, Assam Agricultural University, Jorhat revealed that the treatment comprising of combined application of azotobacter + cowdung + rock phosphate (RP) + phosphate solubilizing bacteria (PSB) yielded the maximum cabbage head 29.39 t ha^{-1} with maximum benefit-cost ratio (3.04) for the trait. The treatment also improved other growth traits viz., number of wrapper leaves, root length and the root spread.

Key words: Organic, cabbage, growth, yield, cowdung, profitability.

Cabbage (*Brassica oleracea* var. *capitata*) is an important winter vegetable crop which provides more vitamins, minerals and fibres to our diet. In modern agriculture, continuous and indiscriminate use of inorganic fertilizers in an order to achieve high productivity has caused serious damage to the soil and ecology. Thus, recent years, have forced many farmers to gradually switch over to the organic means of cultivation to produce safe, tasty and nutritious foodstuff as well as to get higher premium price from the market. The cultivation of crops in most parts of the North-East India is organic by default. Organic manures improve the soil health and render sustainability to agricultural development. Combined application of different organic sources such as cowdung, rock phosphate, vermicompost and bacterial fertilizers results in to high yield and improvement of the quality in vegetables. It is not only helpful for sustainable agricultural development but also avoid chemical-based farming (Sarkar, 2001). Cowdung supplies organic matter to soil and improves physical and biological environments (Kumar and Sharma, 2004). Biofertilizers are agriculturally important beneficial microorganisms, which have ability to mobilize the nutritionally important elements from non-usable to usable form through biological processes (Bahadur *et al*., 2004). It helps in improving the number of biological activities of desired microorganisms and improves plant growth and the yield. Choice of a combination of organic nutrients for enhancement of yield in cabbage has been a matter of interest for rendering sustainability to the agricultural productivity in the crop. Keeping this in view, the present investigation on effect of different combinations of organic inputs for growth, yield and economic feasibility in cabbage was carried out.

MATERIALS AND METHODS

The experiment was conducted at experimental farm, Department of Horticulture, Assam Agricultural University, Jorhat during November 2008 to February 2009 in randomized block design with six treatments, namely T_1, absolute control; T_2, azotobacter + rock phosphate (RP) + phosphate solubilizing bacteria (PSB); T_3, azotobacter + vermicompost + RP+ PSB; T_4 , azotobacter + cowdung + RP+PSB; T_5, azotobacter + optimal compost + RP+PSB and T_6, azotobacter + azolla compost + RP+PSB. The amount of organic nutrients applied were azolla compost @1 t ha^{-1}, optimal compost @ 2 t ha^{-1}, vermicompost @ 3 t ha^{-1}, cowdung @ 3 t ha^{-1} and RP@0.375 t ha^{-1}.

The variety BC-78 was used in the study. The individual plot size was 7.5 m^2. In the treatments except the control, the roots of seedlings were dipped in slurry of Azotobacter and

PSB for 10 minutes before transplanting. Uniform sized, healthy one-month old seedlings were transplanted at a spacing of 60 cm x 60 cm in a raised bed in the month of November 2008. All the cultural operations were done as per normal package of practices. Observation on growth parameters were recorded at harvest. Among the quality characters, the ascorbic acid content of cabbage head was estimated by using 2,6- dichlorophenol indophenol visual titration method (A.O.A.C., 1990). All the plant samples were analyzed for total nitrogen content by Micro Kjeldahl's method (A.O.A.C., 1975). Phosphorus and potassium content were estimated by using tri-acid extract (Jackson, 1958). Head compactness was calculated by using the formula i.e. $Z=c/w^3x100$, where, Z is the index of compactness, c is the net weight of head and w is the average of lateral and polar diameters of head.

RESULTS AND DISCUSSION

Results revealed that different combinations of organic treatments showed variation in respect of head yield and the growth characters viz., number of wrapper leaves, root length and head compactness. The highest mean values were obtained under the treatment T_4 for all the growth characters except head compactness while the lowest were recorded at T_1 for all the growth characters (Figure 1 & Table 1). The improvement in plant growth parameters under the treatment T_4 might be ascribed to cowdung that influenced the physical, chemical and biological properties of soil through supplying macro- and micronutrients leading to better plant growth and development. Earlier studies by Meelu (1996), Patidar and Mali (2004) and Singh *et. al* (2009) had also reported that organic manures increased the growth attributes of rice, sorghum, ginger and other crops.

The highest head yield (29.39 t ha^{-1}) was recorded under T_4 which was at par with T_3. The lowest yield (13.60 t ha^{-1}) was observed under T_1. The application of cowdung in combination with RP and biofertilizers increased the soil organic matter and improved the soil structure as well as biological activity of soil. This would have reduced the loss of nitrogen by increasing cation and anion exchange capacities in the soil, thereby, enhancing the head development of cabbage. Further, by improving the structure of the soil by more aggregation, the water holding capacity and air permeability was increased. These comprehensive changes in soil might have improved the head development. This was in line with the findings of Mizuno (1996) and Sankar *et al* (2009). Further, reduced loss of nitrogen through ammonia volatilization and narrower C: N ratio might have also contributed to the better performance of crop supplied with farmyard manure (Kirchmann and Witter, 1992). In T_3, vermicompost along with RP and biofertilizers also contributed to the similar extent as in T_4 for the traits head yield and number of wrapper leaves. There was improvement in mean values for all the traits under the treatment T_3 and these were all at par with T_4. Except for the specific gravity, both T_4 and T_3 differed significantly over the T_1 (absolute control). In case of quality parameters viz., moisture, nitrogen, phosphorus and potassium content of the leaves, significant variations were observed among the treatments.

So far as the benefit-cost ratio is concerned (Table 2), the maximum profit of Rs. 3.04 per unit cost was recorded in T_4 in comparison to other treatments and it was at par with the profit gained under T_2. The treatment combination T_3 was found a costly organic treatment and the benefit-cost ratio was found low (1.19) despite its contribution to high head yield.

Table 1. Effect of organic manures, rock phosphate and biofertilizers on some growth characters and quality traits of cabbage at harvest

Treatment	Root length (cm)	Root spread (cm)	Specific gravity (g/cc)	Moisture content (%)	Ascorbic acid content (mg $100g^{-1}$)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1	9.43	15.75	0.55	92.00	42.75	2.32	0.51	3.55
T_2	9.62	16.50	0.61	92.09	46.22	2.76	0.62	3.12
T_3	12.35	18.12	0.59	92.45	46.06	3.22	0.52	3.55
T_4	13.55	18.37	0.62	91.83	45.18	3.32	0.57	3.85
T_5	9.50	16.31	0.59	91.74	45.28	4.33	0.61	3.60
T_6	12.36	18.36	0.61	92.27	46.46	4.03	0.52	3.67
C.D. (P=0.05)	1.64	2.26	0.36	0.85	3.87	0.06	0.02	0.13

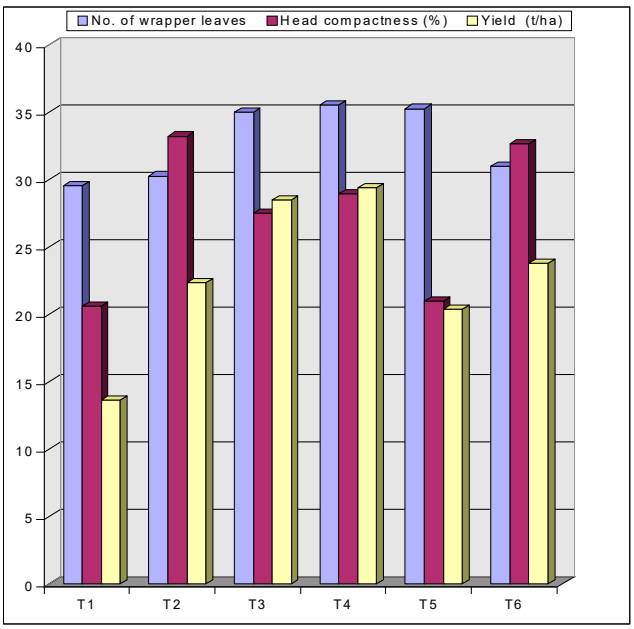

Fig 1: Relative performance of different combinations of organic manures, RP and biofertilizers for head yield, head compactness and number of wrapper/leaves.

Table 2. Economics of production of cabbage under different treatments

Treatment	Gross return (Rs. Ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit-cost ratio
T_1	68013.00	26590.00	41423.00	1.56
T_2	111613.00	31165.00	80448.00	2.58
T_3	142388.00	65040.00	77348.00	1.19
T_4	146963.00	36390.00	110573.00	3.04
T_5	101863.00	41165.00	60698.00	1.47
T_6	118975.00	41165.00	77810.00	1.89
CD (P=0.05)	22830.00	0.00	22830.00	0.57

Selling rate of cabbage: Rs.5/kg; Buying rate of cowdung: Rs. 450/t; vermicompost :Rs. 10/kg.; Azolla compost :Rs. 10/kg; optimal compost: Rs. 5/kg; RP: Rs. 10/kg; Azotobacter : Rs. 25/100g; PSB : Rs. 25/100 g; Seed : Rs.100/10 g.

It was thus concluded that the treatment T_4 that comprised of azotobacor @ t ha^{-1} + cowdung @ 3t ha^{-1} + rock phosphate @ 375 t ha^{-1} and phosphate soluble bacteria gave the highest mean values for all the growth characters except head compactness. The benefit-cost ratio was also the maximum (Rs. 3.04 per unit cost) against all other treatments proving its credential over other treatments in terms of growth, yield and profitability. This may open up vistas to farmers resorting to organic cultivation of cabbage for enhanced yield and profitability.

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Impact of organic manure and organic spray on soil microbial population and enzyme activity in green chillies

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ABSTRACT

The pot culture experiment conducted at the Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore, to evaluate the effects of concentrated organic manure (jatropha oilcake) and panchagavya (organic foliar spray) on soil microbial population and enzymes activity revealed higher soil microbial population viz., bacteria, fungi and actinomycetes under the application of 100% jatropha oil cake with 3% foliar spray of panchagavya. Soil enzymes activity *viz.,* dehydrogenase, urease and catalase were maximum in treatment receiving 100% jatropha oil cake with 3% foliar spray of panchagavya.

Key words: Jatropha oil cake, Panchagavya, Green chillies, Soil microbial population and Enzyme activity.

Addition of organic manures such as farm yard manure (FYM), poultry manure, oil cakes, biofertilizers and bio-waste are the important sources to increase the organic matter content, soil microbial population and to sustain agricultural production. The oil cakes obtained after the oil is extracted from oil seeds and dried as cake are used as concentrated organic manure. These are of two different types *viz*., edible and non edible oil cakes. Edible oil cakes of coconut and ground nut are safely fed to livestock, whereas the non-edible ones of jatropha, castor, neem and mahua, which are not fit for livestock consumption because of its toxic principles or antifactors (Makkar and Becker, 1997), serve as a good source of organic manure especially for horticultural crops. Nutrients present in oil cakes, after mineralization, are made available to crops within 7-10 days after application. Most of these are valued much for their alkaloid content, which inhibits the nitrification process in soil (Sahrawat and Parmar, 1975). Among the non-edible oil cakes, jatropha oil cake, approximately one ton of which is equivalent to 200 kg of mineral fertilizer, is a good source of organic plant nutrients, similar to that of chicken manure.

The biochemical processes associated with nutrient recycling are mediated by soil enzymes which are derived from soil microbes and plant roots (Tabatabai, 1982). Hence, the impact of jatropha oilcake and panchagavya spray on the soil microbial population and the enzymes activity was studied.

MATERIALS AND METHODS

The pot culture experiment was carried out in moderately deep, well grained sandy clay loam with a pH of 8.39 on green chilli variety K_2 at the Department of Environmental Science, Tamil Nadu Agricultural University, Coimbatore. The soil was low (205.62 kg ha^{-1}), medium (16.51 kg ha^{-1}) and high (620.25 kg ha^{-1}) in available N, P and K, respectively. The experiment was laid out in completely randomized design with three replications. There were seven treatments *viz*., T_1 -100% recommended dose of fertilizer (120:60:30 kg NPK ha^{-1}) + chlorpyriphos (3 ml l^{-1}), T_2-100% jatropha oil cake + 3% foliar spray of panchagavya, T_3- 75% jatropha oil cake + 25% RDF* + 3% foliar spray of panchagavya , T_4-50% jatropha oil cake + 50% RDF* + 3% foliar spray of panchagavya, T_5-100% neem oil cake + 3% foliar spray of panchagavya, T_6-100% castor oil cake + 3% foliar spray of panchagavya and T_7- absolute control in three replications. Organic manures were analyzed for their nutrient content and the quantity of organic manures were decided based on N equivalent ratio.

Chilli seeds were treated with *Pseudomonas fluorescens* powder (10 g kg^{-1} of seeds) before sowing. Nursery beds were watered with rose cane to facilitate quick germination and good growth of seedlings. Seedlings 35-40 days old were transplanted into pots filled with 7 kg of processed soil and recommended doses of fertilizers and manures. The oil cakes were applied in powder form.

The ingredients used to prepare approximately 20 litres of panchagavya stock solution were the cow dung (5 kg), cow's urine (3 litres), cow's milk (2 litres), cow's curd (2 litres) and cow's clarified butter / ghee (1 litre). In addition, sugarcane juice (3 litres), tender coconut water (3 litres) and ripe banana (1 kg) were also added to accelerate the fermentation process. All the ingradients were added to a wide mouth mud pot and kept open under shade. The contents were stirred twice a day for about 20 minutes, in the morning and evening to facilitate aerobic microbial activity. The Panchagavya stock solution was ready after 10 days. From the stock solution 3% concentration was prepared for spraying.

RESULT AND DISCUSSION

Assessment of soil microbial population

Higher microbial population viz., bacteria, fungi and actinomycetes were recorded under 100% jatropha oil cake with 3% foliar spray of panchagavya treatment. Population of microbes under organic treatments acted as an index of soil fertility because it serves as a temporary sink of nutrient flux as reported by Hassink *et al.* (1991). Somasundaram and Sankaran (2004) also reported that the soil applied with organic manures recorded the maximum microbial population as compared to recommended dose of inorganic fertilizers. Khan *et al.* (1996) revealed that the application of oil cakes of neem, groundnut and castor increased the fungi population in rhizosphere, suppressed the number of parasitic fungi and phytophagus nematodes. Naidu *et al.* (1999) also reported that bacterial, fungal and actinomycetes count were maximum under organic manures treatments. The lowest population of microbial population (Table 1) was recorded under control (T7) which might be due to low availability of nutrients and organic carbon content of the soil.

Table 1: Effect of concentrated organic manure (jatropha oilcake) and panchagavya (organic foliar spray) on soil microbial population

Treatment	Microbial population		
	Bacteria x 10^{-6} cfu g^{-1} of soil	Fungi x 10^{-4} cfu g^{-1} of soil	Actinomycetes x 10^{-3} cfu g^{-1} of soil
T1	32.67	17.00	20.00
T2	39.67	21.00	30.67
T3	38.33	20.00	28.33
T4	35.67	15.33	17.33
T5	37.67	21.00	25.67
T6	36.00	20.00	25.33
T7	27.67	13.67	15.67
SEd	1.927	1.564	1.345
CD (0.05)	4.134	3.354	2.885

*cfu – colony forming unit

Assay of soil enzyme activity:

Addition of organic sources of nutrition increased the soil enzyme activity from initial level. The highest soil enzyme activities viz, dehydrogenase, urease and catalase were recorded in treatment (T_2) that received 100% jatropha oil cake with 3% foliar spray of panchagavya (Table 2). The high organic carbon content in the soil applied with jatropha oil cake with foliar spray of panchagavya might have stimulated the microorganism by serving as a source of carbon, energy and other nutrients, essential for the growth and multiplication of micro organisms and thus increased the soil enzyme activity. These results are in line with the finding of Suryanarayana Reddy (2002) and Boomiraj and Christopher Lourduraj (2004). Singaram and Kamalakumari (1995) also reported that application of organic manures increased the enzyme activity in the soil. The lowest activities of enzymes were observed in control (T_7) because of reduced microbial population due to lower organic carbon content.

Table 2: Effect of concentrated organic manure (jatropha oilcake) and panchagavya (organic foliar spray) on enzyme activity of post harvested soil

Treatment	Enzyme activity		
	Dehyrogenase (µg TPF g^{-1} soil hr^{-1})	Urease (µg of NH3 g^{-1} soil 24 hr^{-1})	Catalase (mg O2 consumed g^{-1} soil hr^{-1})
Initial	8.07	27.2	8.12
T1	17.67	39.13	10.37
T2	21.07	41.10	11.73
T3	20.83	40.37	11.10
T4	19.23	38.57	10.30
T5	20.73	40.97	10.83
T6	20.47	40.37	10.53
T7	16.40	36.30	9.00
SEd	0.722	0.632	0.508
CD (0.05)	1.549	1.356	1.090

It is thus concluded that application of 100% jatropha oil cake (organic manure) with 3% spray of panchagavya (organic foliar pray) improves the soil microbial population and also increase enzyme activities in the soil.

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Effect of organic manures and biofertilizers on production of organic litchi

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ABSTRACT

The investigation carried out during 2006-2008 at the farmer's field of Murshidabad district, West Bengal, revealed that different treatments of organic manures and biofertilizers significantly improved the soil health, fruit quality, yield, leaf mineral content and microbial population of rhizosphere soil of litchi. Among different treatments, T_5 consisting of *Azotobacter* + *Azospirillum* + VAM + vermicompost showed maximum soil organic carbon, available nitrogen, phosphorus and potasium with higher (6.92) soil pH. This treatment also exhibited highest (99.72 kg/plant) yield with maximum (21.20^0 brix) TSS, total sugar (14.87%) and TSS : acid ratio (37.1 : 1) while control recorded minimum of these qualities. Leaf mineral content and soil microbial population were also influenced by the application of organic manures and bio-fertilizers. Maximum (1.89%) N content of leaf and microbial population were measured from T_5 while maximum P and K content were measured from T_6 (*Azospirillum* + VAM + Vermicompost) and T_8 (*Azospirillum* + Vermicompost) respectively. It is concluded that T_5 (*Azotobacter* + *Azospirillum* + VAM+Vermicompost) can be applied for production of organic litchi which are considered safe and residue free.

Key words : Soil health, Organic manure, Bio-fertilizers, Fruit quality, Litchi.

Litchi is one of the excellent delicious fruit of sub-tropical region of the world with tremendous export potentiality. Abundant use of chemical fertilizers has resulted in increase of soil salinity and decrease in porosity. Since accumulation of nitrates have created water pollution leading to carcinogenic effect on human body and damage of important organs, it has become imperative to adapt eco-friendly methods for sustainable fruit production. Biofertilizer and bio pesticides which are microbial in origin, offer themselves as viable alternatives. Organic food products have a growing domestic as well as global market and fetch premium price over conventional products. Therefore, there is a great need to standardise the eco-friendly technologies for the production of safe and residue freeorganic litchi as per cordex standard for getting high economic return. Keeping this in view, the present investigation was carried out.

MATERIALS AND METHODS

The study was conducted during 2006-2008 at the farmer's litchi orchard in Murshidabad district on 30 year old tree of litchi cv. Bombai spaced at 10 m x 10 m. The plants were uniform in growth and vigour. The orchard soil was clayloam having pH 6.72, 0.52% organic carbon, available nitrogen 271.00 kg ha^{-1}, phosphorus 28.11 kg ha^{-1} and potassium 210.00 kg ha^{-1}. The combination of treatments were T_1 (*Azotobacter* + VAM), T_2 (*Azospirillum* + VAM), T_3 (*Azotobacter* + *Azospirillum* + *VAM*), T_4 (*Azotobacter* + VAM + vermicompost), T_5 (*Azotobacter* + *Azospirillum* + VAM + vermicompost), T_6 (*Azospirillum* + VAM + vermicompost), T_7 (*Azotobacter* + vermicompost), T_8 (*Azospirillum* + vermicompost), T_9 (vermicompost + VAM) and T_{10} (Control). The biofertilizers @ 150 g $plant^{-1}$ $year^{-1}$ and vermicompost @ 5 kg $plant^{-1}$ $year^{-1}$ alongwith fixed dose of 2 kg FYM were applied as per treatment combination around the trunk of the soil during July. The experiment was laid out in randomised block design with three replications. The mature ripe fruits were harvested and physico-chemical analysis were done following the standard methods as described by Ranganna (2000). The soil properties leaf mineral content (N, P and K) were measured following standard methods. Soil microbial population was counted using methods as described by Collin and Lyne (1985). The plant protection measures were taken through organic means.

RESULTS AND DISCUSSION

Soil properties

Different combination of nutrients significantly increased the soil pH, organic carbon and available nutrient

Table 1 : Soil pH, organic carbon, available N, P and K as influenced by different nutrient treatments

Treatments	pH	O.C. (%)	Available N (Kg ha^{-1})	Available P (Kg ha^{-1})	Available K (Kg ha^{-1})
T_1 – *Azotobacter* + VAM	6.77	0.70	279.17	29.12	211.62
T_2 – *Azospirillum* + VAM	6.74	0.79	280.10	29.44	211.72
T_3 – *Azotobacter* + *Azospirillum* + *VAM*	6.79	0.84	281.32	28.99	211.92
T_4 – *Azotobacter* + VAM + vermicompost	6.81	0.82	280.14	29.31	210.92
T_5 – *Azotobacter* + *Azospirillum* + VAM+Vermicompost	6.92	0.97	284.12	29.94	213.73
T_6 –*Azospirillum* + VAM + vermicompost	6.79	0.97	280.11	29.11	211.17
T_7 – *Azotobacter* + vermicompost	6.88	0.71	274.11	28.99	211.72
T_8 – *Azospirillum* + vermicompost	6.74	0.63	274.11	28.77	212.00
T_9 – Vermicompost + VAM	6.74	0.61	279.00	28.92	213.11
T_{10} - Control	6.72	0.52	271.00	28.11	210.00
CD 5%	0.01	0.11	0.36	0.24	0.73

Table 2 : Effect of organic manures and bio-fertilizers on physico-chemical qualities of litchi fruit cv, Bombai

Treatments	Fruit wt. (g)	Fruit length/ diameter (cm)	Yield (kg/plant)	TSS (^{0}Brix)	Total sugar (%)	Acidity (%)	Anothocyan in (mg/100 g)	TSS : acid ratio
T_1 – *Azotobacter* + VAM	21.10	3.3/3.0	97.72	19.80	13.02	0.62	19.74	31.9 : 1
T_2 – *Azospirillum* + VAM	20.99	3.2/3.0	96.92	19.80	13.11	0.61	20.00	32.4 : 1
T_3 – *Azotobacter* + *Azospirillum* + *VAM*	21.94	3.3/3.1	98.11	120.00	13.62	0.63	20.11	31.7 : 1
T_4 – *Azotobacter* + VAM + vermicompost	21.98	3.0/3.1	98.00	20.40	13.92	0.61	19.75	33.4 : 1
T_5 – *Azotobacter* + *Azospirillum* + VAM+vermicompost	22.11	3.7/3.2	99.72	21.20	14.87	0.57	21.41	37.1 : 1
T_6 –*Azospirillum* + VAM + vermicompost	21.77	3.1/3.0	97.44	20.00	13.80	0.54	21.72	37.0 : 1
T_7 – *Azotobacter* + vermicompost	21.91	2.9/2.8	96.12	20.40	13.42	0.62	21.93	32.9 : 1
T_8 – *Azospirillum* + vermicompost	20.94	3.0/2.9	94.17	20.00	13.72	0.55	20.11	36.3 : 1
T_9 – Vermicompost + VAM	21.84	3.2/3.1	93.77	19.90	13.32	0.73	20.72	27.2 : 1
T_{10} - Control	20.82	3.0/2.8	90.12	19.20	13.11	0.74	19.72	25.3 : 1
CD at 5%	0.74	0.33/0.24	3.10	0.77	291	N.S.	0.42	-

Table 3 : Effect of organic manure and bio fertilizers on leaf nutrient content and microbial population in rhizosphere soil of litchi

Treatments	N (% dry wt.)	P (% dry wt.)	K (% dry wt.)	Microbial population (Bacteria) (cfug^{-1} soil)
T_1 – *Azotobacter* + VAM	1.81	0.32	0.82	6.9 x 10^6
T_2 – *Azospirillum* + VAM	1.80	0.33	0.81	7.1 x 10^6
T_3 – *Azotobacter* + *Azospirillum* + *VAM*	1.78	0.37	0.79	7.3 x 10^6
T_4 – *Azotobacter* + VAM + vermicompost	1.82	0.30	0.81	7.4 x 10^6
T_5 – *Azotobacter* + *Azospirillum* + VAM+ vermicompost	1.89	0.31	0.81	8.5 x 10^6
T_6 –*Azospirillum* + VAM + vermicompost	1.81	0.37	0.79	7.8 x 10^6
T_7 – *Azotobacter* + vermicompost	1.89	0.29	0.82	7.0 x 10^6
T_8 – *Azospirillum* + vermicompost	1.81	0.28	0.87	6.3 x 10^6
T_9 – Vermicompost + VAM	1.77	0.31	0.78	5.1 x 10^6
T_{10} - Control	1.74	0.28	0.78	2.7 x 10^5
CD 5%	0.06	0.09	2.11	-

(N, P and K) (Table 1). Higher soil pH i.e. near to neutral was recorded from T_5 (*Azotobacter* + *Azospirillum* + VAM + vermicompost) followed by T_7 (*Azotobacter* + vermicompost) while control recorded reduced soil pH which indicated the acidity of soil. Similar observations were also observed by Verma (2008) in apple. There was improvement in soil health due to application of organic manure and biofertilizer. T_5/ T_6 recorded maximum (0.97%) organic carbon of soil which might be due to the addition of organic matter through organic manure and recycling of organic materials in the form of crop residues like roots and leaf fall. These results are in close conformity with the earlier findings of Verma and Bhardwaj (2005). There was increase in the available N, P and K content of soil with the application of biofertilizers and organic manure. Similar results were also obtained by Verma (2008) in apple.

Fruits characters and yield

Different treatments of nutrients significantly increased the physico-chemicals characters of fruit (Table 2). T_5 (*Azotobacter* + *Azospirillum* + VAM + vermicompost) showed maximum fruit weight (22.11 g), fruit length / diameter (3.7/ 3.2 cm) and fruit yield (99.72 kg plant^{-1}) while T_{10} (control) recorded minimum of these qualities. Increase in physico-chemical parameters of fruits might be due to their role in nitrogen fixation, production of phytohormone like substances and increased uptake of nitrogen (Govindan and Purushothaman, 1984). Similar observations were also noted by Biswas (2008) in litchi. Biochemical constituents were also affected by the application of different nutrients. Data showed significant effect of treatments on fruit quality parameters also. The highest TSS (21.20^0 Brix), total sugar (14.87%), TSS : acid ratio (37.1 : 1) was recorded in T_5 (*Azotobacter* + *Azospirillum* + VAM+Vermicompos) which was followed by T_6 (*Azospirillum* + VAM + Vermicompost). The fruit acidity was maximum (0.74%) in control though treatments did not show any significant differnence in the acidity of fruits. The improvement in fruit quality may be attributed to the improvement in soil physical properties, water holding capacity, bulk density and chemical properties like nutrient status, soil pH and hormone (Chattopadhyay, 1994).

Leaf mineral content and soil microbial population

Perusal of data presented in Table 3 revealed that different treatment nutrients significantly influenced the leaf N, P and K. T_5 (*Azotobacter* + *Azospirillum* + VAM + Vermicompost) recorded maximum N and K content of leaf, while T_3/T_6 recorded maximum P against the least in control. The higher nutrient status of soil due to organic manure might be due to slow release of nutrients from organic manures and better uptake of nutrients by the plant which in turn increased the leaf mineral content of litchi. The present findings are in close conformity with the earlier findings of Naik and Haribabu (2007) in guava. Microbial population in rhizosphere soil of litchi tree improved after application of different treatments. Bacterial count was maximum in T_5 (*Azotobacter* + *Azospirillum* + VAM + vermicompost) followed by T_6 (*Azospirillum* + VAM + vermicompost) while control recorded the least. Micro organisms are important component of soil environment (Arshad and Frankenberger, 1992). Their large number is indicative of better soil health and improved nutrient availability to the plant and the fruits. Thus, utilization of organic fertilizer could be better preposotion for improving biological attributes of soil, which in turn may increase quality and productivity potential of various crops (Allen *et al.* 2002). Therefore, it can be concluded that the organic manure and biofertilizers can be applied for quality litchi fruit production which are safe and residue-free for human consumption.

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Effect of organic manure on yield and quality of litchi cv. Rose Scented

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ABSTRACT

The field experiment conducted at Horticulture Research Centre, Patharchatta with ten treatments including vermicompost, poultry manure and FYM at different rates revealed maximum fruiting, fruit set, fruit volume, edible portion and maximum yield with application of vermicompost at the rate of 75 kg tree^{-1}, while maximum TSS, ascorbic acidity and total sugar were recorded under the treatment of FYM @ 150 kg ha^{-1}. Titrable acidity was maximum under control. No significant result regarding fruit cracking percentage was obtained.

Key words: Vermicompost, poultry manure, FYM, Litchi.

Litchi (*Litchi chinensis*), one of the member of family sapindaceae and subfamily naphalae, is evergreen subtropical fruit and known as "Queen of fruit" due to its delicious flavored sweet and juicy aril. Its area in India is estimated to be about 63000 ha with annual production 3.81 lakh tones, ranking next only to China (Anonymous, 2005-06), at an average productivity of 6.0 t ha^{-1} occupying the share of 0.6 % in total production. It is widely cultivated in the Bihar, Jharkhand, West Bengal, Uttarakhand and Tarai belt of Uttar Pradesh due to suitable agro-climatic conditions and has great demand in our domestic market fetching good price. The export value of organically produced product is more. Indiscriminate use of chemicals adversely affect the soil fertility, crop productivity, fruit quality and the environment because of their long persistance in the soil. Similarly, chemical fertilizers which although contribute a lot in fulfilling the nutrient requirement of the crop, their regular, excessive and unbalanced use leads to problems of health and ecological hazards and depletion of physico-chemical properties of soil affecting the crop yields. This needed search for alternate sources of safe fertilizers which leavings no adverse effects on soil properties besides may enhance the crop yields. The use of organic manures seems to be a ray of hope in this direction. Among various organic manures, vermicompost, poultry manure and FYM have long been used to enhance the production of various field and fruit crops and have become essential part of quality crop production. The effects of organic manure on yield and quality of litchi cv. Rose Scented were therefore investigated.

MATERIALS AND METHODS

The experiment was conducted at the Horticulture Research Centre, Patharchatta, G.B.P.U.A&T., Pantnagar during the year 2007-08 on twenty year old trees of litchi cultivar "Rose Scented", planted at 10 m distance in square system in randomized block design and maintained under uniform cultural practices. The treatments included. T_1 - vermicompost @ 25 kg plant^{-1}, T_2 - vermicompost @ 50 kg plant^{-1}, T_3 - vermicompost @ 75 kg plant^{-1}, T_4 - poultry manure @ 25 kg plant^{-1}, T_5 - poultry manure @ 50 kg plant^{-1}, T_6 - poultry manure @ 75 kg plant^{-1}, T_7 - FYM @ 100 kg plant^{-1}, T_8 - FYM @ 125 kg plant^{-1}, T_9 - FYM @ 150 kg plant^{-1} and T_{10} - Control. All the treatments were replicated thrice and 10 trees served as a unit of treatment in each replication.

Four panicles treatment^{-1} replication^{-1} were tagged all around the tree for recording the fruit's physical and chemical quality attributes. The average fruit weight was recorded by taking the fruits randomly from each tagged panicles. The fruit yield tree^{-1} was recorded in kg. The total soluble solids (^{0}Brix) of fruit pulp was determined with the help of digital refractometer. Titrable acidity (%) was calculated by titrating the pulp extract with N/10 NaOH as described by Ranganna (1986) using phenolpthalene as the indicator and ascorbic acid content (mg/100 gm of pulp) of litchi fruits was determined by 2,6-dichlorophenol indophenol by titration method (Ranganna, 1986).

RESULTS AND DISCUSSION

Data presented in Table 1 revealed maximum no. of fruit set per panicle in the treatment T_3 (53.27) followed by T_6 (52.78), against minimum in control (50.12). Maximum fruit weight (20.75 g) and fruit volume (19.62 ml) was also recorded under T_3 against minimum in control. There was no significant difference in fruit cracking. The data on fruit yield (Table 1) showed that the fruit yield was maximum under treatment T_3 (125.06 kg tree^{-1}) followed by T_6 (124.23 kg tree^{-1}) while the minimum fruit yield was recorded under control (110.24 kg tree^{-1}). The results also revealed that the trees treated with higher doses of organic manure recorded maximum fruit set, fruit weight, fruit volume and fruit yield over control. Naik and Babu (2007) experiencing similar results reported significant increase in average fruit weight and fruit yield in comparison to control through vermicompost and poultry manure in guava. Korwar *et. al.* (2006) reported highest number of harvested fruits from aonla by the application of vermicompost and FYM. Increase in yield and other yield components apparently resulted from improved soil chemical and physical properties were induced by organic manure application (Mahendra *et. al.,* 1988).

The TSS contents of fruits were also significantly influenced by organic manure. The maximum TSS (21.12^0Brix) was recorded under treatment T_9 followed by T_8 (21.12^0Brix) and minimum (17.32^0Brix) under control. The maximum ascorbic acidity content was found under the treatment T_9 (26.35 mg 100 g pulp^{-1}) against the minimum under the control (24.04 mg 100g pulp^{-1}) (Table 2). Data showed that the titrable acidity was significantly influenced by various treatment of organic manure. The maximum titrable acidity was recorded under the control (0.50 %).

Table 1 Response of organic manure on fruit set, fruit weight, fruit volume, fruit cracking & yield in litchi cv. Rose Scented.

	Treatment	kg plant^{-1}	Fruit set per panicle	Fruit weight (g)	Fruit volume (ml)	Fruit cracking (%)	Fruit yield (kg)
T_1	Vermicompost	25	50.35	19.14	17.35	6.25	122.73
T_2	Vermicompost	50	52.19	19.86	17.72	5.25	123.24
T_3	Vermicompost	75	53.27	20.75	19.62	6.38	125.06
T_4	Poultry manure	25	51.36	19.04	18.23	5.21	121.24
T_5	Poultry manure	50	51.76	19.78	17.09	5.31	123.06
T_6	Poultry manure	75	52.78	20.42	19.23	6.83	124.23
T_7	FYM	100	50.31	19.21	18.67	6.72	120.74
T_8	FYM	125	51.64	19.16	18.21	6.16	122.25
T_9	FYM	150	52.41	20.30	20.14	5.38	124.06
T_{10}	Control		50.12	17.13	16.02	6.13	110.24
CD at 5%			0.24	0.31	0.23	NS	0.69

Table 2**:** Effect of organic manure on TSS, ascorbic acid, titrable acidity of litchi cv. Rose Scented

	Treatment	kg plant^{-1}	TSS (^{0}Brix)	Ascorbic acid (mg/100 gm pulp)	Titrable acidity (%)	Total sugar (%)
T_1	Vermicompost	25	17.79	24.26	0.63	11.85
T_2	Vermicompost	50	18.13	24.92	0.67	12.15
T_3	Vermicompost	75	19.33	25.13	0.61	13.12
T_4	Poultry manure	25	18.35	24.33	0.62	12.25
T_5	Poultry manure	50	18.41	25.18	0.62	12.72
T_6	Poultry manure	75	19.47	25.73	0.60	13.29
T_7	FYM	100	20.03	25.86	0.51	13.91
T_8	FYM	125	20.77	26.19	0.51	14.55
T_9	FYM	150	21.12	26.35	0.50	14.77
T_{10}	Control		17.32	24.04	0.67	11.18
CD at 5%			0.19	0.35	0.72	0.22

Maximum total sugar (14.77) was recorded in T_9 and minimum (11.18) in the control. Similar findings were reported by Pereira and Mitra (1999). They reported superior fruit quality (TSS, vitamin C and TSS/acid ratio) with organic manure when applied alone. Sendu Kumaran *et al*, (1998) found that the quality parameters such as TSS, ascorbic acid and lycopene were comparatively higher in tomato fruit when grown organically. Similar findings were also observed by Heeb *et. al*. (2006) in Tomato. These results are also in agreement with the findings obtained by Rathi (2003) who reported improvement in quality parameters with organic manure application in pear. The improvement in quality of fruit may be attributed to the improvement in soil physical properties, water holding capacity, structure, porosity, bulk density, hardiness, and chemical (nutrient status, soil pH, hormone) as well as the biological (bacteria fungi, actinomycetes and earth worm activity) properties in the soil (Chattopadhya, 1994).

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Nimoria – an effective neem based urea coating agent for increasing fertilizer use efficiency to enhance sugarcane and sugar yields

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ABSTRACT

Application of 275 kg N ha^{-1} as urea coated with 500 g nimoria 50 kg^{-1} bag of urea gave significantly more numbers of tillers (3.80%) and millable canes (13.57%) which ultimately gave significantly more sugarcane (19.11%) and sugar (17.27%) yields over the treatment of 275 kg N ha^{-1} as urea alone. The next best treatment was application of 275 kgN ha^{-1} as urea coated with 400 g nimora 50 kg^{-1} bag of urea. The treatment of 275 kg N ha^{-1} as urea + neem cake (5:1),though better than control- no urea, was statistically at par with recommended dose of 275 kg N ha^{-1} as urea alone .However, sugar cane juice quality (CCS%) was not affected by any of the treatments. Based on the economics of the treatments, the application of 275 kg N ha^{-1} as urea coated with 500 g nimoria 50 kg^{-1} bag of urea gave highest net realization of Rs.16,080 ha^{-1} over the recommended dose of 275 kg N ha^{-1} as urea alone.

Key words : Urea, Nimoria, sugarcane, sugar, yields, net realization.

Sugarcane (*Sachharum officinarum,L.*) is an important commercial crop producing sugar required in our daily diet. India is the largest consumer and second largest producer of sugar in the world. The sugar industry, the largest in the rural India, has a turn of over of 10,000 millions US dollars per annum contributing almost 1,500 millions US dollars to the central and state exchequer as tax, cess and excise duty every year. There are 492 operating sugar mills in India involving about 50 million sugarcane farmers and a large numbers of agricultural labours constituting 7.5% of the rural population in sugarcane cultivation and ancillary activities. Besides, the industry provides employment to about 2 million skilled/semiskilled workers (Jain, 2008).

It is cultivated in almost all the states of the country but UP and Maharashtra are the principal states (Anon., 2008). Urea containing 46% nitrogen (N) is the major nitrogenous fertilizer used for faster crop growth and higher yield. But when applied on dry soil surface it gets volatilized or in stagnant water (rice crop) gets leached out in the lower strata finally is not available to the plants. Hence, efficacy of nimoria – a neem based coating agent in increasing fertilizer use efficiency in enhancing production of sugarcane cane and sugar yields was studied.

MATERIALS AND METHODS

The study was conducted at Sugarcane Research Station, Cuddalore. Tamil Nadu Agricultural University Coimbatore (TN) during early season of 2001-2002 (plant crop) with treatments involving 275 kg N ha^{-1} as urea +500g Nimoria for every 50 kg bag of urea; 275 kg N ha^{-1} as urea +400 g nimoria for every 50 kg bag of urea; 275 kg N ha^{-1} as urea + neem cake (5:1 ratio); 275 kg N ha^{-1} as urea alone and control- no urea (Check).

The treatments were replicated four times in randomized block design. The ruling sugarcane variety CoSi 95071 was transplanted at inter and intra row spacing of 80 cm x10 cm in 40 m^2 plot on February,2001. Nimoria(1.63% nitrogen, 4.90% potassium oxide (K_2O), 0.40% magnasium, 1.80% calcium, 0.01% molybdenum, 0,02% manganese, 1.00% iron, 0.01% zinc, 1.00% phosphorous pentoxide, 0.85% sulphur, 77.03% organic matter, 0.26% acidity and 0.80% moisture on percent by mass basis) as urea coating agent was applied in three splits at 30 (end of germination phase), 60 (active tillering stage) and 90 (end of tillering phase/ beginning of vegetative phase) days. The observations on shoot count, millable canes, cane & sugar yields and juice quality (CCS %) were recorded.

RESULTS AND DISCUSSION

Results presented in table 1 indicated that application of 275 kg N ha^{-1} as urea coated with 500 g nimoria 50 kg bag^{-1} of urea gave significantly more numbers of tillers (3.80%) and millable canes (13.57%) and ultimately significantly more sugarcane and sugar yields of 19.11% and 17.27%, respectively over the recommended dose of 275 kg N ha^{-1} as urea alone. Application of 275kg N ha^{-1} as urea coated with 400 g nimoria 50 kg bag^{-1} of urea was the next best treatment. However, it differed for numbers of millable canes which was not statistically at par with the treatment of 275 kg N ha^{-1} as urea coated with 500g nimoria 50 kg bag^{-1} of urea. The treatment of 275 kg N ha^{-1} as urea + neem cake in 5:1 ratio was better than control- no urea. But this treatment was statistically at par with recommended dose of 275 kg N ha^{-1} as urea alone. The sugarcane juice was not affected by various treatments.

Looking to the economics of the treatments, it was observed that the application of 275 kg N ha^{-1} as urea coated with 500 g nimoria 50 kg bag^{-1} of urea recorded highest net realization of Rs. 16,080 ha^{-1} over the recommended dose of 275 kg N ha^{-1} as urea alone (Table 2). Literature scanned indicated that no information on effect of nimoria or any other coating agent on fertilizer use efficiency of urea on the crop growth and development of sugarcane and thereby on the quantum and quality of the crop is available. This reveals that this may be perhaps the first information available on the effect of nimoria coated urea on the sugarcane crop.

It can thus be concluded that application of 275 kg N ha^{-1} as urea coated with nimoria @ 500g 50 kg bag^{-1} of urea gave maximum numbers of tillers and millable canes by 3.80% and 13.57%, respectively over recommended control. The treatment also yielded significantly higher sugarcane cane and sugar yields by 19.11% and 17.27%, respectively over the control. Hence, the farmers of sugarcane growing areas are advised to go for application of urea fertilizer coated with NIMORIA @ 500g 50 kg bag^{-1} of urea for getting higher sugarcane and sugar yields and more income (Rs. 16,080 ha^{-1}).

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Table 1: Effect of Nimoria on yield and quality of sugarcane

Treatment	No ha^{-1}		Yield, t ha^{-1}		CCS%
	Tillers	Millablecanes	Sugarcane	Sugar	(Juice quality)
275 kg N/ha-urea + 500g Nimoria / 50 kg bag	1,15,592^{ab}	72,273^{a}	85.71^{a}	10.66^{a}	12.44^{a}
	(3.80)	(13.57)	(19.11)	(17.27)	
275 kg N/ha-urea + 400 g Nimoria / 50 kg bag	1,20,540^{a}	68,831^{b}	82.01^{ab}	10.95^{a}	13.35^{a}
	(8.25)	(8.16)	(13.97)	(20.46)	
275 kg N/ha-urea + neem cake (5:1)	1,11,815^{b}	68,221^{b}	77.43^{b}	9.52^{c}	12.28^{a}
	(0.41)	(7.21)	(7.60)	(4.73)	
275 kg N/ha-urea alone	1,11,360^{b}	63,636^{c}	71.96^{c}	9.09^{c}	12.66^{a}
Control – No urea	1,03,665^{c}	54,011^{d}	68.78^{c}	8.77^{c}	12.75^{a}
SEm	2465	1380	2.21	0.61	0.82
CD 0.05	5372	3007	4.81	1.32	NS

Figures indicating common letters do not differ with each other at 5% level of significance according to DNMRT.
Figures in parentheses indicate percent increase over T4.

Table 2: Economics of Treatments

Treatment	Yield, t ha^{-1}	Increase in yield over T4,t ha^{-1}	Additional income, Rs. ha^{-1}	Cost of nimoria, Rs. ha^{-1}	Net realization, Rs. ha^{-1}
T1	85.71	13.75	16,500	420	16,080
T2	82.01	10.05	12,060	---	---
T3	77.43	5.47	6,564	---	---
T4	71.96	---	---	---	---
T5	68.78	---	---	---	---

Selling rate of sugarcane -Rs.1200 ton^{-1}. Urea bag ha^{-1}: 12 bags (275 kg N ha^{-1}).

Cost of nimoria -Rs.70 -per kg^{-1}. Nimoria required : 6.0 kg / 12 bags of urea.

Cost of nimoria - Rs. 35/50 kg bag i.e. Rs.35 X 12 bags urea.

= Rs.420.00 ha^{-1}.

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Bio-efficacy of plant growth regulators in Bt. cotton

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ABSTRACT

The field experiment conducted during *Kharif* 2006-07 with ten treatments *viz.,* mepiquat pentaborate (1000, 1500, 2000, 4000 and 6000 ppm), chloromequat chloride (60 and 100 ppm), mepiquat chloride (100 and 200 ppm) and control on Bt Cotton (JK-99) revealed that, the application of mepiquat pentaborate @ 1000 ppm increased the plant height as compared to other treatments. However, the plant height was significantly higher than all other treatments. The morpho-physiological triats *viz.,* number of sympodial branches, number of nodes, stem girth and total dry matter content were significantly increased with application of mepiquat pentaborate (1000 ppm) over all the treatments. The growth parameters like LAI, CGR, SLW and LAD also increased significantly due to application of 1000 ppm mepiquat pentaborate. Similarly, the treatment registered significantly maximum seed cotton yield as compared to all other treatments.

Key words: Bioefficacy, Bt. cotton, sympodial branch, yield.

The cotton, called as "white gold", is the most important fibre crop, grown commercially in about 111 countries in the world and is the most important raw material of the textile industry, the single largest organized industry in the country. It sustains livelihood and employment to millions of farmers, industrial workers and traders. Nearly one third of foreign exchange (Rs. 55,000 crores) is earned by cotton textile export (Venugopal *et al*., 2002). During 2007, the total area of 55 lakh hectares in the country was covered under Bt. cotton as against 40 lakh hectares in 2006 and 25 Lha in 2005, which represents just about 1% of 8.8 m.ha of total cotton grown in India. In the world scenario Bt cotton offered high level of resistance against cotton boll worm (Shelton, *et al*., 2002). Under Indian conditions, the transgenic cotton showed great resistance against American cotton boll worm, *H. armigera* both under laboratory and field conditions (Ghosh, 2001 and Kranthi, 2002).

Though the cotton growing area in the country is more, the productivity is low because of 70% of the area remaining under rainfed condition and out of this 28% is covered by desi cotton which yields low due to long duration, genetic and physiological constraints like shedding of plant parts, leaf reddening, bad bolls opening and exposure to biotic and abiotic stresses. In many cases these factors are not well balanced for which the plant growth regulators are very much required to maintain proper plant size, promote setting of bolls and fevor early maturity. Certain indeterminate varieties also require external application of plant growth regulators to shift cotton from vegetative to reproductive growth. Therefore, it is right time to give more emphasis on evaluation of plant growth regulators for growth performance, yield potential and quality improvement. However, hardly any precise and conclusive information on effect of plant growth regulators on various phonological processes and productivity potential of Bt. cotton is available. Hence, the present study on bio-efficacy of plant growth regulators on growth and yield of Bt. cotton was made .

MATERIALS AND METHODS

The field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *Kharif* 2006-07 on Bt. cotton (var. JK 99)

The experiment consisted of 10 treatments i.e. five levels of mepiquat pentaborate (1000, 1500, 2000, 4000 and 6000 ppm), chloromequat chloride (60 and 100 ppm), mepiquat chloride (100 and 200 ppm) and the control and laidout in randomized block design with three replications. The foliar application of these growth retardants was made twice at 70 and 90 days after sowing. The observations on plant height, number of sympodial branches, number of nodes, stem diameter, total dry matter content and seed cotton yield were taken by following the standard procedures. Leaf area index (LAI), specific leaf weight (SLW), crop growth rate (CGR) and leaf area duration (LAD) were worked out as per

procedures of Sestak *et al.* (1971) and Radford (1967) Watson (1952) and Power *et al.,* (1967), respectively.

RESULTS AND DISCUSSION

The data (Table 1) indicated that the application of mepiquat penta borate @ 1000 ppm recorded higher plant height as compared to other treatments. However, the plant height was more in control while chloromequat chloride (200 ppm) recorded significantly lowest plant height. The decrease in plant height in cotton plant sprayed with mepiquat penta borate, chloromequat chloride and mepiquat chloride could be due to the fact that these chemicals are growth retardants and interfere in GA biosynthetic pathway. Mepiquat products are reported to help cotton growers to manage excess vegetative development and maturity of crop (Anon, 2000). Similar results were also reported by Philip *et al.* (2000) and Joseph and Johnson (2006) in cotton.

The data also revealed maximum number of sympodial branches with application of mepiquat penta borate @ 1000 ppm as compared to other treatments which also provided seat for more number of nodes with sympodial branches. This is in conformity with the findings of (Khargade and Ekbote, 1980). Increased number of sympodial branches were also noticed in cotton by Abdullah and Sholaby (1980) and Pothiraj *et al.,* (1995). Similarly, significant differences in the number of nodes, an important morphological character and is directly related to yield, were noticed. Mepiquat penta borate (1000 ppm and 1500 ppm) produced maximum number of nodes as compared to control. Whereas, mepiquat penta borate (6000 ppm) recorded the lowest number of nodes. These results are also in concurrence with Wallace *et al.,* (1993), and Joseph and Johnson (2006).

Yield improvement in any crop could be attributed to better partitioning of photosynthetes towards reproductive parts (Sink). Cotton is basically an indeterminate crop where the vegetative and reproductive phases results in intraplant competition for photosynthates between the developing bolls and vegetative parts. In general all the treatments recorded maximum total dry matter upto harvest (Table 2) and among the treatments, application of mepiquat penta borate (1000 ppm) recorded significantly maximum total dry matter production as compared to control. Similar observations on dry matter partitioning were reported by Nagabhushana (1993). The present study indicated that leaf area index (LAI) increased with the age of the crop upto 150 days after sowing (DAS) and decreased lateron (Table 2) which was due to ageing and senescence of leaves. The application of mepiquat penta borate (1000 ppm) recorded more LAI as compared to other treatments. This variation in LAI could be attributed to the mode of action of growth retardants and might be due to leaf area expansion and stem elongation (Reddy *et al.,* 1996).

Specific leaf weight (SLW) indicates the thickness of the leaf and is known to have direct correlation with photosynthetic rate. The results (Table 2) indicated that SLW increased upto 120 DAS and declined thereafter. Mepiquat pentaborate (1000 and 1500 ppm) registered maximum SLW as against control. Increase in SLW may be either due to enhanced layers of mesophyll cells or increased thickness of conducting vessels. Gausman *et al.,* (1979) reported that application of mepiquat chloride at different concentrations increased leaf thickness by 29% due to longer palisade and strong spongy parenchyma cells in cotton.

The data (Table 3) revealed that leaf area duration (LAD) was significantly increased with application of mepiquat pentaborate (1000 and 1500 ppm) as compared to other

Table 1: Effect of plant growth regulators on morpho-physiology in Bt. cotton var. JK-99

	Treatment	Plant height (cm)	No. of sympodia Plant^{-1}	No. of nodes plant^{-1}	Stem diameter (mm)
T1	Mepiquat pentaborate (1000 ppm)	85.4	25.1	38.1	16.9
T2	Mepiquat penta borate (1500 ppm)	83.0	24.1	36.4	15.7
T3	Mepiquat penta borate (2000 ppm)	82.5	23.1	35.2	15.5
T4	Mepiquat penta borate (4000 ppm)	81.1	22.2	33.1	15.2
T5	Mepiquat penta borate (6000 ppm)	79.2	19.7	27.3	13.5
T6	Chloromequat chloride (60 ppm)	78.3	19.1	29.9	14.4
T7	Chloromequat chloride (100 ppm)	77.4	20.6	30.9	14.5
T8	Mepiquat chloride (100 ppm)	75.3	19.9	29.9	14.0
T9	Mepiquat chloride (200 ppm)	73.2	20.9	30.7	15.3
T10	Control	90.1	20.1	29.2	14.9
	SEm+	**4.6**	**1.0**	**1.5**	**0.6**
	CD(5%)	**13.3**	**3.0**	**4.4**	**1.6**

Table 2: Effect of plant growth regulators on growth parameters in Bt. cotton var. JK-99

	Treatment	Total dry weight (g plant^{-1})				Leaf area index				Specific leaf weight (mg cm^2)			
		90 DAS	120 DAS	150 DAS	180 DAS	90 DAS	120 DAS	150 DAS	180 DAS	90 DAS	120 DAS	150 DAS	180 DAS
T1	Mepiquat pentaborate (1000 ppm)	119.7	151.9	155.7	163.6	0.71	1.00	1.21	0.72	9.0	9.2	7.8	6.6
T2	Mepiquat penta borate (1500 ppm)	114.4	147.1	155.8	160.4	0.67	0.91	1.17	0.69	8.8	9.1	7.7	6.5
T3	Mepiquat penta borate (2000 ppm)	109.9	145.2	149.4	156.4	0.65	0.85	1.14	0.64	8.3	9.0	7.6	6.4
T4	Mepiquat penta borate (4000 ppm)	103.4	140.3	147.1	152.5	0.64	0.84	1.13	0.60	8.2	8.5	7.3	6.3
T5	Mepiquat penta borate (6000 ppm)	86.3	120.2	127.9	131.3	0.49	0.55	0.92	0.41	6.7	6.7	7.0	5.9
T6	Chloromequat chloride (60 ppm)	96.3	130.6	134.1	136.0	0.58	0.76	1.01	0.49	6.9	7.3	7.1	6.2
T7	Chloromequat chloride (100 ppm)	99.1	133.0	138.6	143.9	0.61	0.79	1.04	0.55	7.7	7.8	7.4	6.3
T8	Mepiquat chloride (100 ppm)	92.0	125.2	133.5	136.1	0.47	0.71	0.99	0.43	6.7	7.2	7.5	6.2
T9	Mepiquat chloride (200 ppm)	99.5	133.3	140.5	146.2	0.58	0.75	1.00	0.47	7.9	7.8	7.7	6.5
T10	Control	98.3	135.4	142.8	146.7	0.61	0.81	1.08	0.58	7.6	7.1	7.2	6.0
	SEm+	**4.6**	**4.5**	**4.8**	**4.3**	**0.03**	**0.06**	**0.08**	**0.02**	**0.3**	**0.3**	**0.3**	**0.2**
	CD(5%)	**13.2**	**12.8**	**13.7**	**12.5**	**0.08**	**0.18**	**0.23**	**0.05**	**0.8**	**0.9**	**0.9**	**0.6**

DAS: Days after sowing

Table 3: Effect of plant growth regulators on growth parameters and yield in Bt cotton var. JK-99

	Treatment	Crop Growth rate (g m^2 plant^{-1})			Leaf area duration (days)			Seed cotton yield (kg ha^{-1})
		90-120 DAS	120-150 DAS	150-180 DAS	90-120 DAS	120-150 DAS	150-180 DAS	
T1	Mepiquat pentaborate (1000 ppm)	2.31	0.53	0.14	25.7	33.2	29.0	858.4
T2	Mepiquat pentaborate (1500 ppm)	2.28	0.47	0.08	23.7	31.2	27.9	750.4
T3	Mepiquat penta borate (2000 ppm)	2.23	0.44	0.13	22.4	29.9	26.7	678.5
T4	Mepiquat penta borate (4000 ppm)	2.05	0.42	0.10	22.2	29.6	26.0	670.9
T5	Mepiquat pentaborate (6000 ppm)	1.98	0.22	0.06	15.6	22.1	20.0	514.7
T6	Chloromequat chloride (60 ppm)	2.06	0.37	0.04	21.0	26.6	22.5	575.7
T7	Chloromequat chloride (100 ppm)	2.14	0.41	0.09	21.0	27.5	23.9	585.9
T8	Mepiquat chloride (100 ppm)	2.01	0.25	0.05	17.7	25.5	21.3	591.1
T9	Mepiquat chloride (200 ppm)	2.16	0.34	0.11	19.9	26.3	22.1	665.5
T10	Control	2.03	0.41	0.07	21.3	27.2	24.9	544.8
	SEm+	**0.09**	**0.04**	**0.02**				**107.2**
	CD (5%)	**0.27**	**0.12**	**NS**				**308.2**

DAS: Days after sowing

treatments. The increase in LAD could be attributed to the retention of green leaves for longer duration and higher LA!.

The study indicated that the application of mepiquat pentaborate @ 1000 ppm has recorded significantly higher seed cotton yield which accounted for 57.6% increase over control. This is due to relatively higher biomass, better partitioning of photosynthates towards reproductive structures, higher values of SLW, CGR and LAD. Several authors have also reported increased seed cotton yield due to application of mepiquat penta borate (Joseph and Johnson 2006; Zakaria *et al*., (2006).

The study thus concludes that the use of growth retardants is beneficial to check the excess vegetative crops growth thereby redirecting the nutrients towards reproductive parts to increase the seed cotton yield.

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Effect of plant growth regulators on growth, biochemical traits, yield and yield attributes in Bt Cotton

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ABSTRACT

The field experiment conducted on Bt cotton var. JK 99 during *kharif* 2006-07 at MARS, Dharwad revealed that application of mepiquat pentaborate @ 1000 ppm recorded significantly maximum total dry matter content, increased chlorophyll content, nitrate reductase and higher seed cotton yield over the control.

Keywords: Bt cotton, growth retardant, nitrate reductase, yield component.

Cotton (*Gossypium* spp.) is one of the most important commercial crops grown in about 111 countries. In India, it is cultivated in 8.97 m ha with a production of 21.3 million bales of seed cotton (Anon., 2005a). The average productivity in India is 463 kg ha^{-1} (Anon., 2006) against the world average of 621 kg ha^{-1}, occupying 20% of global cotton area and contributing to 12% of world production (Anon., 2002). Despite the larger area, the productivity in India is low because of many reasons 70% of cotton area is under rainfed conditions and out of that, 28% is covered by desi cotton which are low yielders due to long duration, genetic and physiological constraints like leaf shedding, leaf reddening. Above all, the ravages caused by insect pests particularly, the boll worms are of paramount significance in reducing the yield. The trend of transgenic cotton is tuned to resist kind of pests since, cotton plants contain Bt, a gene toxic to target pests.

Plant growth regulators, that are the substances added in small amounts to modify the growth, are considered a new generation agro-chemicals after fertilizers, pesticides / herbicides and like promoters, inhibitors or retardants play a key role in internal control mechanism of growth by interacting with metaboic processes such as nucleic acid and protein synthesis. Among the growth retardants, mepiquat pentaborate, a new growth regulator containing boron, which can help cotton growers to manage the development and maturity of crop and facilitate insect management, decrease boll rot and increase yield (Edmistein, 2000), was tried. Since, there is hardly any precise and conclusive information available on effect of plant growth regulators on productivity potenital in Bt cotton, an attempt was made to study their effect on growth, biochemical traits, yield and yield components in Bt cotton.

MATERIAL AND METHODS

The field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2006-07. The experiment consisted of 10 treatments *viz.*, five levels of mepiquat pentaborate (1000, 1500, 2000, 4000 and 6000 ppm), two levels of chloromequat chloride (60 and 100 ppm) , two levels of mepiquat chloride (100 and 200 ppm) and control. The experiment was laid out in randomized block design with three replications. Foliar application of these chemicals was taken twice i.e., at 70 and 90 days after sowing (DAS) of the crop. The observations on plant height and total dry matter content were taken at different stages as per the standard procedure. The yield and yield components *viz.*, number of bolls per plant, boll weights were worked out by following standard procedure. The bio-chemical parameters like total chlorophyll content and nitrate reductase were estimated by following the procedure of Hiscox and Israeltam (1979) and Jaworski (1971), respectively and harvest index was calculated by using formula of Donald (1962).

RESULTS AND DISCUSSION

The data (Table 1) indicated that the plant height increased from 90 to 180 days after sowing (DAS). Among the treatments, the plant height was more with application of mepiquat pentaborate (1000 ppm) but it was significantly

lower as compared to control. The decrease in plant height in cotton plants sprayed with these chemicals could be due to the fact that these chemicals interfere in GA biosynthetic pathway. Thus, mepiquat products have been found to help cotton growers to manage excess vegetative growth and maturity of crop (Anon., 2000). It has been reported that these products hasten the maturity by reducing plant height and facilitate insect pest management. The reduction in plant height was due to retardation of transverse cell division particularly in cambium which is the zone of meristmatic activity at the base of internode. Such decrease in plant height was reported by Joseph and Johnson (2006) in cotton.

The present study indicated significant differences in dry matter production from 90 to 180 DAS (Table 1) and among the treatments, the application of mepiquat pentaborate @1000 ppm reduced maximum total dry matter production compared to any other treatment. Whereas the lowest total dry matter content was observed with the application of mepiquat pentboate (6000 ppm). This is because of higher concentration (toxic level) as it inhibits growth and development. Meredith and Wells (1989) also reported that high yielding cultivars partitioned greater proportion of assimilates to reproductive parts. It is thus concluded that plant growth regulators have profound effect on production of dry matter and partitioning between various organs of the plant.

Chlorophyll determines the photosynthetic capacity of the genotypes and influences the rate of photosynthesis, dry matter production and yield in cotton (Krasichkova *et al.*, 1989). The data on total chlorophyll content (Table 2) indicated that mepiquat pentaborate (1000 ppm) recorded maximum total chlorophyll content as compared to other treatments. These findings are similar to the findings of Norton *et al.* (2005) who reported that the application of growth retardants produced thicker leaf blades. Similarly, the effect of growth regulators exhibited significant differences in nitrate reductase in leaf. The enzyme nitrate reductase catalyses reduction of nitrate to nitrate (Beevers and Hageman, 1969) and this is the rate limiting step in nitrogen metabolism. It has been observed from the data (Table 2) that nitrate reductase activity increased significantly with mepiquat pentaborate @ 1000 ppm over all the other treatments. It is generally belived that nitrate reductase activity depends on the activity of substrate and proteinaceous compound and therefore it is suggested that the application of plant growth regulators enhance nitrate uptake by plants (Kuchenberg and Jung, 1988). Similarly, Goswami and Srivastave (1989) also reported increase in nitrate reductase activity due to application of growth regulators.

The study (Table 3) revealed significantly higher seed cotton yield with the application of mepiquat pentaborate (1000 ppm) which accounted for 57.6% higher than control. Higher seed cotton yield could be due to relatively more biomass production, better partitioning of photo assimilates towards reproductive parts like number of bolls per plant, boll weight and harvest index. Several authors have also reported increase in seed cotton yield due to application of mepiquat pentaborate (Joseph and Johnson, 2006; Zakaria *et al.*, 2006). The increase in boll numbers is due to reduction in the abscission of buds and bolls. Moreover mepiquat pentaborate completely counteracted the promotive effect of ABA and thus, reduced shedding of reproductive structures over untreated treatment (control). It was also suggested that

Table 1: Influence of growth retardants on plant height and dry matter content in Bt cotton

	Plant height (cm)				Total dry matter (g plant^{-1})			
Treatment	**90 DAS**	**120 DAS**	**150 DAS**	**180 DAS**	**90 DAS**	**120 DAS**	**150 DAS**	**180 DAS**
T_1 – Mepiquat pentaborate (1000 ppm)	76.5	79.3	84.7	85.4	119.7	151.9	155.7	163.6
T_2 - Mepiquat pentaborate (1500 ppm)	73.5	77.5	83.1	83.0	114.4	147.1	155.8	160.4
T_3 - Mepiquat pentaborate (2000 ppm)	71.5	76.3	82.4	82.5	109.9	145.2	149.4	156.4
T_4 - Mepiquat pentaborate (4000 ppm)	69.8	72.0	79.1	81.1	103.4	140.3	147.1	152.5
T_5 - Mepiquat pentaborate (6000 ppm)	68.2	71.4	78.3	79.2	86.3	120.2	127.9	131.3
T_6 – Chloromequat chloride (60 ppm)	67.4	69.5	77.2	78.3	96.3	130.6	134.1	136.0
T_7 - Chloromequat chloride (100 ppm)	65.5	67.8	75.1	77.4	99.1	133.0	138.6	143.9
T_8 – Mepiquat chloride (100 ppm)	63.8	65.8	73.2	75.3	92.0	125.2	133.5	136.1
T_9 - Mepiquat chloride (200 ppm)	62.1	64.5	72.4	73.2	99.5	133.3	140.5	146.2
T_{10} - Control	77.3	80.4	88.0	90.1	98.3	135.4	142.8	146.7
SEm±	**3.1**	**3.0**	**3.3**	**4.6**	**4.6**	**4.5**	**4.8**	**4.3**
CD (5%)	**9.0**	**8.7**	**9.6**	**13.3**	**13.2**	**12.8**	**13.7**	**12.5**

DAS - Days after sowing

Table 2: Influence of growth retardants on biochemical parameter in Bt cotton

	Total chlorophyll content (mg g^{-1} fresh weight)				Nitrate reductase activity (g NO_2 g^{-1} fresh weight hr^{-1})			
Treatment	**90 DAS**	**120 DAS**	**150 DAS**	**180 DAS**	**90 DAS**	**120 DAS**	**150 DAS**	**180 DAS**
T_1 – Mepiquat pentaborate (1000 ppm)	2.30	2.33	1.97	1.87	42.6	71.3	66.3	34.3
T_2 - Mepiquat pentaborate (1500 ppm)	2.14	2.23	1.92	1.69	39.3	70.0	63.3	32.3
T_3 - Mepiquat pentaborate (2000 ppm)	2.26	2.16	1.87	1.63	38.3	69.0	62.6	31.1
T_4 - Mepiquat pentaborate (4000 ppm)	2.03	2.13	1.83	1.59	38.0	68.3	62.0	31.0
T_5 - Mepiquat pentaborate (6000 ppm)	1.70	1.78	1.54	1.37	26.0	62.0	61.0	22.0
T_6 – Chloromequat chloride (60 ppm)	1.82	2.00	1.73	1.44	28.0	64.3	62.0	28.6
T_7 - Chloromequat chloride (100 ppm)	2.04	2.37	1.83	1.49	34.3	67.3	63.6	29.6
T_8 – Mepiquat chloride (100 ppm)	1.83	2.89	1.76	1.47	27.0	63.6	61.5	28.0
T_9 - Mepiquat chloride (200 ppm)	2.06	2.99	1.84	1.56	34.8	67.6	64.3	29.8
T_{10} - Control	1.98	2.09	1.82	1.45	35.6	64.0	61.2	29.0
SEm±	**0.09**	**0.11**	**0.08**	**0.11**	**2.4**	**2.4**	**1.8**	**1.2**
CD (5%)	**0.26**	**0.32**	**0.22**	**0.31**	**6.9**	**6.8**	**5.3**	**3.4**

DAS - Days after sowing

Table 3: Influence of growth retardants on on yield and yield in Bt cotton

Treatment	**No. of days to 50% flowering**	**No. of bolls $plants^{-1}$**	**Boll weight (g)**	**Yield (kg ha^{-1})**	**Harvest index (%)**
T_1 – Mepiquat pentaborate (1000 ppm)	78.8	31.4	2.7	858.4	28.5
T_2 - Mepiquat pentaborate (1500 ppm)	80.7	28.5	2.6	750.4	25.2
T_3 - Mepiquat pentaborate (2000 ppm)	83.0	26.4	2.4	678.5	23.7
T_4 - Mepiquat pentaborate (4000 ppm)	83.6	25.1	2.3	670.9	20.8
T_5 - Mepiquat pentaborate (6000 ppm)	84.6	18.6	1.7	514.7	17.6
T_6 – Chloromequat chloride (60 ppm)	86.6	21.4	1.9	575.7	18.1
T_7 - Chloromequat chloride (100 ppm)	85.6	23.1	2.0	585.9	18.3
T_8 – Mepiquat chloride (100 ppm)	87.6	23.6	2.1	591.1	17.3
T_9 - Mepiquat chloride (200 ppm)	86.1	24.7	2.2	665.5	21.6
T_{10} - Control	87.1	24.0	1.8	544.8	21.0
SEm±	**2.6**	**1.1**	**0.1**	**107.2**	**1.1**
CD (5%)	**7.6**	**3.2**	**0.3**	**308.2**	**3.3**

endogenous aurin content might have played a key role in reducing abscission (Varma, 1978). Thus, it is inferred that the mepiquat pentaborate (1000 ppm) is most effective in enhancing yield potential in Bt cotton.

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Influence of seed hardening chemicals, growth retardants and chemicals on morpho-physiological traits and yield in Chickpea (*Cicer arietinum* L.)

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ABSTRACT

The experiment conducted during *rabi* 2005 and 2006 on influence of seed hardening chemicals, growth retardant and chemicals on morpho-physiological traits and yield of chickpea (*Cicar arietinum* L.) revealed significant increase in the plant height and total dry matter content due to seed treatment with $CaCl_2$ (2%) as compared to other treatments. Further, significant increase in the growth parameters *viz.,* leaf area index (LAI), crop growth rate (CGR), specific growth rate (SGR), leaf area duration (LAD), biomass duration (BMD), relative water content (RWC) as also as the seed hardening and chickpea seed yield was also recorded under $CaCl_2$ (2%) seed treatment followed by CCC (500 and 1000 ppm).

Key words: Chickpea, growth parameter, relative water content, seed hardening yield.

The chickpea (*Cicer arietinum* L.), one among the important pulse crops known for the highest protein yielding legume (126 kg ha^{-1}), next only to groundnut and soyabean, is essentially a rainfed or post monsoon winter crop grown during *rabi* season in the country. The crop with its first rank among legume, occupying 4.8 m hactare area under cultivation and producing 3.5 m tonnes at 7.2 qha^{-1} productivity levels (Anon., 2003), plays an important role in Indian agriculture. The average yield in India is very low which might be due to the cultivation of this crop under residual soil moisture in cool dry season. As a consequence, plants experience progressively increasing degree of terminal moisture stress that acts as a major limiting factor for determining the growth and yield of chickpea in peninsular India. Such situation particularly affects the pod formation which is the most critical point for determining the yield poetntial in chickpea (Verma and Promilakumari, 1978).

Research and management practices aimed at overcoming aboitic stress limitations to increase yield have demostrated that significant progress can be made. Most of the research work done so far has been on understanding the mechanism underlying productivity but, very little work has been done with respect to the possiblity of overcoming stresses imposed by environmental factors. Therefore, there is an urgent need to concentrate on how best the productivity potential under rainfed conditions can be enhanced by identifying suitable ameliorative measures and overcome the effect of moisture stress. Hence, the present investigation on the effect of seed hardening technique and foliar spray of agrochemicals on morpho-physiological traits and yield in chickpea was carried out.

MATERIAL AND METHODS

The field experiment was conducted at main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *rabi* 2006 and 2007 with a view to study the effect of seed hardening chemicals, growth retardant and chemicals on growth, morpho-physiological traits and yield in chickpea var. Annigeri-1.

The experiment consisted of 13 treatments viz., seed treatments with water soaking $CaCl_2$ (2%), CCC (500 and 1000 ppm), foliar spray of KCl (1 and 2%) KNO_3 (1 and 2%), ethanol (2 and 4%), methanol (2 and 4%) and control. The experiment was laidout in randomized block design with three replications. A day before sowing, the chickpea seeds were soaked separately with $CaCl_2$ (2%), CCC (500 and 1000 ppm) and water for two hours and then dried under shade and used for sowing.The foliar spray of KCl, KNO_3, ethanol and methanol was done 45 days after sowing. Observations

on plant height, total dry matter production and yield were recorded by following standard procedure. Leaf area index (LAI) and biomass duration (BMD) were worked out by following the of Sestak *et al*., (1971), while crop growth rate (CGR) and relative water content (RWC) was measured by following the formulae of Watson (1952) and Barrs and Weatherly (1962), respectively.

RESULTS AND DISCUSSION

Morphological characters such as plant height and total dry matter production were significantly influenced by various treatments (Table 1). The study indicated overall increase in the plant height over control under all except CCC (500 and 1000 ppm) seed treatment which recorded less plant height as compared to control. Further, the plant height was significantly higher in pre-sowing seed treatment with 2% $CaCl_2$ (47.66 cm) followed by (4%) ethanol (45.596 cm) and methanol (45.69 cm). This clearly indicated that mode of action is quite different in different chemicals studied. Similarly, seed hardening with 2% $CaCl_2$ in increasing plant height in finger millet was more effective and such effect was reported due to redistribution of nutrient reserves leading to cell enlargement and increase in normal cell division (Karivartharaju and Ramkrishanan, 1985). Another possible reason for increased plant height could be the growth promoting activity of methanol and ethanol. Mer, (1957) also reported growth promoting activity of ethanol in oat seedling. The mechanism of reduction of plant height due to seed hardening with CCC appears to be due to redued cell size and cell wall thickening or reduction in cell division activity (Ginzo, 1977). Since, CCC is a growth retardant the absorption of chemical by seed is likely to cause antigibberellin effect.

The amout of total dry matter produced is an indicator of the overall efficiency of utilization of resources and better light interception. The data (Table 1) indicted that total dry matter content increased continously from 40 DAS to 80 DAS and among the treatments $CaCl_2$ (2%) recorded significantly maximum total dry matter content followed by CCC (1000 and 500 ppm) as compared to other treatments while, it was lowest in control. These results are in concurrence with Arjunan and Srinivasan (1989) who reported that seed treatment with $CaCl_2$ (1%) significantly increased total dry matter production in groundnut. The increase in dry matter content could be due to the possibility of reduced net radiation on leaves by using chemicals which intern may promote dry matter after accumulation by reducing respiration and thereby maintaining optimum water balance in leaves for increased photosynthesis and other metabolic processes (Nanomulra and Benson, 1992). In the present study (Table 1) it was observed that the leaf area index (LAI) increased upto 60 DAS and decreased thereafter due to senescence and ageing of the leaves. In general, the seed hardening treatments, use of growth retardant and chemicals showed profound significant effect over these parameters. However, seed hardening with 2% $CaCl_2$ recorded significantly higher LAI followed by 4% ethanol and methanol. Maitra *et al*., (1998) also reported that seed hardening with 2% $CaCl_2$ recorded significantly higher LAI as compared to control in finger millet. The computation of crop growth rate (CGR) at different growth stages (Table 1) indicated that CGR was maximum at 60-80 DAS and among the treatments seed hardening with $CaCl_2$ (2%) recorded significantly maximum CGR followed by 1000 ppm CCC. Maitra *et al*., (1998) also revealed that seed hardening with 2% $CaCl_2$ significantly increased CGR over control in finger millet.

The data (Table 2) indicated that specific leaf weight (SLW) increased upto 60 DAS and declined thereafter. Among the treatments SLW was significantly more in seed treatment with CCC (500 and 1000 ppm) followed by $CaCl_2$ (2%). The increase in SLW indicates that leaf thickness was due to stacking of palisade cells. Since, chickpea is a C3 plant the photosynthetic efficiency per unit leaf area is low and their increased thickness could probably enhance the photosynthetic efficiency due to stacking of mesophyll cells thereby recapturing CO_2 released in photo respiratory process. The present study (Table 2) revealed that the leaf area duration (LAD) increased up to 80 DAS and among the treatments seed hardening with $CaCl_2$ (2%) recorded significantly higher LAD as compared to other treatments. These results were in conformity with Write *et al*., 1993 who observed higher grain yield due to higher LAI and LAD in sorghum. Chetti and Sirohi (1995) reported that leaf area duration is an useful concept not only predicting the efficiency of photosynthetic system but also for dry matter production. Further, they also reported that the maintenance of assimilatory surface area over a period of time is a pre requisite for prolonged photosynthetic activity and ultimate productivity in crop plants. The increase in LAD could be mainly due to the maintenance of more green leaf area. The biomass duration (BMD) increased significantly due to seed hardening with 2% $CaCl_2$ followed CCC @ 500 and 1000 ppm as compared to control (Table 2) which could be attributed to increased dry matter production. Similarity, Koti (1997) showed positive association with BMD and seed yield in soybean.

Relative water content (RWC) is a measure of amount of water present in leaf tissue and the treatments having higher RWC under stress condition would be preferable to maintain water balance. In present data (Table 3) the seed hardening with 2% $CaCl_2$ recorded significantly higher RWC

Table 1: Influence of seed hardening techniques, use of growth retardant and chemicals on plant height, leaf area index (LAI) crop growth rate (CGR) and total dry matter content in chickpea (pooled analysis of 2005 and 2006)

Treatment	Plan height (cm)	Leaf area index			Total dry matter (g plant $^{-1}$)			Crop growth rate (g dm^{-2} day^{-1})	
		40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS	40-60 DAS	60-80 DAS
T_1 - Control	40.50	0.64	1.52	1.31	1.82	6.05	13.72	7.1	12.8
T_2 - Water soaking	43.00	0.71	1.68	1.36	2.30	8.18	16.94	9.8	14.6
T_3 - $CaCl_2$ (2%) seed treatment	47.66	0.72	1.96	1.64	2.81	11.21	26.70	14.0	25.8
T_4 - CCC (500 ppm) seed treatment	40.24	0.65	1.66	1.33	2.41	9.50	23.56	11.8	23.4
T_5 - CCC (1000 ppm) seed treatment	39.35	0.64	1.53	1.33	2.62	10.96	24.36	13.8	22.3
T_6 - KCl (1%) foliar spray	43.53	0.65	1.75	1.36	1.69	8.00	15.57	10.5	12.6
T_7 - KCl (2%) foliar spray	44.13	0.65	1.76	1.44	1.97	9.00	17.83	11.7	14.0
T_8 - KNO_3 (1%) foliar spray	43.77	0.65	1.78	1.35	1.86	9.20	18.26	12.3	15.0
T_9 - KNO_3 (2%) foliar spray	44.63	0.65	1.79	1.46	1.94	9.56	18.15	12.7	15.0
T_{10} - Ethanol (2%) foliar spary	44.60	0.65	1.82	1.46	1.85	9.59	18.17	12.9	14.3
T_{11} - Ethanol (4%) foliar spary	45.96	0.65	1.86	1.52	1.92	9.90	21.54	13.3	19.4
T_{12} - Methanol (2%) foliar spary	44.95	0.65	1.80	1.45	1.73	9.15	18.75	12.4	16.3
T_{13} - Methanol (4%) foliar spary	45.69	0.65	1.84	1.48	1.87	9.57	20.27	12.8	17.2
SEm+	**1.28**	**0.04**	**0.056**	**0.04**	**0.24**	**0.38**	**0.83**	**0.4**	**0.7**
CD (5%)	**3.74**	**NS**	**0.14**	**0.12**	**NS**	**1.11**	**2.42**	**1.3**	**1.9**

DAS – Days after sowing

Table 2: Influence of seed hardening techniques, use of growth retardant and chemicals on specific leaf weight (SLW) leaf area duration (LAD) and biomass duration (9 days) in chickpea (pooled analysis of 2005 and 2006)

Treatment	Specific leaf weight (mg cm^2)			Biomass duriation (9 days)			Leaf area duration (days)	
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS	40-60 DAS	60-80 DAS
T_1 - Control	5.54	5.67	4.76	78.8	197.8	288.0	21.56	28.60
T_2 - Water soaking	6.29	6.69	5.51	104.9	251.3	354.0	23.90	30.40
T_3 - $CaCl_2$ (2%) seed treatment	7.50	7.96	7.52	140.2	379.1	535.2	26.82	25.97
T_4 - CCC (500 ppm) seed treatment	7.29	8.58	8.32	119.2	33.07	477.4	21.75	29.03
T_5 - CCC (1000 ppm) seed treatment	7.98	9.84	8.72	135.9	353.3	490.1	22.67	29.30
T_6 - KCl (1%) foliar spray	5.72	6.57	4.92	96.9	235.8	326.7	24.06	31.13
T_7 - KCl (2%) foliar spray	5.68	7.23	5.62	109.7	263.9	352.5	24.16	32.03
T_8 - KNO_3 (1%) foliar spray	5.34	7.86	5.63	111.2	275.2	376.2	24.37	31.36
T_9 - KNO_3 (2%) foliar spray	5.64	7.90	5.22	115.1	281.5	390.8	24.47	32.56
T_{10} - Ethanol (2%) foliar spary	5.68	8.00	6.34	114.5	277.6	398.1	24.76	32.86
T_{11} - Ethanol (4%) foliar spary	5.97	8.13	7.11	118.3	314.4	440.2	25.17	32.86
T_{12} - Methanol (2%) foliar spary	5.12	7.47	6.22	108.8	274.7	381.7	24.53	32.53
T_{13} - Methanol (4%) foliar spary	5.64	7.69	6.12	113.9	293.6	408.8	24.93	33.20
SEm+	**0.48**	**0.33**	**0.29**	**8.86**	**11.31**	**12.15**	**0.69**	**0.94**
CD (5%)	**NS**	**0.97**	**0.86**	**25.88**	**33.02**	**35.47**	**2.04**	**2.74**

DAS – Days after sowing

Table 3: Influence of seed hardening techniques, use of growth retardant and chemicals on specific leaf weight (SLW) leaf area duration (LAD) and biomass duration (9 days) in chickpea (pooled analysis of 2005 and 2006)

Treatment	Relative water content (%)			Seed yield (Q/ha)
	40 DAS	60 DAS	80 DAS	
T_1 - Control	80.20	52.35	46.16	15.41
T_2 - Water soaking	81.30	59.26	51.32	18.84
T_3 - $CaCl_2$ (2%) seed treatment	84.00	68.11	58.45	25.12
T_4 - CCC (500 ppm) seed treatment	82.20	62.78	54.85	22.03
T_5 - CCC (1000 ppm) seed treatment	83.50	64.97	56.90	22.60
T_6 - KCl (1%) foliar spray	79.20	59.13	50.83	18.68
T_7 - KCl (2%) foliar spray	81.00	58.86	51.58	19.45
T_8 - KNO_3 (1%) foliar spray	79.30	59.93	52.18	20.40
T_9 - KNO_3 (2%) foliar spray	80.20	60.68	52.33	21.03
T_{10} - Ethanol (2%) foliar spary	79.40	62.13	53.25	21.43
T_{11} - Ethanol (4%) foliar spary	80.50	62.53	54.60	22.32
T_{12} - Methanol (2%) foliar spary	79.10	61.57	53.85	21.31
T_{13} - Methanol (4%) foliar spary	80.20	62.23	54.50	21.56
SEm+	**3.69**	**2.06**	**1.69**	**1.05**
CD (5%)	**NS**	**6.03**	**4.96**	**3.07**

DAS – Days after sowing

values followed by CCC (1000 ppm). Similar results were reported by Amaregowda *et al*., 1994 in wheat. The data on yield (Table 3) revealed significant increase in the yield due to seed treatment with $CaCl_2$ (2%) followed by CCC (500 and 1000 ppm) as compared to other treatment and was significantly lowest in control. The increase in seed yield could be attributed to betterment in the growth parameters viz., CGR, SLW, LAD and BD. Arjunan and Srinivasan (1989) also reported significantly maximum seed yield due to seed treatment with $CaCl_2$ (1%) in groundnut. It was thus concluded that sowing of chickpea seeds treated with 2% $CaCl_2$ recorded significant increase in all the growth parameters as well as seed hardening and the grain yield.

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Optimization of plantlet stage for vetiver (*Vetiveria zizanioides*) plantation in different soil provenances

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ABSTRACT

Vetiver plantlets, 4, 5 and 6-leaf stages were planted in the pots, containing soil of selected provenances, i.e., ditch site (DSS), before effluent entry (BEE) and after effluent entry (AEE) and analysed monthly for six months to find out its suitability for culturable wastelands reclamation. Among all the sets, 6-leaf stage AEE grown pot plantation could not survive up to the end of 5 months and died. On the basis of tillering, per cent organic carbon (%OC) and nitrogen status in soil and plant during study period (0-5 months) 5-leaf plantlets responded well in all experimental soil compared to irrigated garden soil (IGS) (control) and were selected for further work. Among the 3 leaf stages, the plantlets of 5-leaf stage seem suitable for plantation for reclamation of wasteland.

Key words: Vetiver, soil reclamation, wastelands, miracle grass

The total area under wastelands in India is approximately 53.28 million hectare, which accounts for 17.45 per cent of total geographical area. Moreover, a number of factors such as population pressure, destruction of forest cover, unscientific practice, alkalinity, salinity, soil erosion, industrialization etc. are turning the culturable lands into wastelands and affecting the food production. Therefore, such wasteland needs reclamation for which some plant species with specific characteristics may be tested. These characteristics are, the species must accumulate the nutrients, change the structure of soil, mitigate the toxicity levels of soil, have deep and better root system, fast growing ability and could grow under different environmental conditions, require least input and negligible attention and must be economically viable. Vetiver (*Vetiveria zizanioides*), a grass belonging to family Poaceae is considered as a 'miracle grass' and having all the above mentioned criteria, can play an important role (Shu and Xia, 2003). Vetiver system is highly suitable for phytoremediation because of its extra ordinary features, including tolerance to a wide range of soil salinity (Vimala and Kataria, 2003), alkalinity, acidity, sodicity and elevated levels of Al, Mn and heavy metals such as As, Cd, Cr, Ni, Pb, Zn, Hg, Cu etc. in soil (Chen *et al.*, 2003). It can be grown with nursery raised seedlings as well as by slips, separated from clumps with intact rhizome (plantlets). In present investigation attempts have been made to find out the suitable stage of plantlets for plantation in different soil provenances and results are reported.

MATERIALS AND METHODS

Selection of site: Three sites, ditch site soil (DSS), before and after effluent entry (described as BEE and AEE) into municipal sewage channel near Chaudhary Charan Singh University, Meerut, were selected for the study. The plants growing as wild on such selected sites were also listed.

Plant material: The plant material, *Vetiveria zizanioides* (L.) Nash. Var. Sugandha was procured from NGO of Kerala and homogenized in Botanical Garden of Chaudhary Charan Singh University, Meerut.

Morphological and biochemical parameters: The soil from selected sites were collected and filled in pots (approximately 3kg pot^{-1}). The garden soil of Department of Botany designated as irrigated garden soil (IGS) was also filled separately in pots as control. Vetiver plantlets of different leaf stages, i.e., 4, 5 and 6-leaf stages were transplanted in these pots. Each set was prepared in 6 replicates and irrigated properly with tap water. The plants were examined for morphological and biochemical parameters, soil as well as plant leaves were collected at monthly interval up to six months. Data on morphological parameters such as total number of tillers $culm^{-1}$ and number of days for new leaf emergence and for inflorescence emergence were recorded. Total nitrogen and organic carbon in pot soil and plant leaves were estimated as per the methods of Datta *et al.*, 1962, and data recorded.

RESULTS AND DISCUSSION

Morphological Parameters

Vetiveria zizanioides plantlets planted in different soil provenances had varying changes at morphological level during 3rd to 6th month. Plantlets of 4-leaf stage developed maximum tillers in AEE by 3rd month, which increased upto 4th month and almost stable in 6th month (14 tillers in single culm). In case of DSS not more than 2 tillers developed in each young plantlets. However, by the end of 6th month there were upto 9 tillers in case of BEE and IGS. Emergence of new leaf was earliest in AEE, *i.e.*, 7 days, whereas in DSS it was upto 10 days and in IGS and BEE upto 8 and 9 days. The inflorescence emerged in AEE and BEE by 90 days of planting, whereas inflorescence did not emerge upto 90 days in IGS and DSS.

Plantlets of 5-leaf stage resulted in maximum number of tillers in AEE by 6th month followed by BEE, DSS and IGS. There was no tillering upto 3rd and 4th month in DSS and IGS. New leaves emerged by 5th day of planting in AEE, while it was 10th day in DSS and BEE and 13th day in IGS. Inflorescence emerged by 60th day in AEE and 90th day in DSS but it did not emerge in IGS and BEE. However, the plantlets of 6-leaf stage resulted in higher number of tillers (18) under same soil provenance in BEE. Similarly in case of AEE, number of tillers were least (4) and even the plant died by fifth month of planting. New leaf emerged by 5th day in IGS, whereas in BEE and DSS it took 10 days as in case of plantlets of 5-leaf stage. In AEE new leaf emerged by 7th day, though the plantlet died. Inflorescence emerged only in BEE and it took maximum period (105 days) in comparison to other plantlets. Among the 4, 5 and 6- leaf stage plantlets, former produced greater number of tillers in IGS and AEE, but could not respond proportionately in all soil provenances. Similarly, plantlets of 6-leaf stage failed to respond in all provenances but the plantlets of 5-leaf stage produced more number of tillers in all soil provenances in comparison to control (IGS). This adds to the earlier report that the nutrient contents of the soil provenance are responsible for increasing the number of tillers (Shengluan, 2003). However, the stage of plantlet to be planted is also important in increasing the number of tillers. Therefore, the 5-leaf stage plantlet appears better for binding the soil in polluted areas with proper vegetative and reproductive growth.

Biochemical parameters

(a) Organic carbon

Soil: Amongst all soils, maximum increase in soil OC in 4, 5 and 6-leaf stages of vetiver plantation was 49.7, 231.42 and 541.08 per cent, in DSS during 3rd-4th month. Its decrease was higher (-68.42%) in IGS in 4-leaf stage and in AEE (-88.15%) in 5-leaf stage during 4th-5th month and in AEE (-84.0%) in 6-leaf stage during 3rd-4th month of plantation **(Fig.1)**. Carbon mineralization occurs during 3-4 months of plantation in DSS, whereas during 0-3 months in AEE in 4 or 5-leaf stage plantation which has been delayed upto 4-5 months with 6-leaf stage. In case of BEE, C-mineralization was during 4-5 months with 5-leaf plantlets and 3-4 months with plantlets of 6-leaf stage. However, C-mineralization was not found during 4-5 months with plantlets of any leaf stage. This is suggestive of early loss of OC in control soil but its retention in AEE and BEE soils.

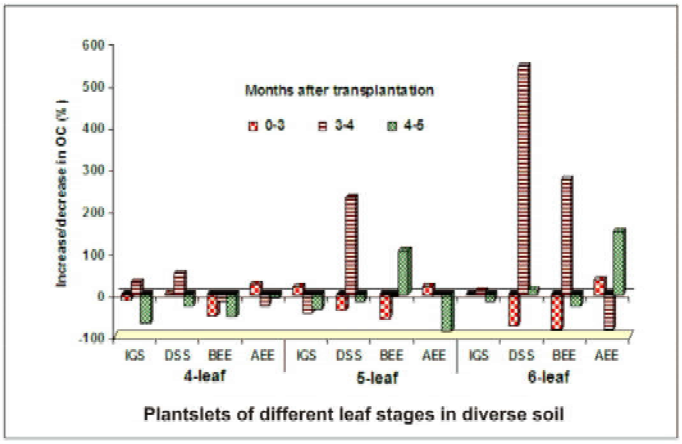

Fig.1. Per cent increase and decrease in organic carbon in pot soil planted with plantlets of *Vetiveria zizanioides* (4, 5, 6-leaf stages) during 0-5 months period

Plant: Maximum increase (30.18%) and decrease (-29.64%) in plant organic carbon was recorded during 3rd-4th month in 4-leaf stage plantation in DSS and IGS, respectively. In case of 5-leaf stage plantation increase was higher (128.02%) in BEE during 3rd-4th month, whereas, its decrease (-46.67%) was higher in AEE during 4th-5th month. Vetiver plantation of 6-leaf stage exhibited more increase (121.05%) and decrease (-25.36%) in plants organic carbon in BEE during 0-3rd and 4th-5th months, respectively. The AEE grown pot plant did not survive up to 5th month and died after 4th month of plantation **(Fig. 2)**.

Both in soil as well as in plants increase in per cent organic carbon in 5-leaf stage plantation during 4th-5th month in BEE and during 3rd-4th month in DSS indicating C-sequestration, whereas in other sets it declined in soils as well as in plants indicating its net loss. Vetiver is known to be suitable for C-sequestration (Lavania and Lavania, 2009), yet its stage of plantation and type of soil provenance also contribute towards increased C-sequestration.

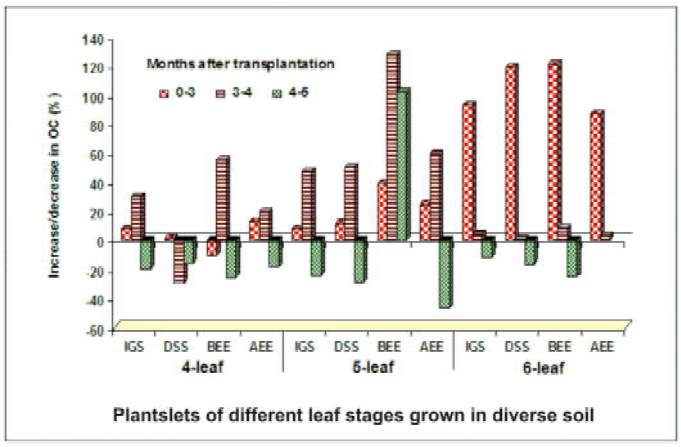

Fig.2. Per cent increase and decrease in organic carbon in plants grown with plantlets (4, 5, 6-leaf stages) of *Vetiveria zizanioides* in pots filled with soil of different provenances during 0-5 months period

(b) Nitrogen

Soil: Maximum increase in soil nitrogen (116.84 and 94.31%) was recorded in AEE during 0-3rd month in 4 and 6-leaf stages of vetiver plantation. In these two stages of plantation, decrease was also highest (-59.41 and -48.42%) during 3rd-4th month. However, in case of 5-leaf stage plantation, maximum increase in nitrogen (57.59%), was in AEE during 4th-5th month, while highest decrease (35.29%) was in DSS during 3rd-4th month, indicating variability in C:N ratio at all the sites **(Fig.3)**. Probably higher nitrogen content in AEE soil might be due to presence of excessive nitrogen fixing microflora. It has been reported by Thuy *et al.* (2006) that growing vetiver in soil with high acidity and low contents of N, P, K in combination with three species of

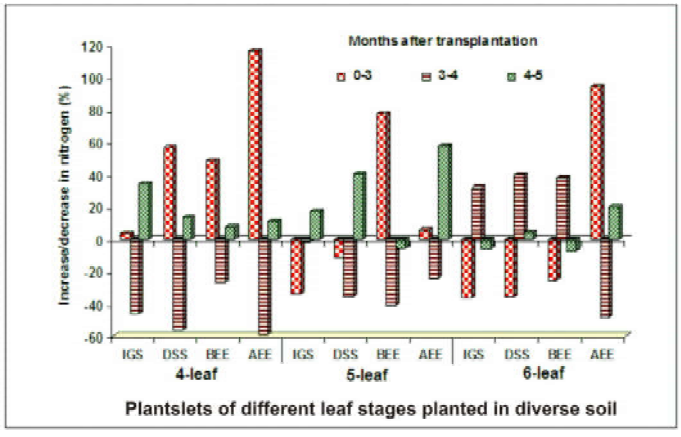

Fig.3. Per cent increase and decrease in nitrogen content of soil in pots planted with plantlets of *Vetiveria zizanioides* (4,5,6-leaf stages) from different provenances during 0-5 months period

mycorrhiza and a free living nitrogen fixing bacterium along with chemical and bio-liquid fertilizers, increased soil fertility and crop productivity in corn and sorghum.

Plant: Increase in plant nitrogen was highest (1746.15%) in IGS during 0-3rd month in 4-leaf stage, 300 per cent during 4th-5th month in 5-leaf stage in same provenance (IGS) and 1340.47 per cent in DSS during 4th-5th month in 6-leaf stage plantation. Its decline was highest (-74.36%) in 4-leaf stage during 4th-5th month, while in case of 5-leaf stage plantation it was maximum (-99.08%) in DSS during 3rd-4th month and in 6-leaf stage (-96.56%) in IGS during 4th-5th month **(Fig.4)**.

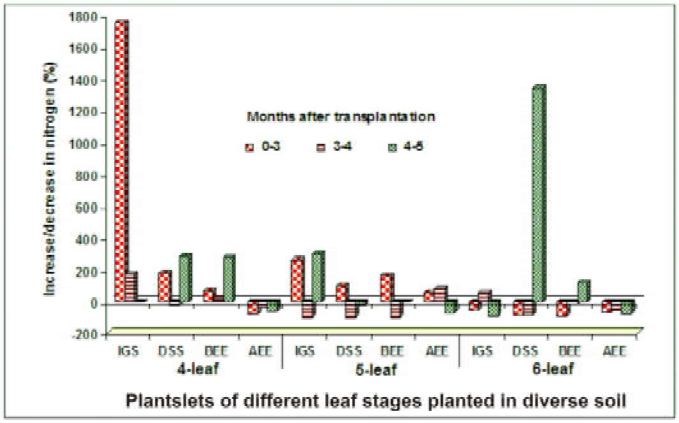

Fig.4. Per cent increase and decrease in nitrogen content in potted plants grown with plantlets of 4, 5, 6-leaf stages of *Vetiveria zizanioides* in soil of different provenances during 0-5 months period

Both soil and plant nitrogen increased in DSS and BEE with 4-leaf stage, in IGS with 5-leaf stage and in DSS with 6-leaf stage of plantation during 4th-5th month. Interestingly, increase in plant nitrogen was much more in DSS during 4th-5th month in 6-leaf stage of plantation although initially, *i.e.*, during 0-3rd month IGS of 4-leaf stage also showed increasing trend, but it declined by the end of 5th month. Moreover, both organic carbon and nitrogen could not increase in soil and plant simultaneously in any soil provenance up to 5 months of transfer of plantlets of evaluated stages. However, due to death of most of the plants, planted at 6-leaf stage in pots, sample size could not be maintained and 4-leaf pot plants were small for the dry matter. Hence, on the basis of soil and plant organic carbon study and also on the basis of sustenance of plants, 5-leaf stage plantlets may be used for plantation.

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Ecofriendly management of Sorghum shoot fly, *Atherigona soccata* Rondani through seed treatment

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ABSTRACT

Studies conducted on the management of shoot fly *Athertigona soccata* Rondani in sorghum through treatment of its seed with various organics during *kharif* 2008 at Dharwad revealed that NSKE (5%) seed treatment recorded significantly less mean number of shoot fly eggs plant^{-1} (0.68) and least number of deadhearts (31.00%). Neem oil (2%) seed treatment recorded the highest yield (15.21 q ha^{-1}) which was on par with NSKE 5% (14.72 q ha^{-1}), Azagro 5% (14.14 ha^{-1}) and plant mixture 5% (14.57 ha^{-1}). However, endosulfan and imidacloprid seed treatments recorded significantly less deadheards (17.66% and 18.33%, respectively) and highest grain yield (17.32 and 17.12 q ha^{-1}, respectively) than all organic treatments. NSKE (5%), among all organic treatments, recorded highest incremental benefit cost ratio (210.8:1).

Key words: Sorghum shoot fly, organic, plant extract, seed treatment

Sorghum (*Sorghum bicolor* (L.) Moench), a major food and fodder crop in the tropics and semi arid tropics, suffers around 32 % loss due to insect pests in India, including 5 % (Borad and Mittal, 1983; Jotwani, 1983) due to sorghum shoot fly. Pesticides like carbofuran, phorate, endosulfan, malathion, methyl demeton and cypermethrin are effective but the small farmers cultivating sorghum cannot afford these costly insecticides. Consequently, the envrionmental safety calls for development of safer and cost effective pest management strategies were evolved. Hence, the present field experiment to assess various organic material against sorghum shoot fly was conducted.

MATERIAL AND METHODS

Experiment was laid out in the RBD design in three replications with a plot size of 4x2.8 m^2. Sorghum cultivar CSH-16 with a spacing of 45x15 cm^2 was sown during second fortnight of June (2008). To know the efficacy of treatment,s treated check of insecticides as well as untreated check was maintained. All the recommended package of practices was followed except plant protection. For botanical extract preparation,fresh leaves (and bulb in case of garlic) of plants were collected and brought to the laboratory and washed thoroughly 3-4 times with tap water and finally with distilled water. Later they were chopped into small pieces with a sharp knife. Fifty grams of chopped material was macerated in mortar and pestle and extracted with a small quantity of distilled water. The extract was squeezed through muslin cloth and made up to 1 liter with distilled water. Fifty grams seeds of Neem (*Azadirechta indica* A.Juss) and *Butea monosperma* L. were smashed and soaked overnight in distilled water, and 5% solution was made with distilled water. Oils of *Pongamia pinnata L.*, neem and *Jatropha caracass* L. were brought and diluted with distilled water to get 2 % concentration just before seed treatment. For preparation of plant mixture, fresh leaves of *Vitex negundo* L., *Ricinus communis* L., *Clerodendron inerme* l., *Calotropis gigantia* W.T.Aiton and *Parthenium hysterophorus* L. were collected. Ten g each of these were taken and 5% solution was prepared. Seeds were kept in petri plates containing the respective treatment solution for two to three minutes and taken out and dried under shade for about three-four hours. In case of endosulfan 35 EC treatment, seeds were soaked in 0.07 % endosulfan 35 EC for 8 hours and dried under shade. All seeds were sown after proper drying. Total number of shoot fly eggs on ten randomly selected plants in each plot was averaged to represent the eggs present per plant. Egg count was taken at 7, 14 and 21 days after emergence (DAE) of plants. Deadheart counts were taken at 21 and 28 DAE of crop by counting total number of plants in each treatment. After harvesting, grain yield was converted to per hectare. Cost economics for the treatments, found better than untreated check, was calculated.

Table 1. Effect of seed treatment with organics on oviposition of shoot fly in sorghum

Treatments	Number of eggs plant^{-1}			
	7 DAE	14 DAE	21 DAE	Mean
Cow urine 5%	1.03a (1.43)*	1.66a (1.63)	2.00a (1.73)	1.56a
Vermiwash 5%	1.03a (1.43)	1.66a (1.63)	2.00a (1.73)	1.56a
Butea monosperma seed extract 5%	0.46d (1.21)	0.86d (1.36)	1.46cd (1.57)	0.93de
Butea monosperma leaf extract 5%	0.46d (1.21)	0.86d (1.36)	1.46cd (1.57)	0.94de
Vitex negundo leaf extract 5%	0.86bc (1.37)	1.33b (1.53)	1.66bc (1.63)	1.28abc
Castor leaf extract 5%	0.86bc (1.37)	1.33b (1.53)	1.66bc (1.63)	1.28abc
Garlic bulb extract 5%	0.50d (1.22)	0.73de (1.32)	1.53c (1.59)	0.92de
NSKE 5%	0.40e (1.18)	0.63de (1.28)	1.00e (1.41)	0.68ef
Azagro 5% (1 ml/lit)	0.40e (1.18)	0.63de (1.28)	1.00e (1.41)	0.68ef
Pongamia leaf extract 5%	0.46d (1.21)	1.00c (1.41)	1.66bc (1.63)	1.04cd
Pongamia oil 2%	0.46d (1.21)	1.00c (1.41)	1.66bc (1.63)	1.04cd
Neem oil 2%	0.43de (1.20)	0.50f (1.22)	1.00e (1.41)	0.65ef
Jatropha leaf extract 5%	0.93b (1.39)	1.00c (1.41)	1.66bc (1.63)	1.20bcd
Jatropha oil 2%	0.83c (1.35)	1.00c (1.41)	1.76b (1.66)	1.20bcd
Prosopis julifera leaf extract 5%	0.46d (1.21)	0.73de (1.32)	1.66bc (1.63)	0.95de
Annona squamosa leaf extract 5%	0.86bc (1.37)	1.00c (1.41)	1.33d (1.53)	0.92de
Plant mixture 5%	0.46d (1.21)	0.63de (1.28)	1.00e (1.41)	0.70ef
Endosulfan 35 EC (0.07%)	0.33f (1.15)	0.46f (1.21)	0.66f (1.29)	0.48f
Imidachloprid 2 *g*/kg	0.33f (1.15)	0.46f (1.21)	0.66f (1.29)	0.48f
Untreated control	1.03a (1.43)	1.66a (1.63)	2.00a (1.73)	1.56a
SEm±	**0.01**	**0.01**	**0.01**	**0.09**
CD at 5%	**0.02**	**0.04**	**0.04**	**0.26**

* Figures in parentheses are $\sqrt{x+1}$ transformed values

Means followed by same alphabet in column do not differ significantly (0.05) by DMRT

DAE = Days After Emergence

Table 2. Evaluations of seed treatment with organics against shoot fly and sorghum yield

Treatments	Percent deadhearts		Yield (q ha^{-1})
	21 DAE	28 DAE	
Cow urine 5%	53.33a (41.82)	83.00a (52.17)	9.43f
Vermiwash 5%	50.33ab (40.63)	80.33ab (51.33)	9.91f
Butea monosperma seed extract 5%	27.66e (30.12)	55.33d (42.66)	13.01c
Butea monosperma leaf extract 5%	27.00e (29.75)	60.00d (44.36)	12.98c
Vitex negundo leaf extract 5%	38.66cd (35.61)	70.66c (48.14)	12.99c
Castor leaf extract 5%	50.00ab (40.49)	79.00ab (50.90)	9.94ef
Garlic bulb extract 5%	38.00d (35.30)	73.33bc (49.04)	12.07cd
NSKE 5%	16.33f (23.14)	31.00f (31.88)	14.72b
Azagro 5% (1 ml/lit)	18.33f (24.42)	33.00ef (32.90)	14.14b
Pongamia leaf extract 5%	31.00e (31.88)	59.33d (44.11)	11.81cd
Pongamia oil 2%	37.33d (34.99)	61.66d (44.97)	11.92cd
Neem oil 2%	15.66f (22.66)	32.33ef (32.56)	15.21b
Jatropha leaf extract 5%	41.00cd (36.67)	79.66ab (51.11)	9.73f
Jatropha oil 2%	39.66cd (30.07)	80.00ab (51.22)	9.71f
Prosopis julifera leaf extract 5%	36.66d (34.68)	55.33d (42.66)	11.89cd
Annona squamosa leaf extract 5%	44.33bc (38.13)	73.33bc (51.96)	10.96de
Plant mixture 5%	17.00f (23.61)	36.00ef (34.36)	14.57b
Endosulfan 35 EC (0.07%)	9.33g (17.49)	17.66g (24.07)	17.12a
Imidacloprid 2 *g*/kg	9.66g (17.80)	18.33g (24.52)	17.32a
Untreated control	53.00a (41.69)	81.33ab (51.65)	9.48f
SEm±	**0.86**	**0.84**	**0.39**
CD at 5%	**2.46**	**2.39**	**1.12**

* Figures in parentheses are arc sine transformed values

Means followed by same alphabet in column do not differ significantly (0.05) by DMRT

DAE = Days After Emergence

Table 3. Cost economics for the management of sorghum shoot fly through seed treatments with organics

Treatments	Yield (q ha^{-1})	Increase in yield over control (q ha^{-1})	Per cent increase in yield over control	Cost of pest control (Rs ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	IBC ratio
Butea monosperma seed extract 5%	13.01	3.53	37.24	100.00	19515.00	18512.50	185.1:1
Butea monosperma leaf extract 5%	12.98	3.50	36.92	100.00	19470.00	18470.00	184.8:1
Vitex negundo leaf extract 5%	12.99	3.51	37.03	100.00	19485.00	18485.00	184.9:1
Garlic bulb extract 5%	12.67	2.59	27.32	100.00	18105.00	17105.00	171.1:1
NSKE 5%	14.72	5.24	55.27	100.00	22080.00	21080.00	210.8:1
Azagro 5% (1 ml/l)	14.14	4.66	49.16	111.20	21210.00	21098.00	189.7:1
Pongamia leaf extract 5%	11.81	2.33	24.58	100.00	17715.00	16715.00	167.2:1
Pongamia oil 2%	11.92	2.44	25.74	109.00	17885.00	16795.00	154.1:1
Neem oil 2%	15.21	5.73	60.44	107.20	22815.00	21743.00	202.8:1
Prosopis julifera leaf extract 5%	11.89	2.41	25.42	100.20	17835.00	16835.00	168.0:1
Annona squamosa leaf extract 5%	10.96	1.48	15.61	100.00	16440.00	15440.00	154.4:1
Plant mixture 5%	14.57	5.09	33.69	100.00	21855.00	20855.00	208.6:1
Endosulfan 35 EC (0.07%)	17.12	7.64	86.59	101.05	25680.00	24469.00	242.2:1
Imidacloprid 2 *g*/kg	17.32	7.84	82.70	113.20	25980.00	24848.00	219.5:1
Untreated control	9.48	-	-	-	-	-	-

RESULTS AND DISCUSSION

On 7 DAE, NSKE and Azagro at 5 % recorded significantly less number of eggs (0.40 eggs plant^{-1}) and neem oil (2%) was on par with them (0.43 egg plant^{-1}). However, endosulfan 35 EC (0.07%) and imidacloprid (2 g kg^{-1}) were significantly superior over all organics, each recording 0.33 eggs plant^{-1}. On 14 DAE, neem oil (2%) proved to be the best (0.50 egg plant^{-1}) followed by NSKE (5%), Azagro (5%) and plant mixture (5%) each recording 0.63 egg plant^{-1} (Table 1). Endosulfan 35 EC (0.07%) and imidacloprid (2 *g* kg^{-1}) were the best treatments recording least eggs (0.46 egg plant^{-1}). This trend remained almost similar at 21 DAE also. The perusal of literature revealed that no such work has been done on sorghum. However, it can be compared with the studies of Kareem *et al*. (1989) who found that fewer number of first instar *Nephotettix virescens* (Distant) nymphs reached the adult stage on rice raised from seeds treated before sowing with > 2.5 % neem kernel extract or with 2% neem cake. On 21 DAE, neem oil (2%), NSKE (5%), plant mixture (5%) and Azagro 5 % recording 15.66, 16.33 and 17.0, 18.33% deadhearts, respectively were the best and on par with each other. However, endosulfan 35 EC (0.07%) and imidacloprid recorded least per cent deadhearts (9.33 and 9.66%, respectively) (Table 2). At 28 DAE, NSKE (5%) was the best (31% deadhearts) and Azagro 5 % (1 ml/l), neem oil (2%), plant mixture were on par with NSKE (5%) (33, 32.33 and 36% deadhearts, respectively). Endosulfon 35 EC (0.07%) and imidacloprid (2 g/kg) were superior to rest of the treatments (17.66 and 18.33% deadhearts, respectively).

Praveen (2005) reported that okra seed treatment with neem oil at 8 ml kg^{-1} seeds recorded least per cent fruit damage (68.82%) followed by gaucho 600 FS @ 12 ml kg^{-1} (74.34) and thiamethoxam 70 WS @ 10 *g* kg^{-1} (76.00%). Among organics, 2 % neem oil recorded highest yield (15.21 q ha^{-1}) and it was on par with 5 % NSKE (14.72 q ha^{-1}), 5% plant mixture (14.57 q ha^{-1}) and azagro (14.14 q ha^{-1}). (Table 2). Imidacloprid proved its supremacy as compared to organics by recording higher yield of 17.12 and 17.32 q ha^{-1}, respectively. The

highest incremental benefit cost ratio (210.8:1) was obtained with NSKE (5%) followed by plant mixture 5 % (208.6:1), neem oil 2 % (202.8:1) followed by other botanicals. However, endosulfana and imidacloprid remained superior over organics seed treatments with IBC ratio of 242.2:1 and 219.5:1, respectively. Thus, organic seed treatments were next best only to chemicals in managing shoot fly.

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Efficacy of *Azadirachta* and *Sphaeranthus* in the management of pulse beetle, *Callosobruchus chinensis* L. in greengram

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ABSTRACT

Aqueous, alcohol and acetone extracts of neem seed kernal and gorakhmundi leaves at 0.25 % and 0.50 % concentrations were tested to evaluate their efficacy on prevention of weight loss in green gram, *Vigna radiata* Linn seeds due to pulse beetle *Callosobruchus chinensis* infestation. Data revealed that 0.50 % alcohol extract of neem was highly effective in protecting green gram from *C. chinensis* with minimum loss in the seed weight (1.66 %) throughout the storage period of 24 weeks and was significantly superior to aqueous and acetone extracts of neem at same concentrations (2.32 % and 2.38 %, respectively). The treatment with 0.25% alcohol extract of gorakhmundi recorded considerable loss of (6.44 %). All the treated groups registered significantly lower loss as compared to untreated control (9.68 %).

Key words: Indigenous, Neem, Gorakhmundi, Greengram seeds, Pulse beetle.

Pulses, often referred to as 'Poor Man's meat' (Rout and Senapati, 2006), have a prominent place in daily diet because of being a rich source of vegetable proteins (Aslam *et al.*, 2002) and are of special significance to people of India. Its seeds suffer greater damage during storage due to insect pests attack (Gujar and Yadav, 1978; Ketkar *et al.*, 1987; Chowdhary, 1990). *Callosobruchus chinensis* is the most serious one and often results in significant quantitative losses (Singal, 1995; Singh *et al.*, 2001; Ghosal *et al.*, 2005). The uses of synthetic organic chemicals, though effective in controlling the pests pose residue hazards. This led to diversify control measures against the beetle towards a non-toxic and effective approach. Botanicals have proved to be good seed protectants as reported by earlier workers (Misra, 2000; Dwivedi et al, 2004; Braga *et al.*, 2007). Keeping this in view, the efficacy of solvent extracts of neem and gorakhmundi plants in preventing the weight loss of greengram seed due to infestation by pulse beetle, *C. chinensis* under laboratory conditions was determined.

MATERIALS AND METHODS

Neem seed kernel and gorakhmundi was collected locally during February - July, 2007, washed thoroughly in water, dried in shade and pulverized by mechanical grinder after passing through a sieve of mesh size 0.50 mm. The powder was stored in well stopper plastic container.

Preparation of extract

Aqueous, alcohol and acetone extracts of seed kernel of neem and leaves of gorakhmundi were prepared by using 30 g of dried powder of plants individually and extracted in 300 ml of water (95 ^{0}C), ethanol (74 ^{0}C) and acetone (56 ^{0}C) for 4 h (AR grade, Qualigen). Each extract was 5 fold concentrated on water bath at 50-60 ^{0}C and stored in an airtight dessicator.

Rearing of pulse beetle, *C. chinensis*

The pulse beetle, *C. chinensis* L. was reared in plastic jars (Sun pet, India) of 1 kg capacity. Each jar containing 100 g of pulse seeds (green gram) as a nutritional source and 20 pairs of *C. chinensis* (either sex) were added to each jar. The mouth of jar was tied with muslin cloth, banded and labeled properly. All the rearing jars were placed in BOD chamber (Remi) at 30 ± 2 ^{o}C temperatures and 70 ± 5 % relative humidity.

Pulse seeds (Green gram, *Vigna radiata* L.)

Heathy green gram pulse seeds were procured from local farmers immediately after harvesting. Possible insect contamination was eliminated by thoroughly washing the seeds and drying in bright sunlight for 3 days upto 6 to 7 % moisture content level and stored in airtight containers until required for the experiment.

Seed treatment

100 ml of stock solution of each extracts having 1 % (10 mg ml^{-1}) concentration was prepared in distilled water. These were further diluted with distilled water to make 0.25 & 0.50 % of each extracts with which 1.5 kg of seeds was treated. The plant extracts were applied in the form of spray @ 25 ml kg^{-1} with the help of hand sprayer. The seeds of greengram were spread in 18" x 12" size tray. This was slowly shaken during spraying for uniform application of the extracts. The seeds after drying under sunlight and fan for 4-6 h were stored in airtight glass jars under room conditions.

Percent loss in seed weight

Samples of 50 g greengram seeds from treated lot were drawn after 2 days and subsequently after 4 weeks up to 24^{th} weeks of treatment. Each concentration was replicated thrice and untreated control was kept for comparison. Each sample was kept in plastic containers (6 x 6 cm) having perforated lids in which 20 adult beetles of 1-2 days old were introduced at 0.285 week and subsequently at 4 weeks interval up to 24^{th} week. The observations on percent loss in seed weight were recorded and during 24 weeks of storage. After cessation of adult emergence, the samples were weighed on monopan digital balance. The per cent loss in seed weight was calculated as per following formula:

$$\text{Weight loss}(\%) = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

The data were statistically analyzed using RBD (ANOVA) method (Bansal *et al.*, 1991) and the critical difference (CD) at 5 % level of significance was calculated.

RESULTS AND DISCUSSION

The data presented in Table 1 showed that the treatment with 0.50 % acetone extract of neem effected a minimum loss in seed weight (0.43 %) at 0.285 weeks after treatment. It was at par with 0.50 % aqueous, 0.50 % and 0.25 % alcohol extracts of neem showing 0.47 %, 0.73 % and 0.83 % loss in seed weight respectively. Seeds treated with 0.25 % alcohol extracts of gorakhmundi effected maximum loss of 3.60 % in seed weight and at par with untreated control (6.76 %).

Four weeks after treatment, 0.50 % aqueous extract of neem caused minimum loss in seed weight (1.0%) and were at par with 0.50 % alcohol extract of neem, 0.50% of gorakhmundi and 0.50 % acetone extract of neem recording 1.10 %, 1.17 % and 1.33 % loss in seed weight, respectively. Maximum loss in seed weight (4.47%) was registered in 0.50 % aqueous extract of gorakhmundi and while remaining treated groups showed significantly lower percentage of loss in seed weight against untreated control.

At 8 weeks after treatment, again at the concentration of 0.50 % aqueous extract of neem recorded minimum loss in seed weight (1.60 %) which was at par with 0.50 % alcohol extract of neem, 0.50 % alcohol extract of gorakhmundi and 0.50 % acetone extract of neem registering 1.67 %, 1.80 % and 2.10 % weight loss, respectively. Treatment with 0.25 % aqueous extract of gorakhmundi showed maximum loss (5.20 %) which was at par with untreated control (8.56 %). Alcohol and acetone extract of neem (0.50%) registered lower losses of 1.50 % and 2.63 %, respectively at 12 weeks after treatment. The maximum loss was observed in 0.25 % aqueous extract of gorakhmundi (7.36 %).

At 16 weeks after treatment 0.50 % alcohol extract of neem registered minimum loss in seed weight percentage (2.30 %) and was at par with 0.50 % acetone, 0.50 % aqueous and 0.25 % alcohol extract of neem which recorded loss in percentage of seed weight by 3.00 %, 3.16 % and 3.40 % respectively, Treatment with 0.25 % acetone extract of gorakhmundi recorded maximum (7.80 %) seed weight loss. Similar trend with regard to neem was observed at 20 and 24 weeks of treatment. Alcoholic extract (0.50%) of neem recorded minimum losses of 2.33% and 1.96% and aquous extract (0.25%) of gorakhmunid the maximum of 7.56% and 9.4% in seed weight at 20 and 24 week after treatments also.

The results based on pooled mean indicated that 0.50 % alcoholic, aqueous and acetone extracts of neem were at par with each other and significantly superior to all other treatments. The next in order of effectiveness were 0.50 % alcohol extract of gorakhmundi and 0.25% alcoholic extract of neem. Treatment with 0.25% alcohol extract of gorakhmundi recorded the average maximum loss of 6.44% in seed weight and was significantly lower than the untreated control (9.68 %). The treatment with 0.50% alcohol extract of neem proved effective in protecting the seeds with minimum loss in seed weight (average 1.66%) against *Callosobruchus chinensis* for a period of six months.

Taking in to consideration the average percentage of loss in green gram seed weight at different concentrations of various plant extracts (Table 1), the descending order of efficacy along with the respective concentrations in parenthesis was: alcoholic neem extract (0.50%) > aqueous neem extract (0.50%) > acetone neem extract (0.50 %) > alcohol gorakhmundi extract (0.50%) > alcoholic neem extract (0.25%) > acetone gorakhmundi extract (0.50%) > aqueous neem extract (0.25%) > acetone neem extract (0.25%) > acetone gorakhmundi extract (0.25%) > aqueous gorakhmundi

Table 1 Per cent loss in seed weight exposed to solvent extracts of Neem and Gorakhmundi.

Treatments	Per cent loss in seed weight								
	Duration of storage after treatment before exposure of adult beetles (Weeks)								
	0.285	4	8	12	16	20	24	Pooled mean	ORE
A/a/I	01.97 (08.03)	02.57 (09.30)	02.83 (09.80)	03.93 (11.40)	06.26 (14.52)	06.06 (14.28)	06.70 (15.02)	04.33 (12.02)	07
A/a/II	00.47 (02.68)	01.00 (05.70)	01.60 (07.18)	03.13 (10.20)	03.16 (10.95)	03.73 (11.26)	03.20 (10.30)	02.32 (09.25)	02
A/b//I	00.83 (04.58)	02.03 (08.18)	03.13 (10.28)	03.13 (10.20)	03.40 (11.18)	03.73 (11.26)	03.96 (11.42)	02.88 (09.70)	05
A/b/II	00.73 (04.22)	01.13 (06.22)	01.67 (07.32)	01.50 (07.04)	02.30 (08.72)	02.33 (09.30)	01.96 (07.94)	01.66 (07.30)	01
A/c/I	01.90 (07.92)	02.43 (09.00)	02.80 (09.63)	03.63 (11.10)	05.20 (13.20)	06.70 (14.98)	08.23 (16.64)	04.41 (12.20)	08
A/c/II	00.43 (02.60)	01.33 (06.50)	02.10 (08.33)	02.63 (09.05)	03.00 (10.00)	03.40 (10.76)	03.80 (11.38)	02.38 (09.30)	03
B/a/I	02.67 (09.42)	03.70 (11.23)	05.20 (13.20)	07.36 (16.10)	07.26 (15.68)	07.56 (15.93)	07.23 (15.60)	05.85 (14.00)	11
B/a/II	03.37 (10.60)	04.47 (12.25)	04.93 (12.75)	06.33 (14.90)	07.16 (15.40)	06.87 (15.20)	06.73 (15.00)	05.69 (13.82)	10
B/b/I	03.60 (11.00)	04.13 (11.80)	05.00 (12.90)	07.23 (15.60)	07.10 (15.22)	08.60 (17.15)	09.43 (18.00)	06.44 (14.80)	12
B/b/II	01.07 (06.00)	01.17 (06.40)	01.80 (07.70)	03.10 (10.14)	03.60 (11.00)	03.73 (11.26)	05.10 (13.15)	02.79 (09.62)	04
B/c/I	01.93 (07.96)	02.97 (09.80)	04.50 (12.20)	06.36 (15.00)	07.83 (16.20)	06.73 (15.00)	08.30 (16.76)	05.51 (13.60)	09
B/c/II	01.67 (07.32)	02.47 (09.08)	03.20 (10.34)	04.70 (12.30)	05.50 (13.50)	05.80 (13.90)	04.50 (12.20)	03.98 (11.40)	06
Untreated Control	06.76 (15.00)	06.87 (15.12)	08.56 (17.10)	10.33 (18.74)	11.03 (19.51)	11.33 (19.70)	12.90 (20.92)	09.68 (18.14)	--
S. E. ±	0.500	0.475	0.758	0.398	0.277	0.365	0.366	0.353	--
C. D. (P = 0.05)	1.459	1.387	2.211	1.163	0.809	1.065	1.068	0.996	--

Values in parenthesis are the arc sin transformation of mean values, which are average of three replicas.
A = Neem, B = Gorakhmundi, a = aqueous extract, b = Alcoholic extract, c = acetone extract, I = 0.25 %, II = 0.50%.

extract (0.50%) > aqueous gorakhmundi extract (0.25%) > alcoholic gorakhmundi extract (0.25%). The loss of greengram seed weight by *C. chinensis* L. was observed as much as 9.68 % in untreated control; it was reduced to 1.66 % by application of alcoholic extract of neem at 0.50 % concentration, which was statistically superior to other treated groups. These findings were in agreement with the results of Chowdhary (1990), who found that the oil of neem @ 0.25/100g seed provided significant reduction in seed damage. Miah *et al*., (1993) revealed that use of plant material reduced the weight losses of seed in Chickpea by *Callosobruchus chinensis*. Singh (1995) reported that vegetable oils are effective to control loss of seed up to few months. Misra (2000) reported no loss in seed weight and no damage to quality of legume seeds against *C. chinensis* when treated with plant powders viz., *Azadirachta indica, Annona squamosa, Vitex nigundo, Lantana camara, Datura strantonium, Acorus calamus, Aegle marmelos* and oil of *Brassica nigra* up to 150 days of treatment. Singh *et al.,* (2001) revealed that neem oil and neem leaf powder appear to be most effective to minimize the percent grain damage and prevent loss in seed weight by pulse beetle, *C. chinensis* in stored pea grains and reported as safer grain protectant. Singh (2003) reported minimum loss in seed weight i.e. 1.33 % up to 6 months of storage for pigeon

pea seed against *C. chinensis* L. Ghosal *et al.*, (2005) revealed insecticidal effect of some plant oils against stored legume pest, *C. chinensis*. Recently, Braga *et al.,* (2007) reported reduction in egg laying and percentage of egg hatched indicating reduction in infestation of cowpea seeds by cowpea weevil, *C. maculatus.* Bakkali *et al.*, (2008) stated that essential oils of plant contains variety of terpenes, which can acts as pro-oxidants affecting inner cell membrane like mitochondria and made mitochondrial dysfunction by changing intracellular redox potential.

The Neem tree, *Azadirachta* is so far the most promising example of plant currently used in pest control. Its biopesticidal properties, mode of action and effect on pest as well as natural enemies were already reported by Schmutterer (1990). The gorakhmundi, *S. indicus* is reported as biocidal plant (Patole and Mahajan, 2008). Further researches to purify active ingredients from these plants and to test their efficacy under field conditions is needed as it could serve as an ecofriendly tool for reducing the damage caused by pulse beetle, *C. chinensis*.

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Biology of predatory beetle, *Chilocorus infernalis* Mulsant (Coleoptera: Coccinellidae) on San Jose scale, *Quadraspidiotus perniciosus Comstock* (Homoptera : Diaspididae)

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ABSTRACT

In vitro study on the biology of lady bird beetle, *Chilocorus infernalis on* san jose scale revealed that mean duration of pre-mating, mating, oviposition, incubation, total grub, pre-pupal and pupal stages lasted for 5.20 ± 0.83, 49.20 ± 12.56 (minutes), 29.40 ± 3.78,6.30 ± 0.82, 16.80 ± 0.87,2.60 ± 0.51 and 8.40 ± 0.51 days respectively. The mean adult longevity of male and female was 41.60 ± 2.07 and 67.40 ± 10.81 days with sex ratio of 0.98: 1, respectively.

Keywords: *Chilocorus infernalis,* predatory beetle, biology, San Jose scale,

San jose scale, *Quadraspidiotus perniciosus* Comstock, the most destructive of all armored scales found in almost all the temperate orchards throughout the world, attacks nearly 200 different species of fruits, shrubs and ornamental plants under 26 families (Pruthi and Rao, 1951). Although its exact type locality and range are yet unknown, it is believed to be the native to North China, Soviet Far East and North Korea (Rosen and Debacks, 1978). In India this pest is understood to get entry for the first time in Kashmir Valley during the first decade of 20th century along with some flowering plants such as *Cydonia japonica* Lind. In the Valley, it has broadened its ambit host range in almost all locations and habitations and has been reported earlier to infest more than 70 plants (Masoodi and Trali, 1987). At present it is considered to be a major key pest of apple, besides plum, pear, peach and roses in temperate areas of Jammu and Kashmir, Himachal Pradesh and Uttranchal. The damage is caused by both nymphs and female adult scales which suck the sap from twigs, branches and fruits. As a result the growth of infested plants is checked and in case of heavy infestation, often at younger stages, death of plants occurs. The mode of living of this pest is interesting that is under waxy covering, with high reproductive potential, due to which its chemical control is almost difficult necessiated the use of bioagents. Among the natural enemies, the lady bird beetle, *Chilocorus infernalis* Mulsant was found to be an effective and potential predominant predator beetle on San Jose scale in the Kashmir province (Kapur, 1954). Further Rawat *et al.* (1988) and Thakur *et al.* (1989) noted that *C. infernalis* feeds voraciously on San Jose scale in different localities of Jammu & Kashmir and Himachal Pradesh. However, survey of literature revealed that there is no work on the biology of this predator under Kashmir conditions and this work reports on the work done here invitro.

MATERIALS AND METHODS

The study on various aspects of biology of *C. infernalis* was carried out in Biocontrol Laboratory, Division of Entomology, SKUAST-K, Shalimar, Srinagar at 25-30°C (27±1°C) temperature and 65-70 (67.52±5) % relative humidity on San Jose scale infested pumpkins, using insect rearing cages of 30 cm^3, having 40- mesh wire gauge on three sides, wooden top and bottom and wooden sliding door on front side. For the establishment of culture of host on pumpkin, the San Jose scale infested twigs were collected from an unsprayed apple orchard located at Haripora, Shopian. The pumpkins were washed with tap water and surface sterilized with cotton soaked in 5 % formaldehyde solution and completely dried to get free from formaldehyde smell.

The crawlers were picked up with the help of a fine tip of camel hairbrush and then released on sterilized pumpkins. The pupae of C. *infernalis* were also collected from the field and kept in laboratory for the adult emergence. The freshly emerged beetles were examined to separate the sex and released as pairs on San Jose scale infested pumpkins in

rearing cages to observe pre-mating, mating, pre-oviposition and oviposition periods. To note the fecundity of the beetle, the pumpkins were removed and examined twice a day with the help of a hand lens (10 X magnifications) to mark the freshly laid eggs. The total number of eggs laid by each female during the oviposition period was recorded to denote the fecundity. This was replicated five times. Incubation period was studied by using freshly laid eggs obtained from laboratory culture and placed over filter paper in closed petriplates. The neonated grubs were transferred into San Jose scale infested pumpkins. The observations were recorded on the instar wise grub, total grub, prepupal, and pupal periods. This was replicated ten times. The sex ratio and adult emergence was observed by using two hundred fifty pupae in five replications of fifty each, kept separately in rearing cages and subsequently watched for adult emergence. The beetles were sorted into male and female on the basis of abdominal breadth and general size. Females had broader abdomen and are larger in size than males. Sex wise adult longevity was also observed by using 10 pairs of freshly emerged beetles and periodical observations were recorded after every 24 hours for their survival.

RESULTS AND DISCUSSION

The result pertaining to biology of the predatory beetle, C. *infernalis* is presented in Table 1. It was found that when the freshly emerged beetles were released on San Jose scale infested pumpkins, after feeding, they remained in pair. The adults mated 4-6 days with an average of 5.20 ± 0.83 days after emergence. This is in conformity with that of 4 to 7 days with an average of 5.4 days as reported by Ahmad (1970). The mating period lasted from 30 to 71 (49.20 ± 12.56) minutes. The data collected on pre-oviposition period revealed that the female started egg laying after 9 to 15 (12.40 ± 2.30) days after emergence. Similar observation was made by Mugo (1996) who recorded 12.4 ± 0.28 days in C. *nigripes.* The eggs were often laid by C. *infernalis* singly and in batches of 2 to 3 each, under scale coverings but some eggs were also noticed in between the scales or glued to the pumpkin among the scales. The results indicated that the egg laying capacity of each female ranged from 125 to 170 with an average of 145 ± 19.36 eggs during the oviposition period of 25 to 30 with mean of 29.40 ± 3.78 days. Here findings are in close conformity with the results of Singh (1993) who reported that the egg laying capacity ranged from 123 to 161 eggs with an average of 146 eggs during the oviposition period of 23 to 33 days. However, Jiao *et al. (1997)* recorded high fecundity range of 202 to 815 eggs with an average of 423 eggs with longer oviposition period of 2 months.

The freshly laid eggs were ivory yellow, turning to dull yellow and finally darkening before hatch. The incubation period lasted for 5 to 7 days with mean of 6.30 ± 0.82. The present findings are in close agreement with the results of Muralidharan (1994) and Mugo (1996) according to whom the mean incubation period lasted for 6.11 ± 0.09 and 7.4 days, respectively. The grubs from eggs emerged out by a series of up thrust movement with the body bent and extended. All the four grub instars could easily be distinguished on the basis of body size, head capsule, width and exuvae left after molting. The four consecutive grub instars were completed in 3 to 4 (3.50 ± 0.52), 3 to 4 days (3.80 ± 0.42), 4 to 5 (4.30 ± 0.48) and 4 to 6 days (5.20 ± 0.78), respectively with the total grub period of 15 to 18 days (16.80 ± 0.87). These biological parameters are in close agreement with the findings of Jiao and Jiao (1997) recording the mean grub duration of all the four instars as 3.80 ± 0.8, 4.1 ± 0.9,4.5 ± 0.7 and 5.8 ± 1.3 days, respectively.

Table 1: Duration of different developmental stages of *C. **infernalis*** on San Jose scale

Stage	Duration		Mean	SD
	Min.	Max.		
Pre-mating period	4	6	5.20	0.83
Mating period	30	71	49.20	12.56
Pre-ovi positi on	9	15	12.40	2.30
Oviposition period	25	35	29.40	3.78
Fecundity (number)	125	170	145.00	19.36
Incubation period	5	7	6.30	0.82
I instar	3	4	3.50	0.52
II instar	3	4	3.80	0.42
III instar	4	5	4.30	0.48
IV instar	4	6	5.20	0.78
Total grub period	15	18	16.80	0.87
Pre-pupal period	2	3	2.60	0.51
Pupal period	8	9	8.40	0.51

SD: Standard deviation,

The full grown grub showed slightly retarded movement with their body length stretched and swelled up, thus entering into pre-pupal stage. The total pre-pupal and pupal stage varied from 2 to 3 and 8 to 9 (2.60 ± 0.51) and (8.40 ± 0.51) days, respectively. Ahmad (1970) also reported mean pupal period of 8.6 days. The observations further recorded on male female sex ratio revealed that out of 250 pupae, 244 (97.6%) adult beetles emerged out of which 121 male and 123 female beetles. The over all male and female sex ratio was computed to be 0.98: 1. It was found that the female adult beetle lived longer than the male adult beetle and the present finding is in close conformity with the findings of Muralidharan (1994). The female lived for 55 to 81 (67.40 ± 10.81) days, while the male beetle lived for 40 to 45 (41.60 ± 2.07) days. The fecundity data indicated some

variations which may be due to the varying agro-climatic conditions in the Kashmir.

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Efficacy of indigenous materials against *Aphis gossypii* on okra

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ABSTRACT

Investigations on the efficacy of indigenous materials singly and in combination against *A. gossypii,* carried out during *kharif* 2005-06 at Main Agricultural Research Station, Dharwad, revealed that the efficacy of NSKE (5%) + green chilli kerosene [GCK] (0.5%) + cow urine [CU] (5%) treatment was comparable to that of oxydemeton methyl 25EC (0.15%) in reducing the aphid population. The next best treatments included GCK +CU + cow dung [CD], GCK+CU, green chilli extract [GCE] + CU+CD, GCK and NSKE. The maximum good fruit yield was recorded in NSKE+ GCK+CU (41.55 q ha^{-1}) with highest IBC ratio (15.8 :1.0) followed by GCK+CU+CD (37.57q ha^{-1} with IBC ratio 14.5 :1) and GCK+CU (37.56q ha^{-1} with IBC ratio 14.5 :5.0). All the indigenous materials proved safe to natural enemies in okra ecosystem.

Key words: Aphids, indigenous materials, green chilli kerosene, okra.

Okra (*Abelmoschus esculentus* L. Moench) is an extensively cultivated vegetable crop in India. It is one of the important dietary requirements containing several nutritional values. One of the important limiting factors in the cultivation of okra is damage caused by insect pests. Of 72 species of insects recorded on okra (Srinivasa Rao and Rajendran, 2002), the sucking pests, particularly the most predominant aphid, *Aphis gossypii,* are the important ones that suck the sap continuously, make the plants weak and ultimately result in low yield.

A number of chemical insecticides are being indiscriminately sprayed on this vegetable crop which poses many problems like insecticidal resistance, toxic residues in fruits causing health hazards, environmental pollution and adverse effect on natural enemy fauna. To overcome these problems, development of pest management strategies utilizating indigenous materials which by virtue of their having insecticidal properties coupled with quick biodegrading nature may be the suitable alternatives to chemical pesticides (Rajasekharan and Kumarswamy, 1985) is the need of the hour. Since, the information on the efficacy of these against aphids in okra ecosystem is scarce, the present investigation was carried out.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2005-06 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. It was laid out in randomized block design with eleven treatments involving nine combinations of indigenous materials namely green chilli (GCK) 5% + cow urine (CU) 5%, green chilli kerosine (GCK) 5% + cow urine (CU) 5% + cow dung (CD) 1%, NSKE (2.5%) + green chilli kerosine (GCK) 0.5% + cow urine (CU) 5%, lantana extract (LE) 5% + vitex extract (VE) 5% + cow urine (CU) 5%, NSKE 5%, green chilli kerosine (GCK) 0.5%, cow urine (CU) 5% + cow dung (CD) 1%, green chilli extract (GCE) 3% + cow urine (CU) 5% + cow dung (CD) 5% biogas plant surry (BPS) 20% oxydemetion methyl 0.15% as standard chemical check and an untreated control in three replications. The okra hybrid, Rasi-5 was sown at a spacing of 90´30 cm over a plot size of 4.0´3.6 m and the crop was raised by following all recommended packages except insecticidal interventions.

Two need based sprays were imposed. The population count of aphids was made on two apical leaves of each of the five randomly selected plants one day before (pre-treatment) and 3 and 7 days after each spray (post-treatment) and accordingly, the per cent reduction in pest population was calculated. The observations were also made on the activity of predatory population at 7 days of each spray. The

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yield of marketable fruits was recorded at each harvest and was converted on hectare basis. The cost economics for each treatment was worked out. The data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Effect on aphids

The pre-treatment counts made a day before each spraying indicated that there was no significant difference among the treatments (Table 1).

After three days of first spraying, the treatment combination of NSKE+GCK+CU registered significantly lowest aphid population (6.93 aphids/2 leaves) showing highest pest reduction (81.4%). The other indigenous material combinations *viz*., GCK+CU+CD, GCK+CU, GCE+CU+CD, GCK, NSKE and LE + VE + CU recorded aphid population on par with each other (8.54, 8.57, 8.87, 9.93, 10.76 and 12.56 aphids/2 leaves, respectively) with a mortality range of 72.89 to 37.80%. In contrast, the ineffectiveness of CU+CD and BPS treatments was evident from the higher aphid population (20.33 and 20.54 aphids/ 2 leaves) with least pest mortality (36.46 and 34.87%, respectively). However, oxydemeton methyl registered highest reduction (83.87%) as compared to the indigenous materials. A similar trend in the efficacy of various treatments was observed after seven days of treatment imposition.

After second spray also, the application of NSKE+ GCK+CU registered highest pest mortality (83.51% at 3rd day and 82.79% at 7 days after application, respectively). The efficacy of other treatments against aphids was in the order of GCK+CU+CD> GCK+CU > GCE+CU+CD > GCK> NSKE > LE+VE+CU > CU+CD and BPS both at three and seven days of spray with the pest reduction range of 76.70 to 34.88% at 3 DAS and 74.49 to 34.65 % at 7 days after spray.

The superiority of oxydemeton methyl in reducing the aphid population is in accordance with Jayakumar (2002) and Patel *et al*. (2003). The higher efficacy of different indigenous materials *viz*., NSKE+GCK+CU followed by GCK+CU+CD, GCK+CU, GCE+ CU+CD, GCK and NSKE against the aphid population as revealed in the study is in agreement with the reports of Thomas (1995), Vijayalakshmi *et al*. (1997), Srinivasa Murthy and Sharma (1997), Patil *et al*. (1990), Pawar *et al*. (2000) and Jayakumar (2002) in different crop ecosystems.

Table 1: Efficacy of indigenous materials against *A. gossypii* on okra

Treatments	No. of aphids 2 apical leaves^{-1}									
	I - spray					II - spray				
	1 DBS	3 DAS	PR	7 DAS	PR	1 DBS	3 DAS	PR	7 DAS	PR
GCK (0.5%)+CU (5%)	31.64	8.57c	72.81	9.30c	70.60	25.03	5.96b	76.18	6.33b	74.71
GCK (0.5%)+CU (5%)+ CD (1%)	31.51	8.54c	72.89	9.33c	70.39	25.33	5.90b	76.70	6.46b	74.49
NSKE (2.5%)+ GCK (0.5%) +CU (5%)	30.03	6.93b	81.40	7.03b	78.64	24.03	4.03a	83.51	4.26a	82.79
LE (5%)+VE (5%)+CU (5%)	29.77	12.56d	57.80	14.53d	51.19	25.70	10.86c	61.64	11.70d	54.47
NSKE (5%)	30.85	10.76cd	65.12	11.86cd	61.56	26.03	7.43b	71.45	8.53c	67.23
GCK (0.5%)	31.56	9.93cd	68.92	10.46c	67.27	26.33	6.33b	75.95	7.04b	73.26
CU (5%)+CD (1%)	32.12	20.33e	36.46	20.76e	68.27	27.03	16.76d	37.99	17.03e	36.99
GCE (3.0%)+CU (5%)+CD (5%)	31.08	8.87c	71.46	9.86c	68.27	24.86	5.96b	76.02	6.54b	73.69
BPS (20%)	32.03	20.54e	34.87	20.93e	33.65	27.13	17.46d	34.88	17.96e	34.65
Oxy demeton methyl (0.15%)	30.46	4.83a	83.87	5.03a	83.11	24.33	3.73a	84.03	4.03a	83.01
Untreated control	32.54	30.02f	-5.80	30.05f	-7.94	27.33	26.96e	-1.35	26.73	-2.19
S.Em.±	0.21	0.13	-	0.13	-	0.20	0.13	-	0.13	-
C.D. at 5%	NS	0.39	-	0.37	-	NS	0.38	-	0.38	-
C.V. (%)	6.37	7.03	-	6.60	-	6.92	7.47	-	6.72	-

GCK – Garlic chilli kerosene extract NSKE – Neem seed kernel extract BPS – Biogas plant slurry CD – Cow dung
LE – *Lantana camara* extract VE – *Vitex negundo* extract GCE – Garlic chilli aqueous extract CU– Cow urine
DBS – Day before spraying DAS – Days after spraying NS – Non-significant PR - Per cent reduction
Means followed by same alphabet do not differ significantly by DMRT (P=0.05) Statistical analysis was made for Öx+0.5 transformed value

Table 2: Influence of different indigenous materials on natural enemies, fruit yield and IBC ratio in okra ecosystem

Treatments	Coccinellid grubs (No pl^{-1})		Spiders (No pl^{-1})		*Chrysoperla* grubs (No pl^{-1})		Good fruit yield (q ha^{-1})	IBC ratio
	I spray	II spray	I spray	II spray	I spray	II spray		
GCK (0.5%)+CU (5%)	0.60	0.57	0.66	0.57	0.60	0.53	37.56 abc	14.5 :1.0
GCK (0.5%)+CU (5%)+CD (1%)	0.63	0.50	0.63	0.53	0.62	0.53	37.57abc	14.5 :1.0
NSKE (2.5%)+GCK (0.5)+ CU (5%)	0.70	0.66	0.80	0.76	0.70	0.70	41.55 a	15.8 :1.0
LE (5%)+VE (5%)+CU (5%)	0.80	0.80	0.94	0.90	0.80	0.80	29.53 ef	9.0 :1.0
NSKE (5%)	0.76	0.73	0.86	0.80	0.73	0.73	32.42 de	8.6 :1.0
GCK (0.5%)	0.63	0.63	0.60	0.60	0.60	0.56	34.50 cd	11.5 :1.0
CU (5%)+CD (1%)	0.77	0.75	0.86	0.86	0.70	0.69	26.39 f	4.8 :1.0
GCE (3.0%)+CU (5%)+CD (5%)	0.63	0.70	0.86	0.76	0.66	0.66	36.69 bc	8.9 :1.0
BPS (20%)	0.82	0.80	0.80	0.80	0.73	0.70	26.13 f	4.5 :1.0
Oxydemeton methyl (0.15%)	0.50	0.47	0.40	0.53	0.43	0.43	40.21ab	11.4 :1.0
Untreated control	0.92	0.88	1.03	1.10	0.93	0.90	22.02 g	-
S.Em.±	0.06	0.058	0.07	0.08	0.08	0.07	1.96	-
C.D. at 5%	NS	NS	NS	NS	NS	NS	5.87	-
C.V. (%)	9.13	9.36	9.07	9.13	11.66	11.28	9.24	-

GCK – Garlic chilli kerosene extract NSKE – Neem seed kernel extract CU – Cow urine CD – Cow dung
LE – *Lantana camara* extract VE – *Vitex negundo* extract GCE – Garlic chilli aqueous extract
BPS – Biogas plant slurry NS – Non-significant

Effect on natural enemies

The natural enemies fauna in okra ecosystem was not much influenced owing to spray imposition as evidenced by non-significant difference observed among various treatments after seven days of application (Table 2). Thus, all the treatments proved to be safe to natural enemies *viz.*, coccinellid grubs, spiders and *Chrysoperla* grubs. These findings are in agreement with Jayakumar (2002) who observed the safety of many plant products to natural enemies. Further, the studies are also supported by Rosaiah (2001a and 2001b) who documented safety of plant products in okra and brinjal ecosystem. The safety of neem products to natural enemies especially to spiders has been documented by Kaethner (1991) and Guddewar *et al.* (1994). However, on numerical basis, garlic chilli extract treatments recorded relatively lower number of natural enemies as compared to other products. The findings of Naseeh (1982), Bhaskaran (1995) and Jayakumar (2002) on garlic extracts against natural enemies support the present observations.

Yield and IBC ratio

Among the various treatments, NSKE+GCK+CU and oxydemeton methyl recorded significantly higher good fruit yield (41.55q ha^{-1} and 40.21q ha^{-1}, respectively). However, these treatments failed to differ statistically from GCK+CU+CD (37.57q ha^{-1}), GCK+CU (37.56q ha^{-1}) and GCE+CU+CD (36.69q ha^{-1}). The next treatments were GCK (34.50 q ha^{-1}) and NSKE (32.42 q ha^{-1}) (Table 2). The higher yields obtained by applying effective indigenous materials are in confirmation with Jayakumar (2002) and Hegde (2004).

With regard to the cost effectiveness, the indigenous materials in general proved superior. Although, the oxydemeton methyl treatment recorded the yield on par with indigenous materials, it could not reveal high incremental benefit cost (IBC) ratio due to high input cost. The maximum IBC ratio of 15.8:1.0, 14.5:1.0 and 14.5:1.0 were obtained in NSKE+GCK+CU, GCK+CU+CD and GCK+CU treatments as compared to oxydemeton methyl (11.4:1.0) (Table 2). These findings are in accordance with Jayakumar (2002) and Patil (2003).

The studies thus reveal that the efficacy of NSKE+GCK +CU treatment is closely related to that of oxydemeton methyl 25EC [0.15%] against *A. gossypii* on okra. The next best treatments included GCK+CU+CD, GCK+CU, GCE+CU+CD, GCK and NSKE. The maximum good fruit yield was recorded in NSKE+GCK+CU with highest IBC ratio, followed by GCK+CU+CD and GCK+CU.

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Field evaluation of entomopathogenic fungus, *Acremonium zeylanicum* (Petch) W. Gams and H. C. Evans against sugarcane woolly aphid, *Ceratovacuna lanigera* Zehtner

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ABSTRACT

Field evaluation of entomopathogenic fungi, *A. zeylanicum* against sugarcane woolly aphid revealed significant reduction of pest grade in treatments with higher concentrations of the fungus (1×10^{10} conidia/l and 1×10^{8} conidia/l) which recorded 2.01 and 2.40 grade, respectively at 14 days after spraying. However, lower concentrations reduced the pest intensity at moderate level. In general, there was significant reduction in aphid population after 14 days of application in all the fungal treatments (63.47, 50.29, 46.24 and 36.25 % reduction in T_1, T_2, T_3 and T_4, respectively) in spite of increasing trend in the aphid population as evidenced from untreated check. The influence of fungal sprays on natural enemies indicated that population of *Encarsia flavoscutellum* Zehntner reduced from 14.35 to 9.90 adults/leaf in 1×10^{10} conidia/l concentration due to reduced aphid number. However, the population of the predators (*viz*., *Micromus igorotus* Banks and *Dipha aphidivora* Meyrick) was not much influenced by the treatment imposition.

Key words: *Acremonium zeylanicum*, sugarcane woolly aphid, *Ceratovacuna lanigera*

Sugarcane is the primary raw material for all major sweeteners produced in the country. It also supports two important cottage industries *viz*. *Gur* (jaggery) and Khandsari industries, which together produce about 10 million tonnes of sweeteners by consuming about 28 to 35 % of the cane produced in the country. Cane yield is markedly influenced by many factors like soil fertility, climate, variety, moisture stress, cultivation practices, weeds, insect pests and diseases. The estimated loss from insects accounts to nearly 20 and 15 % in cane and sugar yield, respectively (Avasthy, 1997). In India, sugarcane is infested by more than 289 different species of pests, out of which 213 are insects. Of these, 20 species including moth borers, termites, white grubs, scale insects, *Pyrilla*, whiteflies, mealy bugs, armyworm etc have been considered as major pests. However, the recent havoc of sugarcane woolly aphid (SWA), *Ceratovacuna lanigera* Zehntner has been a new addition to the key pests of sugarcane causing severe loss in cane yield and sugar recovery during last few years (Patil *et al*., 2004).

Efforts have although been made to make use of available biocontrol agents like *Micromus igorotus* Banks and *Dipha aphidivora* Meyrick etc. in the management of SWA, the recently identified entomopathogenic fungus, *Acremonium zeylanicum* (Petch) W.Gams and H.C. Evans seems to be a potential bioagent against the pest (Tippannavar *et al*. 2006). Hence, primary investigations on this pathogen with regard to its utilization in the pest management were caried out.

MATERIALS AND METHODS

Different concentrations of the fungus were evaluated against SWA in farmer's field on 8 month old sugarcane crop (Co-86032 variety) in Gotur village near Agricultural Research Station, Sankeshwar. Sugarcane plots with more or less uniform pest density were selected for the study. The experiment was laid out in Randomized Block Design with five treatments replicated four times over a plot size of 10 x 5 meter. The crop was sprayed twice at an interval of 10 days

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with different concentrations of the fungal suspension *viz.* $1X10^{10}$, $1X10^{8}$, $1X10^{6}$, and $1X10^{4}$ conidia/l. An untreated check was maintained by spraying water along with 0.2 % Tween 80.

The pre and post treatment observations on number counts of aphids, aphid grade and natural enemies on five leaves selected at random in each plot at 1, 3, 7 and 14 days after spray were made. The aphid grade was recorded at 1 to 6 scale as rated below.

Aphid grade	Leaf coverage by aphids
1	No infestation
2	1 to 20% leaf coverage
3	21 to 40% leaf coverage
4	41 to 60% leaf coverage
5	61 to 80% leaf coverage
6	81 to 100% leaf coverage

Observation on aphid count was taken by counting number of aphids present in 2.5 cm^2 window on leaf while, observations on natural enemies was made from 5 leaves per plot. The data after suitable transformation were subjected to statistical analysis.

RESULTS AND DISCUSSION

Aphid grade

The initial pest grade a day before imposition of treatments, was statistically on par among all the treatments which ranged from 4.35 to 4.60 indicating uniform distribution of the pest in the experimental field (Table 1). After 3 days of application however, there was significant reduction in pest grade both in 1×10^{10} conidia/l (3.80) and 1×10^{8} conidia/l (3.95) treatments as compared to other treatments. Further, a week after spray, the pest grade was reduced to 2.15 in the highest concentration treatment followed by 2.75 in 1×10^{8} conidia/l concentration. However, T_3 and T_4 also recorded pest grade (3.2 and 3.5, respectively) superior over untreated check (4.80). At 14 DAS, there was further reduction in pest grade in all the fungus treated plots (2.01, 2.40, 3.00 and 3.80 in T_1, T_2, T_3 and T_4, respectively) which differed significantly among each other.

Aphid population

Even before the application of treatments, there was varied aphid population in the experimental area, as indicated by statistical variation observed a day before spraying (Table 2). However, after 3 days of treatment imposition, there was significant reduction (13.71 to 25.08%) in aphid population in all the treatments (90.42, 95.29, 107.65 and 113.56 aphids /2.5cm^2 in T_1, T_2, T_3 and T_4, respectively).

Table 1. Field evaluation of *Acremonium zeylanicum* against sugarcane woolly aphid (aphid grade)

Treatments	Aphid grade (1-6 scale)			
	1 DBS	3 DAS	7 DAS	14 DAS
$1X10^{10}$ conidia/l	4.35a	3.80c	2.15e	2.01e
$1X10^{8}$ conidia/l	4.60a	3.95bc	2.75d	2.40d
$1X10^{6}$ conidia/l	4.40a	4.20abc	3.20c	3.00c
$1X10^{4}$ conidia/l	4.45a	4.40ab	3.50b	3.80b
Untreated check	4.35a	4.64a	4.80a	4.85a
S. Em. ±	0.265	0.327	0.079	0.084
C.D. at 5%	0.942	1.164	0.280	0.299
C.V. (%)	11.95	15.58	4.80	5.24

Means followed by same letter in the column do not differ significantly by DMRT (P=0.05)

DAS -Days after spraying DBS- Day before spraying

At 7 DAS, as high as 40.07% population reduction was observed in T_1 followed by T_2, T_3, T_4 and T_5 which varied statistically with each other. Similarly, at 14 days of application also all the treatments varied significantly among themselves with highest mortality being recorded in 1×10^{10} conidia/l treatment (63.47%) followed by T_2, T_3 and T_4 (50.29, 46.24 and 36.25%, respectively).

Natural enemies

Prior to imposition of the sprays, the field population of *Encarcia flavoscutellum* was quite high (14.35 to 17.80 adults $leaf^{-1}$) as compared to very low population of *Micromus igorotus* (0.10 to 0.25 grubs $leaf^{-1}$) and negligible number of *Dipha aphidivora* (0.00 to 0.10 larvae $leaf^{-1}$) available in the experimental area (Table 3).

With regard to *E. flavoscutellum,* the population was immediately affected in all the treatments including untreated check (9.60 to 11.85 adults $leaf^{-1}$). However, after 7 and 14 days of spray, the population was not much influenced which varied from 9.65 to 12.60 adults $leaf^{-1}$ and 9.90 to 13.05 adults $leaf^{-1}$, respectively.

The population of both the predators (*M. igorotus* and *D. aphidivora*) was not affected by treatment imposition as indicated by the level of population observed in each treatment over a period of time. *M. igorotus* population ranged from 0.10 to 0.25, 0.10 to 0.30, 0.15 to 0.30 and 0.05 to 0.30 grubs $leaf^{-1}$ at 1 DBS, 3, 7 and 10 DAS, respectively.

Table 2. Field evaluation of *Acremonium zeylanicum* against sugarcane woolly aphid (Aphid count)

Treatments	No. of aphids 2.5 cm^2 $leaf^{-1}$						
	1 DBS	3 DAS	% reduction	7 DAS	% reduction	14 DAS	% reduction
$1X10^{10}$ (conidia l^{-1})	120.70c	90.42e	25.08	72.33e	40.07	44.09e	63.47
	(11.01)	(9.54)		(8.53)		(6.68)	
$1X10^{8}$ (conidia l^{-1})	122.85c	95.29d	22.00	76.93d	37.37	61.06d	50.29
	(11.11)	(9.79)		(8.80)		(7.85)	
$1X10^{6}$ (conidia l^{-1})	129.45bc	107.65c	17.74	81.65c	36.92	69.58c	46.24
	(11.40)	(10.40)		(9.06)		(8.37)	
$1X10^{4}$ (conidia l^{-1})	131.25b	113.56b	13.71	95.88b	26.94	83.67b	36.25
	(11.48)	(10.68)		(9.82)		(9.17)	
Untreated check	140.20a	142.98a	-1.90	145.90a	-4.06	147.69a	-5.34
	(11.86)	(11.98)		(12.10)		(12.17)	
S. Em. ±	0.221	0.058	-	0.026	-	0.032	-
C.D. at 5%	0.787	0.206	-	0.091	-	0.113	-
C.V. (%)	3.92	1.11	-	0.53	-	0.72	-

Means followed by same letter in the column do not differ significantly by DMRT (P=0.05)
The figures in the parentheses are square root transformed values
DAS -Days after spraying DBS- Day before spraying

Table 3. Influence of entomopathogen, *A. zeylanicum* on natural enemies of sugarcane woolly aphid

Treatments	*Encarsia flavoscutellum* (No. of adults $leaf^{-1}$)				*Micromus igorotus* (No. of grubs $leaf^{-1}$)				*Dipha aphidivora* (No. of larvae $leaf^{-1}$)			
	1 DBS	3 DAS	7DAS	14 DAS	1 DBS	3 DAS	7 DAS	14 DAS	1 DBS	3 DAS	7 DAS	14 DAS
$1X10^{10}$	14.35b	9.60b	9.65c	9.90c	0.10c	0.10c	0.15b	0.05b	0.00b	0.00b	0.00b	0.00b
(Conidia/l)	(3.85)	(3.18)	(3.19)	(3.22)	(0.77)	(0.77)	(0.81)	(0.74)	(0.71)	(0.71)	(0.71)	(0.71)
$1X10^{8}$	15.10b	9.80b	10.35c	9.95c	0.15bc	0.15bc	0.15b	0.10b	0.00b	0.00b	0.00b	0.00b
(Conidia/l)	(3.95)	(3.21)	(3.29)	(3.23)	(0.81)	(0.81)	(0.81)	(0.77)	(0.71)	(0.71)	(0.71)	(0.71)
$1X10^{6}$	15.30b	10.15b	12.00b	11.25b	0.20ab	0.20ab	0.20ab	0.20a	0.00b	0.05ab	0.00b	0.00b
(Conidia/l)	(3.97)	(3.26)	(3.54)	(3.43)	(0.84)	(0.84)	(0.84)	(0.84)	(0.71)	(0.74)	(0.71)	(0.71)
$1X10^{4}$	16.30ab	10.95b	12.40a	13.20a	0.25a	0.20ab	0.20ab	0.25a	0.05ab	0.10a	0.05ab	0.05ab
(Conidia/l)	(4.10)	(3.28)	(3.63)	(3.70)	(0.87)	(0.84)	(0.84)	(0.87)	(0.74)	(0.77)	(0.74)	(0.74)
Untreated check	17.80a	11.85a	12.60a	13.05a	0.25a	0.30a	0.30a	0.30a	0.10a	0.10a	0.10a	0.10a
	(4.28)	(3.51)	(3.62)	(3.68)	(0.87)	(0.89)	(0.89)	(0.89)	(0.77)	(0.77)	(0.77)	(0.77)
S. Em. ±	0.169	0.085	0.093	0.063	0.040	0.044	0.043	0.041	0.024	0.030	0.024	0.024
C.D. at 5%	0.600	0.303	0.331	0.223	0.141	0.156	0.154	0.144	0.084	0.107	0.084	0.084
C.V. (%)	8.42	5.16	5.38	3.65	9.55	10.59	10.41	9.90	6.51	8.15	6.51	11.09

Means followed by same letter in the column do not differ significantly by DMRT (P=0.05)
The figures in the parentheses are square root transformed values
DAS -Days after spraying DBS- Day before spraying

Similarly, *D. aphidivora* population also varied from 0.00 to 0.10 in all the treatments at different intervals.

There are no previous reports on the field evaluation of *A. zeylanicum* on any of the pest species. However, the present findings on the efficacy of *A. zeylanicum* against SWA are in line with the findings of many workers on other entomopathogenic fungi viz., *Metarhizium anisopliae* Metschinikoff. (Nirmala, 2003; Puttannavar, 2004), *Verticillium lecanii* Zimmerman (Jayaraj, 1989; Nirmala 2003) evaluated on SWA and other crop pests.

In the context of sustainable production, environmental concern, globalization of economy, emphasis on organic farming, the priority would be to reduce the production cost by lowering the intervention cost towards pest management through ecofriendly approaches. From the field evaluation data, it was clear that the fungus was able to suppress the

pest effectively after 14 days of treatment imposition. The aphid grade as well as aphid number/ 2.5 cm^2 reduced considerably with increased concentration of the fungus and decreased with lapse of time. The natural enemies population was not much influenced by the application of fungal sprays. Based on the results of the present investigation, *A. zeylanicum* seems to be potential against SWA and hence could be better utilized in the management of SWA.

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Attraction of syrphid predators in the management of sugarcane woolly aphid

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ABSTRACT

Field studies undertaken to evaluate the role of different attractants in enhancing the activity of syrphids namely, *Eupodes confrater* and *Dideopsis aegrota* in sugarcane ecosystem revealed that molasses and fruit fly diet attractants recorded comparatively more syrphid population (59.25 - 64.49% and 55.48 - 57.67% increase, respectively) eventually registering lower mean aphid grades of 2.64 - 2.67 and 2.94 - 2.98, respectively. The next best treatment was jaggery solution which recorded 43.22 and 29.26% mean increase in larval population as influenced by 1st and 2nd spray application. However, sugar syrup and white coloured attractants proved less effective.

Key words: Sugarcane woolly aphid, syrphids, attractants, fruit fly diet

Sugarcane and sugar beet are the two main sources of white crystal sugar in the world. India contribute 20.4% area (4.32 m. ha) and 18.6% of production (2.70 m. t.) and ranks second among the sugarcane growing countries of the world in both area and production (Anon., 2005). Among 213 species of insects that attack sugarcane, the outbreak of *Ceratovacuna lanigera* Zehntner during 2002 in southern India caused severe loss in cane yield and sugar recovery (Patil *et al*., 2004a), estimated to the tune of 26% in yield and 24% in sugar content (Shankar and Shitole, 2004).

Sugarcane woolly aphid has become a major constraint in the sugarcane cultivation in recent years. Since crop ecosystem do not allow spraying operations due to dense canopy, the role of bioagents, particularly the predators, is of great significance. Among the important predators of sugarcane woolly aphid, syrphids, *Eupodes confrator* and *Dideopsis aegrota* play dominant role next to *Dipha aphidivora* and *Micromus igorotus*. Since, no attempt to exploit these predatory syrphids in SWA management has been made, the role of different attractants in enhancing their activity in sugarcane ecosystem was evaluated.

MATERIALS AND METHODS

A field trial, in farmer's field near Dharwad during 2006-07, with 8 treatments in three replications over a plot size of 7x8m on 7 to 8 months old standing sugarcane crop was laid out in Randomized Block Design.

Five per cent each of sugar syrup, jaggery, molasses and fruit fly diet were prepared using water. The treatments were imposed using Knapsack sprayer @ 400-500 litres of spray solution ha^{-1}. The crop received two sprays at 45 days interval. One of the treatments included white coloured attractants where in, the rectangular pieces (30 x 30cm) of muslin cloth attached to thermocol were kept in plots at the leaf canopy level @ 5000 pieces ha^{-1}.

The syrphid larvae were counted on 10 randomly selected leaves in each plot. The pre-treatment count was made a day before spray and the post treatment counts were taken on 10th, 20th, 30th and 40th day after each spray. Pre and post treatment observations on the aphid grade were also recorded by observing 10 leaves $plot^{-1}$. The untreated plot was maintained for comparison.

RESULTS AND DISCUSSION

Syrphid population

The maggot population in the experimental field, a day before imposition of treatments, was uniform. However, after ten days of application it was significantly higher (1.53 larvae $leaf^{-1}$) in plots treated with molasses followed by fruit fly diet (1.08 larvae $leaf^{-1}$) (Table 1). Other treatments stood at par with jaggery solution (0.80 larvae $leaf^{-1}$). Molasses and fruit fly diet showed maximum increase (337.14 and 217.65%, respectively) of larval population. The next to follow were jaggery and 5% sugar syrup with 135.29 and 103.13% increase, respectively.

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Table 1 : Effect of different attractants on syrphids attraction under 1st and 2nd application

Treatment	Number of larvae leaf^{-1}											
	1 DBA		10 DAA		20 DAA		30 DAA		40 DAA		Mean*	
	I	II	I	II	I	II	I	II	I	II	I	II
T_1 – Sugar syrup (5%)	0.32	0.36	0.65cd (103.13)	0.65bc (80.55)	0.56c (75.00)	0.55b (52.77)	0.42c (31.25)	0.42c (16.66)	0.39c (21.87)	0.38bc (5.55)	0.48 (57.81)	0.50 (38.88)
T_2 – Sugar syrup (2.5%)	0.37	0.39	0.60cde (62.16)	0.64bc (64.10)	0.51c (37.84)	0.52b (33.33)	0.42c (13.51)	0.41c (5.13)	0.38c (2.70)	0.37c (-5.13)	0.45 (29.05)	0.49 (24.36)
T_3 – Jaggery (5%)	0.34	0.41	0.80bc (135.29)	0.86b (109.76)	0.68bc (100.00)	0.61b (48.78)	0.54bc (58.82)	0.52bc (26.83)	0.46bc (35.29)	0.46bc (12.19)	0.62 (82.35)	0.61 (49.39)
T_4 – Molasses (5%)	0.35	0.42	1.53a (337.14)	1.60a (280.95)	1.28a (265.71)	1.30a (209.52)	0.89a (154.28)	0.94a (123.81)	0.72a (105.71)	0.73a (73.81)	1.11 (215.71)	1.14 (172.02)
T_5 – White coloured attractants (@5000/ha)	0.37	0.40	0.50de (35.13)	0.56cd (40.00)	0.51c (37.84)	0.54b (35.00)	0.52bc (40.54)	0.53bc (32.50)	0.49bc (32.43)	0.52abc (30.00)	0.50 (36.48)	0.54 (34.37)
T_6 – Fruit fly diet (5%)	0.34	0.41	1.08b (217.65)	1.32a (221.95)	0.96ab (182.35)	1.14a (178.05)	0.70ab (105.88)	0.85ab (107.32)	0.65ab (91.18)	0.67ab (63.41)	0.84 (149.26)	1.00 (142.68)
T_7 – Untreated check	0.36	0.38	0.37e (2.77)	0.40d (5.26)	0.35c (-2.77)	0.39b (2.63)	0.34c (-5.55)	0.37c (-2.63)	0.33c (-8.33)	0.35c (-7.88)	0.34 (-3.47)	0.38 (-0.65)
CD (5%)	NS	NS	0.13	0.11	0.14	0.17	0.10	0.16	0.10	0.97	-	-
S Em±	0.04	0.04	0.04	0.04	0.44	0.05	0.03	0.05	0.03	0.03	-	-
CV%	8.35	8.11	11.20	15.45	9.30	8.64	8.49	8.53	8.55	9.61	-	-

DBA- Day before application DAA-Days after application * Mean of post treatment counts Means followed by same letter in the column do not differ significantly by DMRT P=0.01) I & II - First & Second application

The figures in the parentheses are per cent increase in syrphid population

Table 2 : Woolly aphid infestation under different attractant treatments in 1st and 2nd application

Treatment	Aphid grade (1-6 scale)											
	1 DBA		10 DAA		20 DAA		30 DAA		40 DAA		Mean*	
	I	II	I	II	I	II	I	II	I	II	I	II
T_1 – Sugar syrup (5%)	3.23	3.76	2.93bc	3.03abc	3.03bc	3.16ab	3.10	3.20a	3.13	3.33a	3.04	3.18
T_2 – Sugar syrup (2.5%)	3.26	3.35	2.96bc	3.17cd	3.06bc	3.33ab	3.13	3.36a	3.16	3.56ab	3.08	3.36
T_3 – Jaggery (5%)	3.16	3.50	2.86abc	2.96abc	2.90bc	3.20ab	3.06	3.26a	3.10	3.43a	2.98	3.21
T_4 – Molasses (5%)	3.20	3.60	2.20a	2.5a	2.70b	2.90a	2.83	3.10a	2.86	3.26a	2.64	2.94
T_5 – White coloured attractants (@5000/ha)	3.33	3.33	3.00bc	3.06bc	3.10bc	3.10ab	3.16	3.16a	3.23	3.23a	3.12	3.14
T_6 – Fruit fly diet (5%)	3.26	3.50	2.30ab	2.53ab	2.66b	2.93a	2.80	3.15a	2.93	3.30a	2.67	2.98
T_7 – Untreated check	3.20	3.63	3.24c	3.66d	3.25c	3.70b	3.26	3.80b	3.3	3.90b	3.26	3.78
CD (5%)	NS	NS	0.6239	0.51	0.4096	0.63	NS	0.43	NS	0.37	-	-
S Em±	0.27	0.29	0.20	0.17	0.13	0.20	0.17	0.14	0.10	0.12	-	-
CV%	14.60	14.08	13.11	9.56	15.80	11.04	9.57	11.50	15.34	13.34	-	-

Aphid grade: 1: No infestation; 2: 1-20%; 3: 21-40%; 4: 41-60%; 5: 61-80%; 6: 81-100% infestation
DBA-Day before application DAA-Days after application * Mean of post treatment counts
Means followed by same letter in the column do not differ significantly by DMRT (P=0.01). I & II = 1st & 2nd application

The molasses and fruit fly diet application treatments continued to exhibit their supremacy in the attraction of adults even at 20, 30 and 40 days of application with 1.28 - 0.96, 0.89- 0.70 and 0.72- 0.65 larvae leaf^{-1}, respectively (Table 1). However, the per cent increase in larval population declined in all the treatments as the time advanced, which could be due to reduction of attractant efficacy with the time lapse.

Aphid grade

The SWA population grade ranged from 3.16 to 3.33 a day before imposition of treatments (Table 2). However, at 10 DAA, the molasses treatment recorded the least aphid grade (2.20) which was at par with fruit fly diet (2.30) and jaggery (2.86) application. By recording 3.00, 2.96 and 2.66 aphid grades, respectively, the treatments *viz*., white coloured attractants, sugar syrup (2.5% and 5%) remained inferior.

Similar trend in aphid grade was observed even at 20, 30 and 40 DAA. However, at a mean aphid grade of 2.64, molasses stood as the best treatment followed by fruit fly diet (2.67). In the other treatments, mean aphid grade varied between 2.98 and 3.12 whereas, the untreated check recorded a mean aphid grade of 3.26.

The data indicated similar trend in the efficacy of various attractants for attracting the syrphids. Molasses and

fruit fly diet further proved to be quite effective in attracting the syrphids. Accordingly, the aphid population build up was restricted in the effective treatments.

There are no previous reports on the attractant property of molasses to syrphids. However, Budenberg and Powell (1992) noticed increased female visit and egg laying by *E. balteatus* when honeydew was applied artificially. Evane and Swallow (1993) also reported positive response of syrphid adults to sugar application.

The studies thus revealed that the molasses and fruit fly diet attractant recorded comparatively more syrphid larval population followed by jaggery solution. However, sugar syrup and white colored attractants proved less effective.

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Botanical pest management in berseem+ mustard mixed forage crop production

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ABSTRACT

The field experiment with various combinations of botanicals evaluated for the management of various pests/diseases in berseem + mustard fodder production system. revealed that although synthetic pesticidal combinations recorded maximum reduction in the stem/root rot intensity in berseem (68.76) and aphid population in mustard (68.22), various combinations of botanicals seed coating with NSK powder + sprays of NSK extract provided maximum protection i.e. a reduction of 68.22% in the stem/root rot intensity in berseem and a reduction of 70.28% aphid population in mustard and 42.0% of plant parasite nematode (PPN) and consequently an increase of 33.61% in GFY over control. The treatment also harboured (approximately triple the population of beneficial soil arthropods, the collembolans and mites in comparison to untreated check. However, the economics of various botanicals revealed maximum net return under trineem + endosulphan (0.07%)+ dithaneM-45 (0.1%) followed by trineem + NSKE (3%) with a cost benefit ratio of 1.01 and 1.03, respectively.

Keywords: Botanicals, disease, forage production system, insect pests and management, micro-arthropods and nematodes.

Fodder and nutritional security for livestock population, that plays a vital and catalytical role in Indian farming system, is a compulsive need for the nation. Various natural and cultivated forages provide about 550 t of green fodder against the present yearly demand of 900 t, indicating a deficit of about 40%. India with only 4.9 % of its cropped area under fodder cultivation and very remote scope for horizontal expansion of arable land, the only alternative left is the vertical expansion through increased crop productivity.

The sustainability of the fodder production system largely depends upon overcoming biotic stress factors like insect pests, plant pathogens and plant parasitic nematodes. In major forage crops the quantitative and qualitative losses caused by these biological stress factors have been reviewed that collectively amounts to the tune of 25-30%. (Ahmed, *et al*., 1996, Saxena *et al*., 2002).

The use of pesticides in fodder crops is not only toxic to animals but produces hazards to the ecosystem. Besides, the poor resource mobilizing capacity, inadequate capital restraint and non-availability of the desired pesticides at the right time are major constraints faced by the farmers. The role of eco-friendly approaches has assumed significance with the current thrust on organic farming. Botanicals hold promise for the management of insect pests in an environmental friendly way. Therefore, various combinations of botanicals as seed/soil treatments along with their foliar sprays were evaluated to manage these constraints in berseem+mustard fodder production system.

MATERIAL AND METHODS

The investigation was carried out during 2003-04 to 2005-06 with combination of two variables: seed/soil treatment (neem seed kernel @ 50 gms kg seed^{-1}, Trineem @ 10 gms kg urea^{-1}, carbofuran 3G+ carbendazim at 2%w/w - as recommended check and no seed /soil treatment); and botanical sprays of (neem (*Azadiracta indica*) and karanje (*Pongamia pinnata*) seed kernel aqueous extract at 3% each, endosulfan 35EC @0.07% + dithane M-45 (@0.09% - as recommended check and no spray of the crop. The experiment was laid out in split plot design with three replications. Pre-sowing treatments (seed/soil treatment) were in main plots while sprays were in sub plots. First spray was given on 30th DAS and the rest on 10th day after each cut. Entomological and pathological data were recorded at various crop growth

stages as per the pest occurrence and nature. Data on plant parasitic nematodes and beneficial micro arthropods was recorded by taking the soil samples at harvest. Green fodder yield (GFY) was recorded at harvest of the crop.

RESULTS AND DISCUSSION

In berseem + mustard crop, incidence of aphid, *Aphis craccivora* was recorded on mustard in all the plots; however treated plots showed significantly less incidence. No significant differences were recorded among various treatments (Table 1). Carbofuran + carbendazim as a seed treatment along with foliar spray of endosulfan + dithane M-45 recorded minimum damage due to root rot/stem rot in berseem. Although maximum biotic stress management was achieved in synthetic pesticidal combinations in which a reduction of 68.76% in the stem/root rot intensity in berseem and a reduction of 68.22% aphid population in mustard was recorded. In this treatment an increase of 43.94% GFY was recorded over control. Among various combinations of botanicals, seed coating with NSK powder + sprays of NSK extract (3%) provided maximum protection (a reduction of 68.22% in the stem/root rot intensity in berseem and a reduction of 70.28% aphid population in mustard) and consequently an increase of 33.61% in GFY over control. Ahmad *et al.* (2000) also reported the efficacy of NSK extract (3%) spray for minimizing the foliar pests and diseases incidence in an intensive fodder production system.

Botanicals seed coating with NSK powder + sprays of NSK extract (3%) provided maximum protection against plant parasitic nematodes (a reduction of 42% PPN). This treatment also harbored maximum number of beneficial soil micro-arthropods approximately triple the population of beneficial collembolans and mites in comparison to untreated check. Carbofuran + carbendazim as seed treatment along with foliar spray of endosulfan + dithane M-45 recorded minimum (1176 average nos./unit area) population of plant parasitic nematodes (PPN). Maximum population of beneficial micro-arthropods (137.75 average nos. of mites and 15.25 nos. of collembolans / unit area) was recorded under seed coating with NSK powder + sprays of NSK extract (3%) treatment. While least numbers of both the beneficial micro-arthropods (39.50 average nos. of mites & 2.75 nos. of collembolans/unit area) was recorded with carbofuran + carbendazim as a seed treatment along with foliar spray of endosulfan + dithane M-45 (Table.2). This suggests the sustainability of the system through the use of botanicals without interrupting with the ecosystem. Thus, under the umbrella of organic farming aptness of neem for the affluence of soil health is worthy.

Neem is well known to have a complex array of bitter constituents termed as melacin. The well-known five C-secomeliacins of neem are nimbin, salanin, 6-desacetylnimbin, desacetylsalanin and azadirachtin (Dev Kumar, 1986). Insect growth regulations are the most important physiological effect of neem. Larvae of *Chilo partellus,* a serious pest of sorghum and maize, when fed on maize stem treated with NSK suspension produced larval – pupal intermediates and when this did not occur the larvae either died during development or the adults emerging from

Table 1. Insect pest infestation, disease incidence and GFY yield (t/ha) in mustard+ berseem crop - *Rabi* (Pooled data for 2003-2006)

Treatment	Mustard	Berseem	Yield (t ha^{-1}) (Four cuts)
	Aphid (nos. 5cm shoot tip^{-1})	Root Stem Rot^{-1}	
T1- (Carbafuran + Carbendazim 2%, w/w) + NSK (3%)	25.06	3.47	87.30
T2 - (Carbafuran + Carbendazim 2%, w/w)+ KSK (3%)	32.52	3.88	82.88
T3 - (Carbafuran + Carbendazim 2% w/w) + [Endo (0.07%) + Dithane (0.1%)]	23.74	2.88	91.36
T4 - (Carbafuran + Carbendazim 2%, w/w) + No spray	58.59	4.36	76.58
T5 - NSK Powder 50 gms/kg seed+NSKE(3%)	22.20	5.00	84.80
T6 - NSK Powder 50 gms/kg seed + KSKE (3%)	30.13	5.89	76.99
T7 - NSK Powder 50 gms/kg seed+ [Endo (0.07%) + Dithane (0.1%)]	17.19	4.22	86.98
T8 - NSK Powder 50 gms/kg seed+ No spray	58.41	6.49	69.07
T9 - Trineem + NSKE (3%)	23.70	6.64	91.23
T10 - Trineem + KSKE (3%)	33.42	7.49	84.05
T11 - Trineem + [Endo(0.07%)+Dithane(0.1%)]	20.53	5.77	93.99
T12 - Trineem + No spray	57.82	7.22	76.84
T13 - No seed / soil treat + NSKE (3%)	29.81	6.16	76.65
T14 - No seed / soil treat + KSKE (3%)	46.94	7.58	69.81
T15 - No seed / soil treat + [Endo (0.07%) + Dithane (0.1%)]	29.99	5.00	76.97
T16 - No seed / soil treat + No spray	74.70	9.22	63.47
CD at 5%	9.05	1.17	7.05

Table 2. Population built up of beneficial micro-fauna under various treatments (pooled data for 2003-2006)

Treatments	Beneficial micro-arthropods	
	Mites	Collembolan
(Carbafuran + Carbendazim 2%, w/w) + NSK (3%)	60.25	5.25
(Carbafuran + Carbendazim 2%, w/w)+ KSK (3%)	64.25	3.75
(Carbafuran + Carbendazim 2% w/w) + [Endo(0.07%)+Dithane(0.1%)]	39.50	2.75
(Carbafuran + Carbendazim 2%, w/w) + No spray	49.75	14.25
NSK Powder 50 gms/kg seed+NSKE(3%)	137.75	15.25
NSK Powder 50 gms/kg seed + KSKE (3%)	47.50	11.25
NSK Powder 50 gms/kg seed+ [Endo(0.07%)+Dithane(0.1%)]	59.75	3.00
NSK Powder 50 gms/kg seed+ No spray	86.50	4.00
Trineem + NSKE (3%)	103.02	4.25
Trineem + KSKE (3%)	77.00	5.00
Trineem + [Endo(0.07%)+Dithane(0.1%)]	62.75	6.50
Trineem + No spray	114.25	5.00
No seed / soil treat + NSKE (3%)	67.75	11.50
No seed / soil treat +KSKE (3%)	77.50	8.75
No seed / soil treat + [Endo(0.07%)+Dithane(0.1%)]	57.50	4.00
No seed / No spray	51.00	4.75
CD at 5%	74.10	10.8

Table 3. Population built up of plant parasitic nematodes under various treatments (pooled data for 2003-2006)

Treatment	PPN Population
(Carbafuran + Carbendazim 2%, w/w) + NSK (3%)	1192
(Carbafuran + Carbendazim 2%, w/w)+ KSK (3%)	1192
(Carbafuran + Carbendazim 2% w/w) + [Endo(0.07%)+Dithane(0.1%)]	1176
(Carbafuran + Carbendazim 2%, w/w) + No spray	1192
NSK Powder 50 gms/kg seed+NSKE(3%)	1424
NSK Powder 50 gms/kg seed + KSKE (3%)	1416
NSK Powder 50 gms/kg seed+ [Endo(0.07%)+Dithane(0.1%)]	1424
NSK Powder 50 gms/kg seed+ No spray	1416
Trineem + NSKE (3%)	1392
Trineem + KSKE (3%)	1376
Trineem + [Endo(0.07%)+Dithane(0.1%)]	1344
Trineem + No spray	1352
No seed / soil treat + NSKE (3%)	2392
No seed / soil treat +KSKE (3%)	2392
No seed / soil treat + [Endo(0.07%)+Dithane(0.1%)]	2504
No seed / No spray	2456
CD at 5 %	48

Table 4. Economics of various botanical treatments

Treatment	Total production (q ha^{-1})	Gross Return (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Return (Rs ha^{-1})	Cost of Production of GFY Rs q^{-1}	Cost Benefit Ratio
T1-(Carbafuran + Carbendazim 2%, w/w) + NSK (3%)	873.00	69,840	35,596.52	34,243.48	**40.77**	**0.96***
T2-(Carbafuran + Carbendazim 2%, w/w) + KSK (3%)	828.80	66,304	35,173.62	31,130.38	42.44	0.89
T3-(Carbafuran + Carbendazim 2% w/w) + [Endo (0.07%) +Dithane (0.1%)]	913.60	73,088	36,815.75	36,272.25	**40.30**	**0.98***
T4-(Carbafuran + Carbendazim 2%, w/w) + No spray	765.80	61,264	32,633.92	28,630.08	42.61	0.88
T5 - NSK Powder 50 gms/kg seed + NSKE (3%)	848.00	67,840	35,055.28	32,784.72	41.34	0.94
T6 - NSK Powder 50 gms/kg seed + KSKE (3%)	769.90	61,592	33,455.88	28,136.12	43.45	0.84
T7 - NSK Powder 50 gms/kg seed+ [Endo (0.07%) + Dithane (0.1%)]	869.80	69,584	36,322.99	33,261.01	41.76	0.92
T8-NSK Powder 50 gms/kg seed+ No spray	690.70	55,256	30,686.76	24,569.24	44.47	0.80
T9 - Trineem + NSKE (3%)	912.30	72,984	35,920.21	37,063.79	**39.37**	**1.03***(I)
T10 - Trineem + KSKE (3%)	840.50	67,240	34,679.61	32,560.39	41.26	0.94
T11 - Trineem + [Endo (0.07%) + Dithane (0.1%)]	939.90	75,192	37,319.40	37,872.60	**39.71**	**1.01***
T12 - Trineem + No spray	768.40	61,472	32,433.49	29,038.51	42.21	0.90
T13 - No seed / soil treat + NSKE (3%)	760.50	60,840	35,565.90	25,274.10	46.77	0.71
T14 - No seed / soil treat + KSKE (3%)	698.10	55,848	31,799.69	24,048.31	45.55	0.76
T15 - No seed / soil treat + [Endo (0.07%) + Dithane (0.1%)]	769.70	61,528	34,046.07	27,481.91	44.23	0.81
T16 - No seed / soil treat + No spray	634.70	51,016	29,489.46	21,526.54	46.46	0.73

surviving larvae were abnormal. Similar effects were also observed in case of *Heliothis* larvae (Anonymous, 1983). Azadirachtin also significantly lowered the food intake, food balance, weight gain, nutrient digestibility and efficiency of conversion of ingested food to body matter in larval stage (Ayyanger and Rao, 1989). Besides insecticidal properties, neem also has bactericidal, nematicidal and fungicidal properties. Harender Raj (1991) found fungistatic properties of crude neem oil against *Fusarium oxysporum* Schl. in tomato. Faruqui and Saxena (2000) repoted that NSK extract was capable of reducing germination of conidi of zonate leaf spot of sorghum, uredospores of *Uromyces striatus* and oospores of *Perenospora trifolli*.

The economics of various botanicals evaluated revealed maximum net return under trineem + endosulphan (0.07%)+dithane (0.1%) followed by trineem + NSKE (3%) where a cost benefit ratio of 1.01 and 1.03 was worked out. Seed coating with NSK powder + sprays of NSK extract provided a cost benefit ratio of 0.94 (Table.4). Pandey *et al.* (2000) also reported a higher net benefit ratio in an IPM with NSK extract (3%) spray for the management of insect pests and diseases in an intensive fodder production system.

The research outcome suggests the aptness of botanicals for the management of major insect pests, diseases and plant parasitic nematodes along with affluence of soil health if the crop is managed under the umbrella of organic farming. The economics of using botanicals also works out to be adequate in low value commodity like forage crops. Thus the present findings strongly advocate the array of botanicals in general and neem in particular for pest management in an organic agriculture.

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Screening of different tomato varieties against major insect pests*

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ABSTRACT

The field trial revealed that varieties TBR-1, Pusa hybrid-2, PAV-1947, H-24 and BSS-9 with lowest infestation of leaf minor (1.0 mines plant^{-1}), tomato fruit borer (8.44% fruit damage), white fly (nil -0.58 plant^{-1} cage^{-1}) and jassid (0.06 plant^{-1}) registered least susceptible reactions, respectively. Although, no variety was rated resistant against any of the insect pest except PAV-1947 for white fly, the Pusa hybrid-1 for leaf minor, Jawahar tomato -99, NDT-5, ARTH-4, NDT-3 and Indira - PKM -1 for white fly and Sun -145 for jassid were tolerant. Varities NDT-5, NDTRX - 73, Pusa hybrid -1 and Arka vikas showed high susceptibility to leaf minor, tomato fruit borer, white fly and jassid infestation, respectively.

Keywords : Screening of tomato varities, *Helicoverpa armigera, Bemasia tabaci, Emposca devastans, Liriomyza trifolii*

Tomato is the most popular vegetable crop widely grown world wide under outdoor and indoor conditions and stands second to potato. (Boss and Som 1986). Its fruits are rich in vitamin C followed by vitamin A, B and B_2 (Nath,1976). Its cultivation throughout the India is influenced by various factors and insect-pests are one of the important constraints that hampers its productivity. Their management through indiscriminate use of insecticides causes hazards to non target organisms and effects soil, water and air pollution. The selection of resistant varieties to manage particular insect pest and to avoid the frequent use of insecticides is the most desirable way to manage their infestation. The present study was conducted with this view.

METHOD AND MATERIALS

Thirty varieties of tomato, collected from Indian Institute of Vegetable Research, Varanasi including the local germplasms and the check (punjab chhuara) were transplanted during the year 2007-08 and 2008-09, in randomized block design having three replications. Standard agronomical practices were followed to raise the crop. Observations on most common and major insect pests viz., tomato fruit borer *Helicovera armigera,* whitefly, *Bemasia tabaci,* jassid *Emposca devastans* and leaf minor *Liriomyza trifolii* infestation were recorded from 15 days after transplanting at weekly interval till last picking. Infestation of tomato fruit borer, ***H. armigera*** was recorded in terms of the per cent fruit damage (number basis) at every picking weekly at fruit development stage (unpicked stage) and fruit ripening stage (picking stage). White fly population was recorded by using split catch kept facing the sun from two randomly selected spots per plot per replications. Population of jasisid nymph and adult was recorded at weekly intervals form upper, middle and lower leaves from five randomly selected plants plots^{-1}. The incidence of leaf minor was recorded at weekly intervals from randomly selected five plants plot^{-1} and actual mines per leaf were counted from upper, middle and lower leaf.

RESULT AND DISCUSSION

I. Leaf minor

Data recorded during 2007-08 revealed significantly less leaf minor infestation in variety TBR – 1 (1.04 mines leaf^{-1}) followed by variety Pusa Hybrid – 1 (1.44 mines leaf^{-1}) The maximum mines leaf^{-1} was recorded in variety NDT – 5, (8.51) followed by variety Arka Saurabh (7.33) ARTH-3 (7.77), NDT X R- 73 (8.03), Arka Vikas (6.34), Selection-7 (6.28), ICT-4 (5.99) and Punjab Chhuara (6.92).

During the year 2008-09 least leaf miner infestation was observed in variety, TBR-1 (1.00) and variety Pusa Hybrid 1 (1.40) which were at par with each other followed by Jawahar Tomato 99 (2.29), BT-120 (2.68), variety DVRT-1 (2.30) respectively. Significantly higher population of mines leaf^{-1} was observed on variety Arka Saurabh (7.31), NDT-5 (6.75) and Selection-7 (6.24), respectively followed by NDTXR – 73 (5.78), ICT-4 (5.69), Sun-145 (5.18) and Punjab

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Chhuara (6.20), respectively.

None of the variety was found least susceptible (0 to 1 mines leaf^{-1}) during 2007-08, while variety TBR-1 came under this group in the year 08-09. Jawahar Tomato 99, Pusa Hybrid 1 and DVRT-1 varieties showed consistent moderately susceptible reaction against leafminer. Similarly, Pusa Hybrid 2, Pusa Hybrid 4, Avinash 2, BSS 90, Arka Abha, H – 24, DT – 10, Azool – T 5, CO – 3, MDXR – 60, BT – 10, PAV 1947, Indira – PKM -1 and Sun 145 reacted susceptibly and Arka Saurabh, Selection – 7, Punjab Chhuara highly susceptible during both the years of observations. Thus, it can be concluded that variety ARTH – 4, BSS – 90, Arka Abha, NDT – 3, DT – 10, Azool T – 5 and Indira PKM – 1 of are moderately susceptible while pusa hybrid – 1, Arka Vikas and BT – 120 are highly susceptible leaf minor .

Fruit borer

The data recorded during 2007-08 revealed that Pusa Hybrid -2, registered significantly less per cent fruit damage (8.76%) and was found superior to rest of the varieties, followed by Jawahar Tomato 99 (10.40%), Pusa Hybrid – 1 (10.45%) and Pusa Hybrid – 4 (11.19%), respectively and these were at par with each other. Maximum fruit damage was recorded in variety NDT XR – 73 (31.25%) and DT – 10 (30.50%). While comparing various susceptible groups none of the variety was found least susceptible. Pusa Hybrid – 1, was rated moderately susceptible, Jawahar Tomato 99, Pusa Hybrid – 4, ARTH – 4, Selection – 7, DVRT – 1, ICT – 4, PAV – 1947 susceptible and the rest were most and highly susceptible. During 2008-09, NDT XR – 73 and DT – 10 showed highly susceptible reaction against fruit borer

Table 1: Reaction of different tomato varieties against major insect pests during 2008-09

Tomato Variety	Mean infestation level of major insect pests				
	Leafminer[1]	*Percent fruit damage by Fruitborer[2]		Whitefly[3]	Jassid[4]
		Development stage	**Ripening stage**		
Jawahar Tomato 99	2.99(1.66)	10.00(18.37)	16.68(24.05)	1.00(1.21)	2.66(1.76)
Pusa Hybrid 1	1.40(1.37)	9.95(18.34)	12.80(20.90)	9.21(3.10)	2.25(1.62)
Pusa Hybrid 2	3.52(2.00)	8.44(16.84)	16.42(23.86)	4.42(2.19)	2.76(1.80)
Pusa Hybrid 4	4.19(2.16)	11.21(19.55)	22.20(28.08)	4.60(2.25)	6.14(2.57)
Arka Saurabh	7.31(2.79)	16.80(24.17)	22.90(28.56)	3.52(2.00)	5.66(2.42)
Arka Vikas	5.00(2.34)	18.78(25.66)	25.63(30.40)	6.75(2.69)	7.40(2.76)
ARTH – 3	4.75(2.28)	14.92(22.68)	21.98(27.95)	9.22(3.10)	7.05(2.74)
ARTH – 4	4.78(2.29)	13.29(21.36)	17.10(24.38)	1.02(1.43)	4.25(2.17)
Avinash – 2	4.29(2.19)	18.25(25.25)	21.71(27.74)	4.40(2.21)	5.47(2.41)
BSS – 90	3.38(1.96)	20.19(26.66)	27.10(30.89)	1.60(1.44)	0.06(0.74)
Arka Abha	4.28(2.18)	16.92(24.25)	25.10(30.04)	1.50(1.41)	1.61(1.44)
HAT – 101	4.98(2.34)	22.28(28.13)	29.17(32.67)	2.01(2.02)	8.03(2.92)
NDT X R – 73	5.75(2.49)	30.95(33.77)	28.70(32.36)	2.55(1.74)	2.45(1.71)
NDT – 5	6.95(2.72)	18.67(25.57)	23.59(29.02)	1.00(1.21)	4.44(2.21)
BT – 120	2.68(1.77)	19.01(25.84)	24.03(29.33)	5.08(2.34)	5.00(2.33)
H – 24	4.70(2.27)	20.91(27.15)	25.59(30.37)	0.58(0.93)	2.19(1.63)
NDT – 3	4.98(2.33)	24.21(29.45)	28.80(32.45)	1.18(1.29)	3.54(1.93)
Selection – 7	6.24(2.59)	12.30(20.50)	17.39(24.59)	2.59(1.75)	5.32(2.39)
DVRT – 1	2.30(1.67)	13.71(21.70)	20.20(26.68)	1.35(2.20)	5.16(2.37)
DT – 10	3.44(1.98)	29.30(32.75)	34.59(35.96)	1.54(1.41)	1.74(1.49)
Azool – T – 5	4.59(2.25)	24.65(29.75)	29.20(32.69)	1.48(1.39)	7.19(2.77)
CO – 3	4.22(2.17)	21.70(27.73)	28.28(32.09)	2.54(1.72)	3.98(2.11)
MDXR – 60	3.42(1.94)	23.61(29.06)	27.23(31.43)	3.50(1.98)	2.49(1.71)
BT – 10	4.33(2.20)	24.15(29.42)	30.08(33.23)	2.35(1.68)	2.46(1.71)
ICT – 4	5.69(2.49)	12.55(20.73)	19.59(26.23)	4.54(2.24)	7.14(2.76)
TBR – 1	1.00(1.25)	14.41(22.30)	20.78(27.06)	2.18(1.63)	6.71(2.68)
PAV – 1947	3.18(1.92)	14.36(22.25)	19.90(26.47)	0.00(0.70)	5.05(2.34)
Indira – PKM – 1	4.00(2.12)	19.51(26.28)	30.56(33.55)	1.49(1.40)	4.44(2.21)
Sun – 145	5.18(2.38)	17.31(24.41)	23.37(28.89)	3.58(2.01)	1.00(1.20)
Punjab Chhuara	6.20(2.58)	15.88(23.67)	20.72(27.01)	2.93(1.83)	6.09(2.54)
Sem ±	**0.068**	**0.25**	**0.58**	**0.16**	**0.16**
C.D. 5%	**0.2**	**0.74**	**1.81**	**0.48**	**0.48**

Values in parenthesis are $\sqrt{x+0.5}$ transformed value. *Values in parenthesis are angular transformed value. 1. Leafminer plant^{-1}, 2. % Fruit damage, 3. Whitefly Plant^{-1} cage^{-1}, 4. Jassid Plant^{-1}

infestation. Pusa Hybrid – 2 (8.44 %) received significantly less fruit damage as compared to the other varieties followed by Jawahar Tomato 99, Pusa Hybrid – 1 with 9.95 and 10.00% fruit damage, respectively. Significantly highest fruit borer infestation, of 13.95 and 29.30 % was recorded in variety NDTXR – 73 and DT 10, respectively. No variety was least susceptible, while Jawahar Tomato 99, Pusa Hybrid – 1 and Pusa Hybrid – 2 were moderatly susceptible and Pusa Hybrid – 4, ARTH – 3, ARTH – 4, Selection – 7, DVRT – 1, ICT – 4, TBR – 1, PAV – 1947 susceptible. The rest of the varieties were most to highly susceptible.

Data further indicated that variety Pusa Hybrid – 2, was moderately susceptible while Pusa Hybrid – 4, ARTH – 4, Selection – 7, DVRT – 1, ICT – 4 and PAV – 1947 were susceptible to fruit borer infestation at early stage of fruit development. Varieties Arka Saurabh, Arka Vikas, Avinash– 2, Arka Abha, NDT – 5, BT – 120, Indira - PKM – 1, Sun – 145 and Punjab Chuara were the most susceptible varieties at early fruit development stage of crop.

In the ripening stage, no variety under least and moderately susceptible group was found. During the year 2008-09, Jawahar Tomato – 99, Pusa Hybrid – 2 and 2-ARTH received significantly less fruit borer infestation (4 16.68, 16.42, 17.10 %) while the variety DT – 10 (34.59 %), BT – 10 (30.08%) and Indira - PKM – 1 (30.56%) the maximum.

The ripening stage of the crop recorded higher fruit borer infestation as compared to the early stage of the fruit development. However, the varieties BSS-90, HAT-101, NDTXR – 73, H-24, NDT – 3, DT-10, CO-3, MDXR – 60 and BT – 10 were found highly susceptible in early as well as in ripening stage of the crop.

Whitefly and Jassid

The variety NDT-3 recorded minimum infestation (1.03) of whitefly plant^{-1} cage^{-1} during 2007-08. The infestation level was at par with JT-99 (1.40), ARTH-4 (2.22), BSS-90 (2.15), Arka Abha (2.22), H-4 (1.32), DT-10 (2.15), Azool-T-5 (1.72), MDXR-60 (1.81), PAV-1947 (1.26) and Indira-PKM-1 (1.84), respectively. Not a single variety was rated as least susceptible. During the year 2008-09, variety PAV-1947 with nil Jawahar Tomato – 99, NDT – 5 and H – 24 with 1.0and below level of white fly infestation were least suspectible.

The variety BSS-90 with least infestation of jassid (0.06 plant^{-1}) proved least susceptible against the jassid infestation.

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Influence of larval age at grafting and number of queen cell cups grafted for larval acceptance for queen production in *Apis mellifera* colonies

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ABSTRACT

Experiments conducted to assess the influence of larval age at grafting and the number of queen cell cups grafted for larval acceptance in mass queen rearing of *Apis mellifera* colonies during the spring and Autumn 2007, the apiary of Division of Entomology SKUAST-K, Shalimar revealed that larval acceptance was highest (30.5%) in autumn and 76.5% in spring when 24 hr old larvae were grafted and minimum (29.5%) in autumn and 76.0% in spring when 72 hr old larvae were grafted. The higher acceptance of 24 hr larvae revealed that younger larvae in April was due to the presence and availability of major bee flora in surplus. Results of next experiment revealed that the mean % acceptance of the grafted larvae was maximum (76.5%) in spring and 30.5% during autumn when 30 queen cell cups were used. Results also exhibited that by increasing the number of queen cell cups (30, 60, 80, 110) decrease in acceptance was recorded.

Key words: Influence, Larval age, grafting, acceptance and *Apis melllifera*

The State of J & K (32^{O}-170^{o} to 37^{o} + 05 N latitude and 72^{o} to 40^{o} to 80^{o}-30 longitude) comprising of 4 agro climate and one ranging from low latitude subtropical and cold arid alpine zone, represents one of the potential area of bee keeping in the country . Temperature ranging from -45 to 45^{o}C and above, plays a dominant role in determining the topography, climate and plant species present in the region. It offers great potential for both migratory and non-migratory bee keeping. The three essential principals for the success of an industry *viz*., availability of raw material, skilled labour and consumer demand of the product are fully met within the state. Kashmir in particular is known for its floral gaity where numerous intensities of cultivated and wild plants bloom from early spring till late fall. This provides sufficient raw material (nectar and pollen) to the honey bees for the production of honey and wax for commercial purposes. Kashmir is also gifted with the best strain of honey bees. This strom of bees is well adopted to geographical, climate and floral conditions of the state. Its capacity to exploit flora to high attitude and at low ambiant temperature is unparalleled. Its yield potential (18.00 kg) is much higher than the national average (4.5 kg) and is thereafter of considerable national importance. It provides gainful employment to thousands of rural families and extra income to unemployed youth. As a matter of fact, the main significance of honey bee and bee keeping is the pollination whereas, hive products such as honey bee wax, propolis etc. are of secondary value. Therefore, the present investigation under the Horticulture Technology Mission-1 project entitled "Mass rearing of queen bees for multiplication of honeybee colonies to promote honey bee as pollinator was taken up.

MATERIAL AND METHODS

The work was conducted at the Apiary of D.O.E. SKUAST-K, Shalimar under the Horticulture Technology Mission Project entitled "Mass rearing of queen bees for multiplication of honey bee colonies to promote honey bee as pollinator" in the year 2007. It was conducted with 10 bees frame colony of *Apis mellifera l.* during spring and autumn 2007. Queen cell cups with 10 mm inner diameter and 11 mm depth were prepared by 2-3 successive dipping of honey water dipped wooden sticks, in light yellow colonies bees wax melted by keeping in hot wetter. The Queen cell cups were then removed from the cell forming sticks by slight with thumb and index finger. The langstruoth size bee frame without wires with three removable horizontal wooden bars spared at equal distance (4.5 cm) from each

other, were used as queen bee rearing frame. The waxen queen cell cups were fixed 2 cm apart using molten bees wax in an inverted position on a thick layer of wax pre coated on the lower surface of horticultural wooden bars. The worker larvae of (24, 28, 72 hours) were grafted with the help of grafting needles after priming the queen cell cups with royal jelly and distilled water (1:1). The breeder colony was managed. The larvae of 24,48, 72 hours age each were grafted in 30 queen cell cups per cell builder colony in triplicate. In another experiment, 24 hour old larvae were grafted in varying number of queen cell cups (30, 60, 80, 110) per cell builder colony. After grafting the larvae, the queen rearing frame was placed between pollen larval brood (older than 3 days). Larval acceptance was recorded 24 hours after larval grafting.

RESULTS AND DISCUSSION

Results revealed highest larval acceptance of 30.5% in autumn to 76.5% in spring when 24 hours old larvae were grafted and minimum 29.5% in autumn and 65.55% in spring when 72 hours old larvae were grafted (Table 1). The higher acceptance for 24 hours larvae reveals that younger larvae were more preferred. Higher mean% acceptance grafted larvae in April was due to the presence and availability of major bee flora at the apiary. The results of other experiment depicts that the mean 5 acceptance of grafted larvae was maximum (76.5%) in spring and 30.5% during autumn when 30 queen cell cups were used. By increasing the number of queen cell cups (60,80, 110) decrease in acceptance was recorded (Table 2). Singh *et al*., (2001) reported that larval acceptance was highest when 24 hrs old larvae were grafted and increase in larval age as well as number of queen cell cups used decreased the larval acceptance. Larval acceptance was higher during spring season. Their studies showed similarity with the present work. Chang and Hsieh (1993) have reported 89.75% larval acceptance when 24 hr old larvae were grafted in 44 queen cell cups per colony. Waff and Hanna (1967) reported higher larval acceptance in spring and autumn and less in winter. As per the observations of Doolittle (1915), 12 cells were sufficient and 24 too many for rearing queens from a colony at a time. Whitcomb and Oertel (1938) decrease in percentage of finish cells when too many cells were given to the cell finishing colony. It was further pointed out that there was a reduction in average weight of virgin queens on emergence from the over- stocked cell forming colony. As per the observations of Snelgrove (1966) a cell bar with 12 cells spaced at one inch apart was minimum and two cell bars with 24 cells were maximum number for obtaining maximum number of grafts. Acceptance to the extent of 70% was considered as good and 80% as excellent. The finding of Laidlaw and Eckert (1962) showed that in addition to the availability of the food, size of the queen largely depends upon the number of nurse bees and number of queen cells the bees have to feed. The results of Eckert (1934) demonstrated that queens reared from 36 and 48 hours old larvae were not appreciably smaller in size than those reared from still younger larvae. Queen reared from 24 hours old larvae were desirable provided they have had an abundance of royal jelly during their first 24 hour period. Furthermore, ovarioles in ovaries did not vary in direct proportion to external size and no variation was found between the number of ovarioles and the amount of brood produced by queens.

Table 1: Effect of larval age at grafting for larval acceptance in *Apis mellifera* colonies in spring and autumn 2007.

Larval age (hour) at grafting	**Mean % Larval acceptance**	
	Spring 2007	**Autumn2007**
24 hours	76.5(9.24)	30.5(6.02)
48 hours	75.5(9.18)	30.09(5.97)
72 hours	75.5(9.18)	29.5(5.93)

C. D at 5% for spring = 0.72
C.D at 5% for autumn = 0.62

Table 2: Impact of larval age at grafting by the number of queen cell cups grafted for larval acceptance in *Apis mellifera* colonies in Spring and autumn 2007.

No. of queen cell cups grafted/coloney (24 hor larvae)	**Mean % Larval acceptance**	
	Spring 2007	Autumn 2007
30	76.5(9.24)	30.5(6.02)
60	72.5(9.01)	29.0(5.88)
80	55.5(7.94)	30.5(6.02)
110	50.2(7.58)	28.5(5.83)

C. D at 5% for spring = 0.98
C.D at 5% for autumn = 0.65

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Management of grapewine anthracnose disease with botanicals and bio-control agents

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ABSTRACT

Antifungal effects of 15 plant extracts, neem oil 80EC, pungam oil 80EC, neem + pungam 60 oil EC and nine antagonistic organisms were invested *in vitro* against the mycelial growth and conidial germinaton of *Gloeosporium ampelophagum* causing anthracnose disease in grapewine. Neem + pungam oil 60EC (3%), leaf extract of *Catharanthus roeus* 10% and neem oil 80 EC (3%) were inhibitory to the mycelial growth and conidial germination of *G. ampelophagum.* Among the antagonistic organisms *Trichoderma viride* and *Pseudomonas fluorescens* adversely affected the growth and conidial germination of the pathogen. Post inoculation spraying of neem + pungam oil 60 EC 3%, *C. roseus* leaf extract 10% and talc based formulation of *P. fluorescens* in the green house was found to be promising in preventing the disease. Spraying of the above mentioned botianicals and biocontrol agent thrice, first after the initiation of the disease and second and third at 10 days intervals effectively controlled the disease in the field.

Keywords: Grapewine anthracnose, plant extracts, plant oils, biocontrol agents, management

Grapewine (*Vitis vinifera* L) anthracnose disease is the most wide spread and serious disease all over the world. All the parts of the plant viz., leaves, petioles, young shoots, tendrils and berries are attacked by the pathogen. On the infected leaves, it produces small circular spots with greyish black centre and red brown margin. The necrotic areas dries and fall out leaving shot hole symptoms. Characteristics round brownish sunken spots resembling bird's eye appears on berries. Anthracnose weakens the vine and reduces the quality and quantity of the affected fruits (Pearson and Goheen, 1988). Young green succulent tissue is most susceptible and growing points of shoots are often killed (Hopkins and Haris, 2000). Anthracnose infection on berries redueces the berry size, weight, juice content, total soluble solids and reducing sugars and increase the acidity of the berries (Thind *et al.,* 2001). Fungicidal applications are required to control anthracnose. However, their indiscriminate use besides being hazardous to human beings also adersely affects the microbial population in the ecosystem. The inherent ill effects of chemical fungicide necessiated need to search alternatives like botanicals and biocontrol agents to manage the disease.Many plant species are reported to possess anti fungal activity against plant pathogens (Amadioha and Obi, 1998; Deokate *et al*., 2004 and Govindachari *et al.,* 1999). In the present investigation 15 plants extracts, emulsifiable formulations of oil viz., neem, pungam and neem + pungam and nine antagonists were tested for their efficacy aganist anthracnose pathogen.

MATERIALS AND METHODS

Isolation and maintenance of *Gleosporium ampelophagum*

Grapevine leaves of cv. Thomposon seedless, showing the typical symptoms of anthracnose, was collected from the field from which *G. ampelophagum* was isolated. The fungus was purified by single spore isolation technique and was maintained on potato dextrose agar (PDA) slants at 25 to 28^{o}C.

In vitro assay of botanicals (plants extracts / plant oils) against mycelial growth and conidial germination of *G. ampelophagum.*

A total of 15 plant extracts and three EC formulations of plant oils were used in this study. Plant extracts were prepared from freshly collected plant leaves. EC formulation viz., neem oil 80 EC and pungum oil 80 EC and neem + pungam oil 60 EC were obtained from Department of Agricultural Entomology, Tamil Nadu Agricultural University, Agricultural College and Research Institute, Madurai. Tamil Nadu, India.

Preparation of plant extracts

The freshly collected plant leaves were washed with tap water and then with alcohol and finally with repeated changes of sterile distilled water. These were separately ground in sterile distilled water (1 ml/g of leaf tissue) in a pestle and mortar. The extract was strained through two layers of muslin cloth, subsequently filtered through What Man No. 1 filter paper and finally passed through through Seitz filter to eliminate bacterial contamination. This formed the standard plant extract solution (100%) which was further diluted to the required concentration with sterile medium or sterile distilled water.

Screening of plant extracts/plants oils against the mycelial growth of *G. ampelophagum*

The efficacy of plant extracts/plant oils was tested against the mycelial growth of *G.ampelophagum* by poisoned food technique. Plant extracts were used at the concentration of 10% and plant oils at 3% concentration. The standard plant extract solution (100%) or plant oil (3%) and PDA medium were mixed at required quantities so as to get the required concentration of plant extracts (10%) or plant oils (3%) in the medium. Twenty ml of this mixture was poured into each sterilized petri dishes under aseptic condition and allowed to set. A nine mm actively growing PDA plug of *G. ampelophagum* cut by sterilized cork borer was placed onto the centre of the medium. Three replications wer maintained. The plates were incubated at room temperature (28 ±2C) for 12 days. Potato Dextrose Agar (PDA) medium withouth plant extract served as control. The radial growth of the mycelium was measured 12 days after inoculation. The results were expressed as percent growth inhibition.

Efficacy of plant extracts/plant oil against the conidial germination of *G. ampelophagum*

The efficacy of antagonistic organisms against *G. ampelophagum* was tested by dual culture technique (Dennis and Webster, 1971). A nine mm actively growing PDA plug of *G. ampelophagum* was placed on to sterilized PDA medium approximately at a distance of 1.5 cm away from the periphery of the plate. Similarly 9 mm culture disc of respective test fungi (viz. *Trichoderma viride, T. harizianum, T. longibrchatum, T. ressei, Gliocladium virens* and *Cheatomium globosum)* was placed on to the medium at the opposite side of the plate.

In the case of *Saccharomyces cerevisiae,* a 10 days old axenic culture and bacterial antagonists viz., *Pseudomonas fluorrescens* and *Bacillus subtilis,* an actively growing 48 h. old culture of the respective bacterium, were streaked on to the medium for 1.5 cm length instead of placing the culture disc. The medium inoculated with the pathogen alone served as the control. Three replications were maintained for each treatment. The plates were incubated at room temperature (28±2°C). The radial growth of the pathogen was measured 12 days after incubation. The results were expressed as percent inhibition of the mycelial growth of the pathogen.

Efficacy of antagonists agsinst the conidial germination of *G. ampelophagum*

The culture filtrates of the above mentioned antagonistic organisms were used for assessing their antagonistic activity against the conidial germination of *G. ampelophagum.* All the seven fungal antagonists were grown separately in PDA broth at 28±2°C for 10 days. The mycelial mat was removed by filtering through Whatman No. 1 filter paper. The culture filtrates of *P. fluorescens* and *B. subtilis* were obtained by growing these organisms in King's B and nutrient broth, respectively at 28±2°C for 48 h. The culture filtrates were centrifuged at 5000 rpm for 20 min at 4°C for clarification. The efficcy fo culture filtrate of the antagonists against the conidial germination of *G. ampelophagum* was carried out by cavity slide technique as mentioned above.

Efficacy of botanials and antagonistic organism against the incidence of anthracnose in the green house

From the *in vitro* screening, three plants extracts, three EC formulations of plant oils and two antagoiistic microbes were selected and tested in the green house along with the chemical check, Copper oxychloride (0.2%) under artificial inoculation. The treatments comprised of T1- *Catharanthus roseus* leaf extract 10%, T2- *Datura stramonium* leaf extract 10%, T3 - *Vitex negundo* leaf extract (10%), T4 - neem oil 80 EC, T5 - pungam oil 80 EC, T6 - neem + pungam 60 EC, T7 - *T. viride* (10^6 spores/ml), T8 - *P. fluorescens* (10^9 cfu/ml), T9 - Copper oxycholoride (0.2%) and T10- Control.

Thompson seedless grapevine stem cuttings were raised in pots and maintained in the green house by regular, uniform and judicious watering. The conidial suspension of *G. ampelophagum* (5 x 10^4 conidial/ml) was sprayed on 120 days old grapevine plants. Necessary water congestion was given both 24 h prior to and after inoculation for maintaining saturated humid condition. After 24 h of inoculation the treatments were imposed by spraying. Five replications were maintained for each treatment. The intensity of the disease were recorded 10 days after spraying using the 0-5 grade (Chandrasekara Rao, 1989). The percent disease index (PDI) was worked out using the formula

$$\text{PDI} = \frac{\text{Sum of all numerical ratings}}{\text{Number of observation}} \times \frac{100}{\text{maximum disease rating}}$$

Efficacy of botanicals and biocontrol agents against the grapevine anthracnose in the field

The botanicals and bio-control agents found promising against the anthracnose in the green house were tested in the field. Field experiments were conducted in a randomized block design with seven treatments and four replications at the commercial vine yard (7 years old) of Odaipatti, Theni, India during 2000-2001 and 2001-2002. This region was identified as endemic area for anthracnose. The treatments consisted of T1 - *C. roseus,* T2 - *V. negundo,* T3 - neem oil 80EC, T4 - Neem + pungam oil 60 EC, T5 - *P. fluorescens* (Talc based formulation), T6 - Copper oxychloride (0.2%) and T7 - Control.

Talc based formulation of *P. fluorescens* was prepared by the method developed by Vidhyasekaran and Muthamilan (1995). In the vine yard pruning was done during October and the initial spraying was done during November. Three sprays were given at 10 days intervals. The observations on incidence of disease was recorded 10 days after last spray using 0-5 scale and the PDI was worked out. The data were analysed statistically (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

All the 15 plant extracts, neem, and pungam oil based EC formulations of plant oils (3 nos) tested *in vitro* inhibited the mycelial growth of *G. ampelophagum* to the varying extent. Among these, neem + pungam oil 60 EC (3%) showed the least mycelial growth of 2.7 cm as against 8.87 cm in the control, which accounted for the growth reduction of 69.56%. It was on par with leaf extract of *C. roseus* (10%) which recorded the mycelial growth of 2.85 cm with 67.87% growth reduction. This was followed by neem oil 80 EC (3%), leaf extract of *V. negundo* (10%), pungam oil 80EC (3%) and leaf extract of *D. stramonium* (10%) which reduced the mycelial growth by 61.66, 61.55, 58.29 and 57.72%, respectively.

The results of the conidial germination assay revealed that the maximum inhibition of 73.77% conidial germination was found in neem + pungam oil 80EC 3%. The leaf extract of *C. roseus* (3%), leaf extract of *V. negundo* (10%), pungam oil 80EC (3%) and leaf extract of *D. stramonium* inhibited the conidial germination by 66.75, 66.00 and 63.85 % respectively. The leaf extract of *Cleome viscosa* was least effective against mycelial growth (17.7%) and conidial germination (25.0%) of *G. ampelophagum* (Table 1).

Antifungal activity of neem + pungam oil 60 EC was previously demonstrated against rice pathogens viz., *Helminthosporium oryzae* and *Pyricularia oryzae* (Rajappan *et al.,* 1995). Neem oil was reported fungitoxic against several phytopathogens viz., *Fusarium oxysporum* fsp *ciceris, Rhizoctonia solani, Sclerotium rolfsii, Sclerotinia sclerotiorum, Botrytis cinerea, Penicillium expansum, Glomeralla cingulata, Alternaria alternata, Aspergillus niger, Curvularia lunata, Sphearotheca fuliginea, Plasmopara viticola. Diplocarpon rosae* and several rust pathogens (Locke, 1995). Leaf extract of *C. roseus* (100%) and carbendazim @ 1.87 ($\mu g\ ml^{-1}$) was observed to be highly inhibitory to the growth of *G.ampelophagum* (Deokate, *et al.,* 2004).

Out of nine antagonists tested for their efficacy against the mycelial growth of *G. ampelophagum in vitro, T. viride* recorded the lowest mycelial growth of 3.39 cm. It was on par with *P. fluorescens* which exhibited the mycelial growth of 3.57 cm. The culture filtrate of *T. viride* and *P. fluorescens* inhibited the conidial germination by 63.75 and 60.60 % *B. subtilis* exhibited the highest mycelial growth of 5.58 cm and the culture filtrate reduced the conidial germination only to the extent of 40.56% (Table 2). The antagonistic activity of *T. viride* against grapevine grey mould pathogen *B. cinerea* was investigated by Jailloux and Froidefond (1987). *Trichoderma* spp. is recognized as a potential biocontrol agents against several fungi which inhibits the pathogen by multiple mechanism involving mycoparasitism, antibiosis, lysis, hyphal interference (Kwee and Keng, 1990). *Pseuodomonas fluorescnes* is well known potential antagonist against array of plant pathogen exerting its antagonistic activity by producing antibiotic and effective pioneering colonist of infection site (Jeyarajan *et al.,* 1994).

Post inoculation spraying of neem + pungam oil 60EC (3%), on green house grown grapevine plants was found to be effective in reducing the disease intensity by 65.60 (32.08 PDI). Neem oil 80EC ranked next by recording the PDI of 36.25 with 61.13 % disease reduction. It was on par with leaf extract of *C. roseus* and *P. fluorescns* which showed the PDI of 37.02 and 38.32, respectively. Copper oxycloride (0.2%) used for comparison showed the minimum PDI of 22.83 as against 93.25 PDI in the control. *T. viride* exhibited the maximum PDI of 50.57 with the minimum disease reduction (45.80%) (Table 3). Earlier, neem oil was found effective against anthracnose in chilli and tomato (Jeyalakshmi and Seetharaman, 1998; Vinoth Magdalene, 2000). The combined application of neem and pungam oil showed more efficacy than the individual application of above oils. This confirmed the additive effect of neem and pungam oil in combating the disease. Although *T. viride* was highly effective in reducing the mycelial growth and conidial germination of *G. ampelophagum,* it failed to reduce the disease incidence appreciably. This indicated the ineffciency of *T. viride* to colonize and sustain on the aerial parts of the plant or due to the completion of other phylloplane microflora and other

Table 1. Efficacy of botanicals against the mycelial growth and conidial germination of *G. ampelophagum in vitro*

Botanicals	Mycelial growth (cm)*	Growth inhibition (%)	Conidial germination (%)*	Germination inhibition (%)
Plant extracts (10%)				
Abutilon indicum	6.5^{gh}	26.72	65.20 (53.88)^{i}	28.40
Aloe vera	5.25^{e}	40.81	53.40 (46.95)^{g}	40.90
Alpinia galanga	5.07^{e}	42.84	51.35 (45.77)^{fg}	43.18
Azadirachta indica	4.3^{d}	51.52	46.43 (42.95)^{e}	48.62
Bougainvillea spectabilis	5.47^{ef}	38.33	54.03 (47.31)^{g}	40.21
Catharanthus roseus	2.85^{a}	67.87	25.30 (30.19)^{a}	72.00
Cleome viscosa	7.3^{i}	17.7	67.78 (55.41)^{i}	25.00
Coleus aromaticus	5.3^{e}	43.29	49.05 (44.45)^{ef}	45.72
Datura stramonium	3.75^{c}	57.72	34.30 (35.84)^{e}	62.04
Lawsonia inermis	5.56^{ef}	37.31	54.46 (47.55)^{g}	39.74
Phyllanthus niruri	4.17^{d}	52.99	40.62 (39.59)^{d}	55.05
Polygala grinersis	6.24^{g}	29.66	60.54 (51.08)^{h}	33.00
Prosophis juliflora	6.07^{g}	31.57	58.74 (50.03)^{h}	35.00
Vitex negundo	3.41^{b}	61.55	30.73 (33.66)^{bc}	66.00
Withania somnifera	5.37^{e}	39.46	51.13 (47.37)^{g}	40.10
Plant oils (3%)				
Neem 80EC	3.40^{b}	61.66	30.05 (33.79)^{b}	66.75
Pungam 80EC (*Pongamia glabra*)	3.70^{b}	58.29	32.71 (34.87)^{bc}	63.50
Neem + pungam 60 EC	2.7^{a}	69.56	23.70 (29.10)^{a}	73.77
Control	8.87^{d}	-	90.37 (71.93)^{i}	-

*Mean of three replications
Data in parentheses represents arc sine transformed values.
Within column mean followed by a common letter do not differ significantly (P=0.05) according to Duncan's Multiple Range Test

Table 2. Efficacy of antagonists against the mycelial growth and conidial germination of *G. ampelophagum in vitro*

Antagonists	Mycelial growth (cm)*	Growth inhibition (%)	Conidial germination (%)*	Germination inhibition (%)
Trichoderma viride	3.39^{a}	62.00	33.25 (35.20)^{a}	63.75
T. harziabum	4.79^{b}	46.36	46.11 (42.77)^{d}	49.73
T. longibrachiatum	5.40^{d}	39.53	52.89 (46.66)^{f}	42.34
T. reesei	4.98^{c}	44.23	48.85 (49.34)^{e}	46.75
Gliocladium virens	5.20^{d}	41.77	49.87 (44.93)^{e}	45.63
Chaetomium globosum	4.69^{b}	47.48	46.83 (43.18)^{d}	48.95
Saccharomyces cerevisiae	4.60^{b}	48.49	42.70 (40.80)^{c}	53.45
Pseudomonas fluorescens	3.57^{a}	60.02	36.14 (36.95)^{b}	60.60
Bacillus subtilis	5.58^{de}	37.51	54.52 (47.60)^{g}	40.56
Control	8.93^{f}	-	91.73 (73.30)^{g}	-

*Mean of three replications
Data in parentheses represents arc sine transformed values.
Within column mean followed by a common letter do not differ significantly (P=0.05) according to Duncan's Multiple Range Test

Table 3. Efficacy of botanicals and bio-control agents against the incidence of grapevine anthracnose in green house

Botanicals/bio-control agents	Percent disease index	Disease reduction (%)
C. roseus	37.02 (37.45)[c]	60.30
D. stramonium	43.64 (41.34)[ef]	53.20
V. negundo	41.50 (40.10)[de]	55.50
Neem oil 80EC	36.25 (37.01)[c]	61.13
Pungam oil 80EC	96.90 (42.93)[fg]	50.24
Neem + pungam oil 60EC	32.08 (34.49)[b]	65.60
T.viride	50.54 (45.30)[q]	45.80
P. fluorescens	38.32 (38.24)[cd]	58.91
Copper oxychloride (0.2%)	22.83 (28.53)[a]	75.52
Control	93.25 (75.04)[g]	-

Leaf extract at 10%. Oils at 3%
*Mean of three replications
Data in parentheses represents arc sine transformed values.
Within column mean followed by a common letter do not differ significantly (P=0.05) according to Duncan's Multiple Range Test

adverse environmental condition viz., non availability of food for their growth and multiplication. Fluorescent Pseudomonas applied as seed treatment resulted in significant reduction of anthracnose disease caused by *Colletotrichum arbicularia* in cucumber (Wei *et al.,* 1996).

Three sprays with neem + pungam oil 60EC (3%), first immediately after the appearance of the disease and second and third at 10 days intervals in the field, was found to be significantly effective in reducing the disease intensity. This treatment recorded the PDI of 30.83 as against 80.50 PDI in the control, which accounted for the disease reduction of 61.70%. It was followed by neem oil 80EC (33.20 PDI) and leaf extract of *C. roseus* (34.30 PDI) and these were on par with each other. Talc based formulation of *P. fluorescens* showed the PDI of 35.60 with 55.78% disease reduction. Copper oxychloride (0.2%) exhibited the highest disease reduction of 70.80% with the lowest PDI (23.50). The results obtained during 2001-2002 showed similar trends and confirmed the findings of previous year (Table 4).

Neem + pungam oil 60 EC is reported to control the grain discolouration in rice (Rajappan *et al,* 2001). Neem derivatives displayed several remarkable qualities because of the presence of an array of highly bioactive chemicals viz., azadirachtin, meliantriol, salanin, nimbin and nimbidin. Efficacy of neem oil at 5000 pp, was comparable with that of carbendazim in the case of chilli anthracnose pathogen, *Collectrotrichum capsici* (Harbant and Korpraditskul, 1999). Triterpenoidal mixture derived from 90% methanol extract of neem oil inhibited many phytopathogenic fungi viz., *Drechslera oryzae, Pythium aphanitermatum* and *Pestalotiopsis mangiferae* (Govindachari, *et al.,* 1996). Unlike the chemical pesticides, these formulations are ecofriendly and easily biodegradable. Moreover, they retain their efficacy even after

Table 4. Grapevine anthracnose incidence in the field sprayed with botanicals and bio-control agents

	2000-2001		2001-2002	
Botanicals/bio-control agent	Percent disease Index (PDI)*	Disease reduction (%)	Percent disease index (PDI)*	Disease reduction (%)
C. roseus	34.30 (35.85)[c]	57.30	36.05 (36.88)[c]	58.70
V. negundo	39.90 (39.17)[d]	50.43	42.86 (40.89)[d]	50.90
Neem oil 80EC	33.20 (35.14)[c]	58.75	35.29 (36.44)[c]	59.58
Neem + pungam oils 60EC	30.83 (33.63)[b]	61.70	32.30 (34.63)[b]	63.00
P. fluorescens	35.60 (36.60)[c]	55.78	38.84 (38.55)[c]	55.50
Copper oxychloride (0.2%)	23.50 (28.97)[a]	70.80	24.20 (29.46)[a]	72.28
Control	80.50 (63.80)[e]	-	87.3 (69.16)[e]	-

Leaf extract at 10%. Oils at 3%
*Mean of three replications
Data in parentheses represents arc sine transformed values.
Within column mean followed by a common letter do not differ significantly (P=0.05) according to Duncan's Multiple Range Test

9 months of storage (Rajappan, *et al*; 2001). Talc based formulation of *P. fluorescens* was found to be effective against chilli fruit rot and dieback (Bharathi *et al.,* 2004). Pre-harvest application of *P. fluorescens* with chitin formulation was found to reduce the mango anthracnose incidence upto 60% over untreated control (Vivekananthan *et al;* 2004).

Fron the study it was concluded that the including of neem + pungam oil 60EC, neem oil 80EC and *P. fluorescnes* as a component in integrated disease management strategy may provide ample scope for sustainable pesticide free grapevine production.

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Comparative batch growth studies of pure cultures and coculture of *Lactobacillus sp.* in submerged fermentation

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ABSTRACT

The study includes three sets of batch experiments carried out in anaerobic submerged fermentation to investigate the comparative biomass growth kinetics and acid formation in terms of pH drop effected by *Lactobacillus delbrueckii* (NCIM) 2025, *L. pentosus* (NCIM) 2912 and their coculture utilizing MRS culture media (without any neutralizer). The first two sets were kept at 30°C, initial pH 7.0, 0.1 g l^{-1} (cell dry weight) as inoculum dose, having 150 rpm and static conditions, respectively, while the third set was carried out at 36° C, 180 rpm, pH 7.0 and inoculum dose of 0.10 g l^{-1} (cell dry weight). The maximum cell dry weights, attained by the coculture in experiments (1), (2) and (3) during 18 h growth study were 16.15,12.21 and 24.12 g l^{-1}, respectively while, the maximum pH drop values were 5.16, 5.22 and 4.39, respectively. It was also found that the coculture exhibited better acid tolerance, thermo tolerance and better adaptablility in comparison to pure stains in all the experiments. The findings suggested superior performance of coculture in biomass growth and acidification than the pure cultures.

Key words : Anaerobic, submerged fermentation, coculture, *L. delbrueckii, L. pentosus*,

Lactobacillus sp. bacterial strains are highly capable multifunctional microorganisms used in chemical, food, biochemical, pharmaceutical and dairy industries. The lactic acid (2-hydroxy propanoic acid) obtained from *Lactobacillus sp*. is preferred over chemical synthesis methods, as it provides steriospecific L(+) and D (-) forms of high purity lactic acid, while chemical synthesis provides a racemic mixture DL lactic acid which is expensive to separate (Altaf *et al*., 2006). To reduce high costs involved in the purification of lactic acid isomers in chemical synthesis, 90% of world wide lactic acid production is based on microbial fermentation (Adsul *et al*., 2007). With large scale utilization of poly lactate biopolymers, about 20-30% of global production of lactic acid has been used as monomer feedstock for this industry in 2005 (Zhang *et al*., 2007). *Lactobacilli* play an active role in pickling of horticultural products such as cabbage, cucumber and olives. They are also involved in partial fermentation of carrots , cauliflower, okra and green tomatoes for mixed pickled products (Vaughn, 1987) . Kinetic studies in microbial fermentations are important to determine the occurence of growth in log phase, biomass production, pH changes effected , product formation etc., for different microbial strains under different set of experimental conditions. Leudking *et al*., (2000), proposed a mathematical model for batch process of lactic acid fermentation known as Leudking -Piret Model, which relates rate of product formation dp/dt , bacterial growth rate dN/dt ,and bacterial cell density N and constant a and b which are function of pH of broth. It may be expressed as follows :-

$dp/dt = a\, dN/dt + bN$. Where constants a and b which are function of pH of culture broth.

The above model shows the involvement of growth dependent and independent terms in lactic acid production kinetics. In lactic acid fermentation by *Lactobacillus sp*. the biomass in fermentation broth is reported to exist in three different physiological states (1) showing growth and acidification (2) non growing but acid forming (3) showing neither growth nor acid formation, (Cachon et al., 1993). While studying the batch culture of *Streptococcus sp.* IO-1,(Ishizaki et al.,1989) , proposed ,that the growth of microbes might be classified into three phases, the lag phase , exponential growth phases with sterile cell formation and without sterile cell formation. The present kinetic experiments were carried out to determine the (1) occurrence of the log phase, biomass generation, acid formation, acid

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tolerance among the bacterial strains,(2) feasibility of the coculture in lactic acid production and effect of enhanced agitation and higher temperature on the biomass production and acid formation with pure strains and coculture of *Lactobacilli*.

MATERIALS AND METHODS

Micro organisms and culture conditions

Pure cultures of bacterial strains, *Lactobacillus delbrueckii* NCIM 2025, *Lactobacillus pentosus* NCIM 2912 were obtained from National Chemical Laboratory (NCL) Pune. The stock cultures were supplied in MRS agar stabs and subcultured monthly as instructed by NCL Pune. The above pure strain and their coculture of *Lactobacillus sp*. were precultured in liquid MRS medium at 30^0C and 150 rpm, (12h) conditions. Equal inoculum doses of the above two strains were used for preparation of the co-culture during preculturing. Three separate batch studies were carried out with *Lactobacillus sp*. pure culture and coculture in 250ml flasks at (1) 30^0C, 150 rpm, an 0.1g l^{-1} inoculum (cell dry weight) with initial pH 7.0 (no control on pH fall) (2) 30°C, static conditions, initial pH 7.0 and 0.1 g l^{-1} inoculum dose (3) 36^0C, 180 rpm an 0.10 g l^{-1} inoculum (cell dry weight) using the MRS culture media in all the cases. The composition per liter for the MRS culture medium was: proteose peptone 10g, yeast extract 5g, beef extract 10g, dextrose 20g , tween 80 1g , ammonium citrate 2g, sodium acetate 5g, $MgSO_4.7H_2O$ 0.1g; $MnSO_4$ 0.05g; K_2HPO_4 2g. The chemicals were of Sd. fine, Qualigen and Merck make. The cell dry weight of bacterial cells was determined by centrifugation of fermentation broth at 8000 rpm for 10 minutes. To separate the cells from supernatant followed by washing with 0.85% NaCl solution and drying in preweighed microporous papers at 70^0C was done till constant weight was attained. The pH drops were measured with the help of digital pH meter.

RESULTS AND DISCUSSION

The first two set of batch experiments with *Lactobacillus* pure strains and their co-culture (Table 1) showed highest pH drops effected by the co-culture in each time interval from 3 h to 18 h of the study, as against *L. delbrueckii* and *L. pentosus* pure strains under the identical conditions. The data also indicated that the decline in pH value through acid production by *L. delbrueckii* was slower but it's coculturing with *L. pentosus* had a stimulating effect on acid production. It was observed from the fig.1 that the coculture, as compared to pure cultures, had highest growth as observed from cell dry weight (biomass) in first 3 hours, accompanied with highest pH drop, during the same time period. The fig. 2 indicated that a sharp fall in pH value due to acid synthesis by biomass in the pure strains and coculture of *lactobacilli* in the first 3h time. The coculture attained the lowest pH followed by *L.pentosus* and *L.delbrueckii* throughout the

Table 1. Biomass growth and pH drops effected by *Lactobacillus sp.* pure strains and coculture in MRS medium at 30° C and 150 rpm.

Time (h)	*L. delbrueckii*		*L. pentosus*		Coculture	
	Biomass (cell dry weight), g/l	pH	Biomass (cell dry weight), g/l	pH	Biomass (cell dry weight), g/l	pH
0	0.1	7.00	0.1	7.00	0.1	7.00
3	3.18	6.80	4.67	6.66	6.88	6.32
6	4.39	5.95	7.00	5.79	8.13	5.72
9	7.99	5.86	9.52	5.55	8.95	5.54
12	11.63	5.74	10.68	5.50	12.01	5.40
15	13.75	5.65	12.53	5.36	13.53	5.15
18	14.28	5.39	15.38	5.33	16.15	5.16

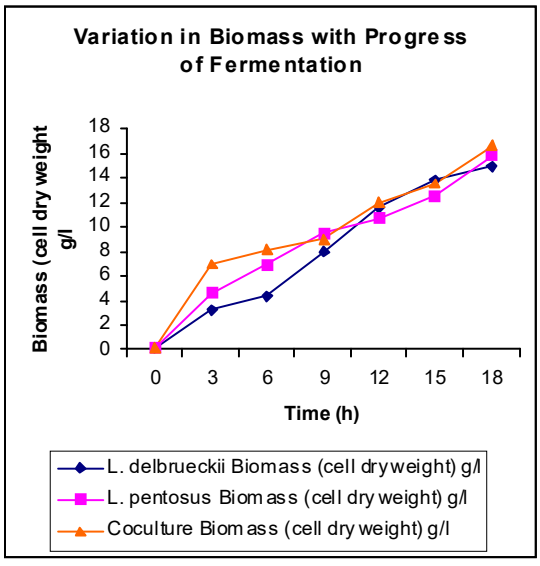

Fig 1 : Variation in biomass growth in initial pH 7.00 (without control of pH) and 30°C 150 rpm conditions with 0.1 g/l inoculum.

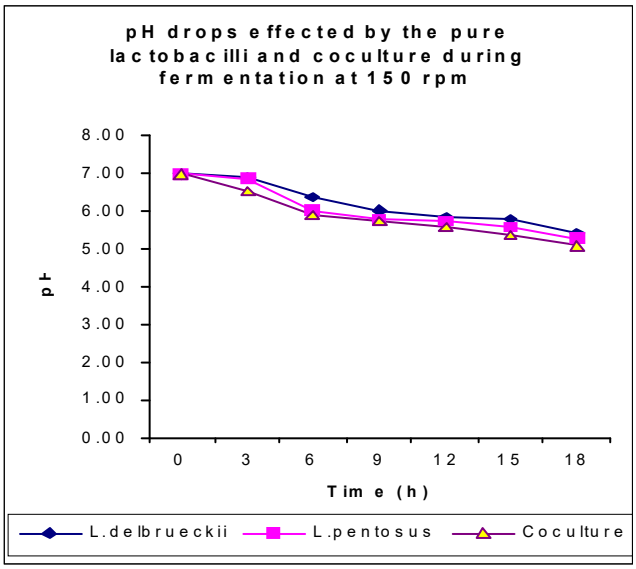

Fig 2 :Variation in pH due to action of *L. delbrueckii* L. pentosus and Coculture 30°C, pH 7.00 (without control of pH) 150 rpm, 0.1 g/l inoculum.

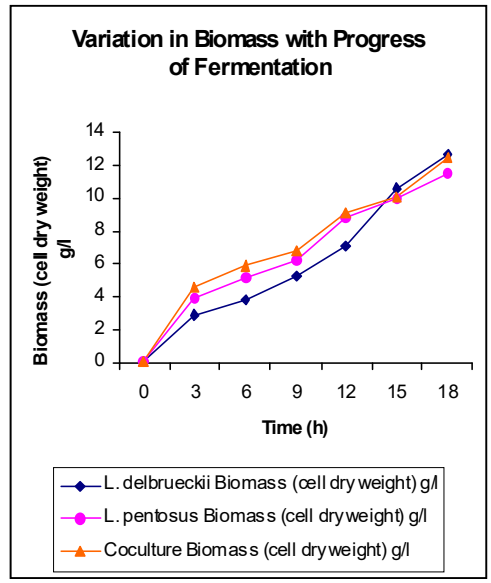

Fig 3 : Variation in biomass growth in *L. delbrueckii* *L. pentosus* and Coculture at 30°C,no neutralizer (without control of pH) under static conditions with 0.1 g/l inoculum dose.

duration of 3h to 18 h. Thus, it is seen that the coculture has quicker gain in biomass during log phase and results in maximum pH drop values i.e. it bears higher acid synthesizing capability hence they may prove more useful for the fermentation industries.

Data (Table 2) clearly shows that the coculture gives higher drops in pH values as compared with *Lactobacillus sp*. pure strains under study. The fig. 3 and table 2 indicate gradual increase of biomass in the log phase of *L. delbrueckii, L. pentosus* and coculture is extended till 18h due to slower growth rate in static conditions while in the first experiment (Table1) log phase biomass growth is faster due to agitation provided at 150 rpm. Highest biomass attained by coculture in 18 h coupled with highest pH drop values was observed as compared with *L. pentosus* and *L.delbrueckii* due to the presence of rapidly growing cells in the biomass,that are physiologically more active in acid synthesis. *L. pentosus* showed next higher drops in pH values in 18 h which clearly suggests that during this stage of culturing, their cells have attained higher acid synthesizing physiological state compared to *L .delbrueckii*.

A sharp decline in pH values in second set of batch was observed (Fig. 4) in 12 h, 9 h and 9 h for *L. delbrueckii, L. pentosus* and coculture, respectively. Delayed occurence of rapid fall stage of pH values for *L. delbrueckii* may be attributed to their higher temperature requirement (36 - 42 °C) for enhanced acid synthesis. Conversely, it can be inferred that *L. pentosus* and coculture perform better than *L. delbrueckii* in the temperatures lower than 36 °C.The table 3 , fig. 5 and fig. 6 indicated higher biomass growth and minimum pH

Table 2.Biomass growth (cell dry weight) & pH drops effected by *Lactobacillus sp.* pure strains and coculture in MRS medium under 30° C and static conditions.

Time (h)	*L. delbrueckii*		*L. pentosus*		Coculture	
	Biomass (cell dry weight) g/l	pH	Biomass (cell dry weight) g/l	pH	Biomass (cell dry weight) g/l	pH
0	0.1	7.0	0.1	7.0	0.1	7.0
3	2.95	6.98	3.94	6.97	4.56	6.95
6	3.76	6.96	5.20	6.93	5.92	6.90
9	5.27	6.93	6.24	6.90	6.84	6.84
12	7.07	6.65	8.85	5.77	9.12	5.52
15	10.65	5.96	9.96	5.48	10.08	5.27
18	12.18	5.48	11.14	5.40	12.21	5.22

Table 3. Biomass growth (cell dry weight) & pH drops effected by *Lactobacillus sp.* pure strains and coculture in MRS medium at 180 rpm, 36°C, 0.10 g/l inoculum dose and initial pH 7.0.

Time (h)	*L. delbrueckii*		*L. pentosus*		Coculture	
	Biomass (cell dry weight) g l^{-1}	pH	Biomass (cell dry weight) g l^{-1}	pH	Biomass (cell dry weight) g l^{-1}	pH
0	0.10	7.00	0.10	7.00	0.10	7.00
2	2.5	6.65	4.0	6.42	6.5	6.26
4	7.0	5.30	5.50	5.41	9.25	5.78
6	12.85	5.08	8.0	5.22	15.0	5.03
8	14.00	4.96	12.50	5.17	17.0	4.92
10	15.85	4.88	15.0	5.07	20.5	4.86
12	17.85	4.84	17.5	4.96	21.33	4.81
14	21.50	4.78	18.18	4.85	22.4	4.74
16	22.30	4.60	20.50	4.70	23.56	4.45
18	23.06	4.48	22.10	4.65	24.12	4.39

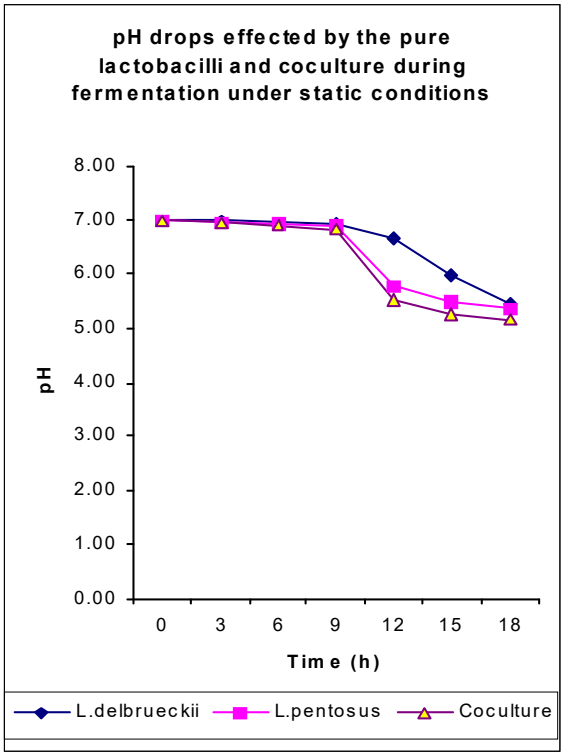

Fig 4 : Variation in pH due to action of L . delbrueckii *L . delbrueckii*, *L. pentosus* and Coculture at 30°C pH 7.00 (with no neutralizer) static conditions with 0.1 g/l inoculum.

value attained by the coculture as compared to *Lactobacillus sp*. pure cultures.

It also revealed that gradual increases of biomass are accompanied with sharp pH drops which, may be due to the fact that the cells were in a physiological state that favors more towards acid production. The data (Table 3) show that

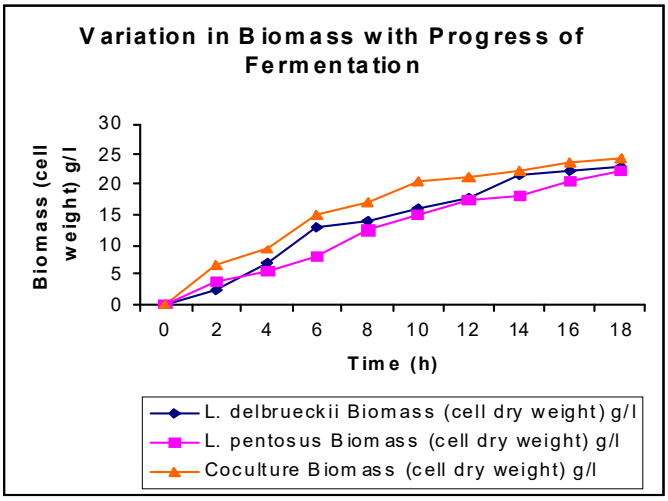

Fig 5 : Variation in biomass growth in *L. delbrueckii, L. pentosus* and Coculture at 36°C, initial pH 7.00 and 180 rpm conditions with 0.1 g/l inoculum dose (cell dry weight).

the *L. delbrueckii* has higher biomass formation and better pH drops than *L. pentosus* because higher temperatures 36°C – 42°C serve better for growth and function of the *L. delbrueckii*. The present batch studies showed that the coculture exhibits better adaptability and performance in terms of thermotolerance, acid tolerance, higher biomass growth and attainment of maximum pH drop (acid formation). The influence of higher agitation (180 rpm) and higher temperature (36°C) was observed (Table 3) where *L. delbrueckii*, *L. pentosus* and the coculture showed higher biomass growth and acid formation as compared with the conditions in first two sets of experiments.

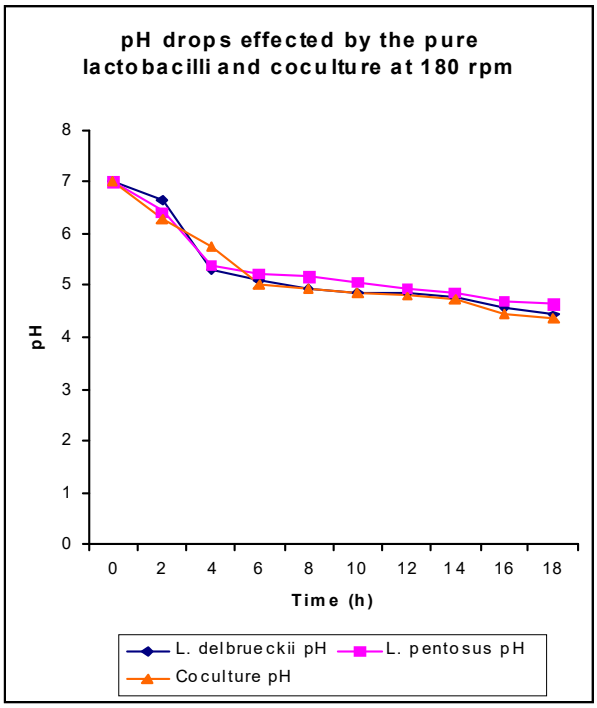

Fig 6 : Variation in pH drop values in *L. delbrueckii, L. pentosus* and Coculture at 36°C, initial pH 7.00 (without control of pH) and 180 rpm conditions with 0.1 g/l inoculum dose (cell dry weight).

It is evident from the investigation that the coculture bears advantage over the pure cultures in terms of biomass production and acid formation having better acid tolerance in an environment with higher acidity. Higher agitation and higher temperature were found beneficial for the coculture and *L. delbrueckii*. Thus, coculture can efficiently be used in fermentation based lactic acid production units with high productivity in the chemical and biochemical industries.

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Effect of metabolites produced by *Trichoderma* spp. against white mould *(Sclerotinia sclerotiorum)* in butter bean

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ABSTRACT

Laboratory experiment on *in vitro* testing of *Trichoderma* spp. (*T. virens, T. harzianum, T. virdae*) for their efficiency in inhibiting the growth of *Sclerotinia sclerotiorum* causing white mould disease in *Phaseolous lunatus* revealed exhibition of fungistatic effect inhibiting *S. sclerotiorum* growth between 0.00 to 25.66% for volatile, 0.00 to 53.33% for non-volatile and 62.22 to 77.78% for direct diffusibles. However, metablities produced by *T. virens* and *T. harzianum* effected significant reduction in *S. sclerotiorum* growth.

Key words: *Trichoderma,* non-volatile and volatile compounds, *Sclerotinia sclerotiorum*

Phaseolous lunatus commonly known as butter bean/ lima bean, is one of the important leguminous crop, used as vegetable and pulses for human consumption and as fodder for cattles in India. Its cultivation due to white mould caused by *Sclerotinia sclerotiorum,* as one of the major disease leading yield loss between 12 to 69% (Naidu, 1992), has become a major threat in recent years. Use of conventional protection methods including resistant cultivars have not given desired results. Biological control through use of fungal antagonists *Trichoderma* spp., emerged as an alternative means of soil borne disease management rendering long term sustenance in the recent past (Harman, 2000; Harman *et al.,* 2004; Howell, 2003) has received serious attention in recent years.

The most common *Trichoderma* species, as biocontrol agents, are *T. virens, T. viride* and *T. harzianum* (Misra and Prasad, 2003). Their importance as producers of valuable metabolites and enzymes viz., trichodermin, trichodermol harzianum A, harzianolide, alkyl pyrones, isonitriles, polyketides, peptaibols, diketopiperazines, sesquiterpenes and steroids has made their distinction status among different genera of fungi (Mishra and Gupta, 2009). They are frequently associated with both biocontrol activity and promotion of plant and root growth (Howell, 1994; 2000; Harman *et al*., 2000; 2004; Chet *et al*., 2006). The addition of *Trichoderma* metabolites that may act as elicitors of plant resistance or the expression of genes in transgenic plants whose products act as elicitors, also results in the synthesis of phytoalexins, PR proteins and other compounds helpful in increasing resistance against several plant pathogens, including fungi and bacteria (Elad *et al*., 2000; Dana *et al*., 2001), as well as resistance to hostile abiotic conditions. Yedida *et al.* (2003) showed that inoculation of cucumber roots with *T. harzianum* (T-203) induced an array of pathogenesis-related proteins, including a number of hydrolytic enzymes.

Hence, *Trichoderma* species from different soil sources were evaluated *in vitro* for their efficiency in inhibiting the growth of *Sclerotinia sclerotiorum.*

MATERIAL AND METHODS

Soil samples were collected from farmer's fields of Faizabad (Utter Pradesh) and different climatic regions of India. *Trichoderma* spp. were isolated using serial dilution plate and soil plate techniques on PDA (potato dextrose agar) and MEA (malt extract agar). *Trichoderma* colonies were identified as per identification key based on branching of conidiophores, shape and emergence of phialides and spore characters (Gams and Bisset, 1998; Nagamani *et al*., 2006). *S. sclerotiorum* was isolated from diseased plant samples and maintained on PDA media. Isolates of *Trichoderma* were tested against *S. sclerotiorum in vitro* by dual culture technique. The assembly was opened after seven days and colony diameter of *S. sclerotiorum* was measured in each plate. Test and control plates for all the experiments were set up in

triplicates and average of the results used for statistical analysis.

Periodic observations on the growth of *Trichoderma* isolates on *S. sclerotiorum* and their ability to inhibit its growth were recorded. Diffusible metabolite production by *Trichoderma* isolates was tested by using standard method (Dennis and Webster, 1971 a,b).

RESULTS AND DISCUSSION

Twenty six isolates on *Trichoderma* spp. were isolated from different soil samples. It included twelve from farmer's fields of Miryalaguda in Nalgonda district, six from farmer's fields of Ranga Reddy district and eight from forest soils of Chamoli district. *Trichoderma asperellum*, *Trichoderma harzianum*, *Trichoderma koningii*, *Trichoderma longibrachiatum* and *Trichoderma viride* were identified in the isolations made from farmer's fields of Nalgonda district while *T. asperellum*, *T. harzianum*, *T. longibrachiatum* and *T. viride* were identified from farmer's fields of Ranga Reddy district. From forest soil samples *T. aureovitide*, *T. longibrachiatum*, *T. virens* and *T. viride* were identified. Nagamani and Mew, 1987 earlier isolated different *Trichoderma* spp. from rice field soils. Besides, *T. polysporum*, *T. piluiferum* and *T. pseudokoningii* were also reported in the present study. *T. asperellum* was found along with *T. longibrachiatum*. Mala *et al.,* 2009 isolated a new strain of *Trichoderma* for the control of phytopahtogenic *S. sclerotiorum.*

All the isolates of *Trichoderma* in dual culture inhibited mycelial growth of *S. sclerotiorum*. The maximum inhibition was 77.78%. A clear visible band was formed in the contact zone between the two fungi. The zone of mycelial growth of *S. sclerotiorum* turned light green because of the presence of invading *Trichoderma* spp. The entire plate was covered by the fungal growth with in seven days with a greenish white mycelium in all *Trichoderma* isolates. *T. harzianum*. *T. koningii* and *T. aureoviride* were more aggressive in inhibiting the mycelial growth of the pathogen. Isolates of *T. aureoviride*, *T. longibrachiatum*, *T. virens* and *T. longibrachiatum* were least effective while *T. koningii* and *T. longibrachiatum* inhibited the sclerotial formation of the pathogen.

The inhibition may be due to competition for food, space, production of metabolites and mycoparasitism. Kucuk and Kivanc (2004) reported that several isolates were highly antagonistic to this pathogen. However, it is well known that all the isolates collected from different sources are not equally antagonistic to a particular pathogen and therefore, searching for effective isolates to suit the purpose locally is important (Harman, 2000). This study also confirmed the fact that isolates from farmer's rice fields of Nalgonda district showed a higher ability to inhibit and thereby suppress the pathogen compared to others.

Table 1: Percentage inhibition of *Sclerotinia sclerotiorum* by isolated *Trichoderma* strains.

Isolated strains	Inhibition (%)		
	Direct Culture Method	Non-Volatile Culture Method	Volatile Culture Method
M1	70	0	23.33
M2	71.11	0	11.11
M3	72.22	50	22.22
M4	77.78	48.89	20.00
M5	71.11	7.78	17.78
M6	72.22	15.56	5.56
M7	62.22	47.78	13.33
M8	71.11	35.56	11.11
M9	72.22	24.44	21.11
M10	77.78	42.22	0.00
M11	77.78	37.78	0.00
M12	63.33	34.44	10.00
M13	68.89	0.00	20.00
M14	65.56	0.00	25.56
M15	63.33	46.67	0.00
M16	75.56	0.00	0.00
M17	73.33	46.67	0.00
M18	75.56	40.00	0.00
M19	76.67	47.78	12.22
M20	68.89	52.22	0.00
M21	74.44	53.33	18.89
M22	67.78	51.11	6.67
M23	62.22	50.00	3.33
M24	73.33	0.00	8.89
M25	68.89	42.22	16.67
M26	76.67	0.00	0.00

Nineteen isolates of *Trichoderma* inhibited the growth of *S. sclerotiorum* by producing non-volatile compounds to a range of 7.78 to 53.33%. Seven isolates showed no effect on the growth of the pathogen. *T. longibrachiatum* showed maximum inhibitions of mycelial and sclerotial growth. All other except *T. asperellum* and *T. longibrachiatum* inhibited sclerotial formation. Prokkola 1992, Barbosa *et al.,* 2001, Bunkcr and Mathur (2001) observed inhibition of many pathogens through the non-volatile substances produced by *Trichoderma* spp., which was considered more advantageous than volatile metabolites as they diffused through the air filled pores in soil and actual contact between pathogen and antagonists might not be necessary for inhibition of the pathogen.

Eighteen isolates of *Trichoderma* spp. inhibited the growth of the *S. sclerotiorum* by the production of volatile compounds with *T. longibrachiatum* that was statistically at par with *T. asperellum* and *T. koningii*. Other isolates showed least inhibition. The antagonistic properties of *Trichoderma* spp. producing volatile and non-volatile compounds inhibiting the growth of various soil borne pathogens has been reviewed (Barbosa *et al*., 2001; Bunker and Mathur, 2001; Kexiang *et al*., 2002 and (Deacon, 2006). The major volatile antibiotic identified was 6-pentyl-á-pyrone (6-PAP) that is known to be produced by *T. viride*, *T. harzianum* and *T. hamatum*.

Major non-volatile metabolites of *Trichoderma* spp. include trichodermin, suzukacillin and alamethicine. *T. virens* is known to produce spectrum of metaboiltes such as gliovirin, heptelidic acid, viridian and gliotoxin that are more active against *S. sclerotiorum in vitro* (Deacon, 2006). The isolates obtained from the farmer's fields showed the highest antagonistic activity against *S. sclerotiorum* in the present study. Other isolates also showed certain degree of antagonism. Sheath blight was reported from Miryalaguda farmer's field (Nagamani *et al*., 2006) It is considered that the potential biocontrol agents from natural ecosystems have a considerable effect on the control of sheath blight pathogen of rice. It is evident that the isolates from native soils and pathogen-infested environments are superior when compared to isolates from other environments.

T. longibrachiatum showed strain variations in inhibiting the growth and sclerotial formation of the pathogen. Present investigation revealed that different strains or species possessed different capability as biological weapons, in inhibiting the pathogen. Prokkola (1992) and Harman (2000) observed an array of mechanism by which *Trichoderma* spp. exerts biocontrol activity and thus they show strain or species variation in controlling the pathogen. The species or strain, which showed maximum antibiosis with non-volatiles, may not produce volatiles and vice-versa. Species variation was also observed in this study indicating that *T. aureoviride* and *T. virens* were isolated from forest soils whereas *T. koningii* was isolated only form soils of farmer's fields in Nalgonda district.

It is thus concluded that the *Trichoderma* spp. from natural ecosystem is more antagonistic in suppressing the mycelia growth and sclerotial formation of sheath blight pathogen, *S. sclerotiorum*. while *T. longibrachiatum* and *T. koningii,* based on growth inhibition, production of non-volatile and volatile metabolites, were identified as the best isolates.

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Potentials of neem seed oil in wood protection through fumigation

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ABSTRACT

The laboratory experiment conducted to determine the potential of neem seed oil as fumigant against wood decaying fungi i.e. *Trametes versicolor* Linn. and *Oligoporus placentus* Murr. revealed that neem seed oil (3.9%) imparted more than 82% protection, reducing weight loss of 6-10% against the control (51-58%), in soft and hard woods.

Key words: Brown rot, Fumigant, Hard wood, Soft wood, White rot

Timber woods, imported or exported, stored at ports or in depots, are generally infected by microbes causing decay and losses in terms of quality and wood life. To make it transportable overseas without damage, fumigation through vapam, vorlex, sulfuryl fluoride, methyl bromide etc. is globally under practice because of its high toxicity and penetrating ability. But because of these causing high mammalian toxicity and environmental hazards, need for testing botanicals, having insecticidal and antimicrobal properties (Tripathi *et al.,* 1978), as an eco-friendly wood fumigants possessing no or very little mammalian toxicity, was desired.

Neem (*Azadirachta indica* A. Juss). considered to be a store house of various biological active compounds such as, azadirachtin, salanin, nimbin, quercetin and widely recognized for its medicinal, insecticidal and anti-microbial properties is now drawing attention throughout the world. Extensive research work is being carried out to evaluate its entomological, pathological properties. Use of its plant parts viz., neem wood against wood destroying white rot fungi *Polyporus versicolor* and *P. hirsutus* and brown rot fungi, *P. palustris* and *P. meliae* (**Rao 1990)**, neem seed kernel fraction impregnated into specimens of mango against *Microcerotermes beesoni* (**Sharma *et al.*, 1998),** ethanolic extracts of neem leaves against *Microcerotermes turneri*, a wood-destroying termite **(Friend, 1995)**, neem oil and copper complex of neem oil against wood destroying termites (**Venmalar and Nagveni 2005)**, neem oil based pellets formulated with various essential oils and volatile substances, clove oil, citronella oil, camphor, borneol, and menthol deterrants against rice weevil, *Sitophilus oryzae L.* **(Sanguanpong *et al.*, 2001),** ware house neem I (mist and spray) and ware house neem II (thermal fog) (Azadirachtin-1500ppm in both) against major storage pests of maize, the rice weevil, *Sitophilus oryzae* and the lesser grain borer, *Rhyzopertha dominica* (**Michaelraj and Sharma 2006**) and neem seed oil against wood decaying fungi (Dhayani *et al.,* 2006) has been documented.

However, no efforts have been done so far to test neem seed oil as wood fumigant. The present test study was therefore, carried out against wood decaying white rot (*Trametes versicolor* Linn.) and brown rot (*Oligoporus placentus* Murr.) in soft wood (*Pinus roxburghii* Sargent) and hard wood (*Populus deltoides* Bartr ex. Marsh).

MATERIALS AND METHODS

Extraction of neem seed oil (NSO)

Fresh neem fruits, collected in the month of June 2007 from Saharanpur (Latitude 29°. 58′N and longitude 77°. 23′E), Uttar Pradesh, India were de-pulped, washed with water and shade dried. The seeds were decorticated and the kernels obtained were pulverized to 40-60 mesh. 300g of pulverized powder was introduced into a Soxhlet apparatus and extracted with petroleum ether (60-80°C). The oil obtained was dried over anhydrous sodium sulphate. It was then separated from the solvent resulting in pale yellow colored oil (yield 13%) **(Browning, 1975; Puri, 1967; Negi, 2005).**

Maintenance of fungal culture

The test fungi, *Trametes versicolor* Linn (for non–conifers – *Populus deltoides* Bartr ex. Marsh) isolated from oak stem, Senji forest area Mussorie, Forest Research Institute Herbarium No. 7437 and *Oligoporus placentus* Murr (for conifers – *Pinus roxburghii* Sargent) received from F.P.R.L.

Princess Risbourgh. England, No. 304-A. (IS: 4873, **2008** and ASTM, 1980) were maintained at 25± 2°C on 2% (w/v) malt agar until inoculation.

Malt agar medium (4%) was prepared by adding 20 gram malt and 20 gram agar powder dissolved in 1 liter of distilled water and was heated till boiling. This medium was sterilized in an autoclave at 15 pound pressure and 120°C temperature for 20 min. **(Datar, 1995)**. After autoclaving 30ml of the medium was poured in each sterilized petri plate (9cm diameter) in culture room. These were allowed to cool for 1 h till the medium solidified. For each concentration of fumigant 6 replicates were taken along with control (fumigant free).

Table 1: Grading of surface coverage of the test fungi on malt agar medium

Growth Type	Surface coverage of mycelium on the medium (%)
None	0
Sporadic	0-5
Little	5-25
Moderate	25-50
Considerable	50-75
Complete	>75

Fumigation of malt agar medium and antifungal activity test

Petri dishes with malt agar medium were placed in desiccators connected with a conical flask with the help of connecting glass tube having stop cock-1. On the other side, the dessicator was also connected with a vacuum pump having stop cock-2 in between. The fumigant was placed in the conical flask and was heated on a hot plate. Before heating, partial vacuum (60mm Hg) was created in the dessicator for 5-10 min. to replace the air by opening stop cock-2. During this period the stop cock-1 was kept closed. After creating vacuum the fumigant was heated and the fumes were allowed to pass into the dessicator through glass tube by opening stop cock-1 while the other stop cock-2 was kept closed at that time. Nso at 5 different concentrations i.e. 0.1, 0.2, 0.3, 0.4 and 0.5% (v/v) were taken for the study. The heating process was carried out for 1 h and the petri dishes were left in the dessicator for 24 h further. The petri dishes containing the medium with or without fumigant were inoculated with an inoculum disc of actively growing 14-16 days old culture of the test fungi. The plates were incubated at 25±2°C temperature and 70±4% relative humidity. The results were recorded after 15 days in terms of percent surface coverage by the test fungi over malt agar medium and shown as total percent growth inhibition **(Kapse, 1996; Wedge *et al.*, 2000).**

The total growth of fungus was rated **as per Goyal and Dev (1982)** and the inhibition in fungi growth was statistically analyzed by SPSS 10.0 package.

Nature of antifungal activity

To determine the nature of antifungal activity, the inoculum discs of the test fungi in which the growth was completely suppressed by the fumigant were transferred to fresh fumigant free malt agar medium. The plates were incubated for 15 days and the results were recorded as described earlier. If the growth was resumed immediately, it was categorized as fungistatic and if no growth took place again then it was termed as fungicidal. This concentration was termed as minimum fungicidal concentration (MFC) **(Iqbal *et al.*, 2004)**. For each concentration and control against each fungus, 3 replicates were taken.

Soil Block Bioassay

Based on preliminary screening tests results of Nso as fumigants by malt agar bioassay, further testing of this fumigant by soil block bioassay was conducted at 5 different concentrations i.e. 0.9, 1.9, 2.9, 3.9 and 4.9% (w/v) against both the test fungi **(IS: 4873, 2008).**

Table 2: Means growth inhibition (%) of fungi in Petri plates fumigated with different concentrations of neem seed oil

Conc. (%)	Fungi	
	T. versicolor	*O. placentus*
Control	0	0
0.1	0	0
0.2	17.27(24.54)	31.34 (34.03)
0.3	43.23 (41.09)	56.90 (48.94)
0.4	76.10 (60.72)	83.02 (65.65)
0.5	100.00 (89.96)	100.00 (89.96)
Mean (fungi)	39.43 (36.05)	45.21 (39.76)

Values in parenthesis are arsine values.
$C.D_{(0.05)}$ Fungi= 0.25, Concentrations= 0.43

Preparation of test blocks

Sapwood of Chir (*Pinus roxburghii* Sargent) and poplar (*Populus deltoides* Bartr. Ex. Marsh) from seasoned planks, free from knots, mold, stain and any other defects was taken. It was converted into the sample size of 19x19x19 mm with a 0.32 mm central hole on the tangential face along the length of grain and weighed (W_1). The test blocks containing about 7% moisture under laboratory conditions were divided into weight groups at 0.1g intervals. Accurate cutting of the blocks, amounted to a rough separation into density groups.

Table 3: Mean weight loss (%) of wood fumigated with neem seed oil due to decay fungi

Conc. (%)	Reten. (gm/m³)	Wood			
		P. roxburghii		*P. deltoides*	
		T. versicolor	*O. placentus*	*T. versicolor*	*O. placentus*
Control	0.00	50.73 (45.40)	53.87 (47.20)	53.11 (46.77)	57.64 (49.38)
0.3	26.20	20.62 (26.99)	25.13 (30.07)	22.45 (28.27)	27.55 (31.65)
0.9	55.31	17.49 (24.71)	20.35 (26.80)	19.84 (26.43)	22.43 (28.25)
1.9	84.43	13.32(21.39)	17.25 (24.53)	13.86 (21.85)	18.55 (25.50)
2.9	113.54	8.91 (17.35)	11.73 (20.02)	11.74 (20.03)	12.74 (20.90)
3.9	142.66	5.76 (13.88)	7.66 (16.06)	7.10 (15.45)	10.38 (18.79)
Mean (Wood)		21.07 (26.20)[a]		23.12 (27.77)[b]	
Mean (Fungi)		20.41 (25.71)[c]		23.77 (28.26)[d]	

Values in parenthesis are arsine values.
a = *T. versicolor*, b = *O. placentus*, c = *P. roxburghii*, d= *P. deltoides*
$C.D_{(0.05)}$ Wood=0.16, Fungi=0.16, Concentrations= 0.27

It was observed from the earlier studies that, by using blocks of closely related densities in any test, the concentration of the treating solution can be adjusted so as to result in a series of blocks with evenly spaced gradient retentions. These blocks were later subjected to 105°C in an oven and the weighed till a constant weight (W_2) was achieved. Moisture content of the wood was calculated from initial weight (W_1) and conditioned weight (W_2) of the test blocks by using the following formula. The moisture content of the wood blocks used for soil block bioassay test was 4%. For each concentration of Nso in each wood against each fungus as well as control, six replicates were used.

$$\text{Moisture content of wood}\,(\%) = \frac{W_1 - W_2}{W_2} \times 100$$

Sterilization and fumigation of test blocks

The test blocks were steamed at 100°C for about 20 minutes at atmospheric pressure in an autoclave in tightly fitted bottles (IS: 4873, 2008). The sterilized test blocks were placed on a wire rack inside desiccators, connected with a vacuum pump. A partial vacuum of 60 mm Hg was created in desiccators for 30 minutes to expel air from dessicator. A known amount of fumigant was then heated in a conical flask on hot plate (40-50°C), which was connected with the desiccators with the help of a glass tube through which fumes passed from conical flask to the dessicator. The heating process was carried out for 3 h and the blocks were left in the dessicator for 3 days. The blocks were then taken out and weighed immediately (W_3).

Preparation of soil culture

Sieved, air-dried garden soil amounting to 125 gm with pH between 5.0-7.0 was filled (compacted by tapping) in screw capped bottles. Sample of the air-dried soil was taken. The pH of the soil was potentiometrically measured in the supernatant suspension of a 1:5 soil: liquid (v/v) mixture (according to Geotechnical test method **(GTM-24), April, 2007).** Distilled water (44 ml) was added to each bottle to obtain 130% of water holding capacity of soil in test bottles. Feeder blocks of size 4x19x35 mm were prepared from sap wood of *Bombax ceiba* (Semal), a highly perishable wood and used for providing nutrients to the growing culture/ mycelium. Two feeder blocks were placed directly on the soil surface. The prepared bottles with caps loosened were sterilized and autoclaved for 30 minutes.

Preparation of test culture

The fungus inoculums from freshly grown culture with 10X10 mm pieces were taken from the outer edge of mycelium of two week old fungal colonies and placed on the edge of the feeder blocks in sterilized culture bottles. The inoculated bottles with slightly loosened lids were incubated in B.O.D. for providing a controlled condition of temperature and humidity. The incubator was maintained at 25±2°C and 70±4% relative humidity for approximately 3 weeks till the mycelia mat had covered the feeder blocks.

Introduction and incubation of the test blocks

Two blocks with cross section face down were placed on feeder blocks in contact with mycelium in each culture bottle. The bottles containing the test blocks were incubated for a period of 14 weeks in the incubator maintained at 25±2°C and a relative humidity of about 70±4% (IS: 4873, 2008).

The incubated blocks were later removed from the culture bottles, cleaned off from the adhering mycelium and leaving the splinters of the wood intact, dried at room

temperature for 3-4 days and in the hot air oven and weighed till a constant weight was obtained. The extent of fungal attack was determined by weight loss using following formula:

$$\text{Weight loss}(\%) = \frac{W_3 - W_4}{W_3} \times 100$$

Where,

W_3 = Conditioned weight of the blocks before test (after fumigation)

W_4 = Conditioned weight of the blocks after test

Weight loss caused by test fungi were statistically analyzed by using SPSS 10.0 package.

Fumigated and non fumigated blocks were powdered and extracted in petroleum ether (60-80°C) separately. The extract obtained was dried and then weighed and the amount of extractive was calculated. For extraction 12 blocks were taken **(Goyal and Dev, 1982).**

$$W_2 - W_1 \text{ g}$$

W_1 = Amount of extractive obtained from non fumigated blocks

W_2 = Amount of extractive obtained from fumigated blocks

On the basis of absorption of fumigant retention was calculated in g/m^3.

RESULTS AND DISCUSSION

Nso, when impregnated in wood **(Dhyani, 2008)** was found effective at 20-22% at 75-124 kg/m^3 retention against wood degrading fungi and termites**,** but its activity as fumigant for wood protection has not been explored so far.

Results of malt agar bioassay showed the activity of neem seed oil (Nso) against wood decaying fungi. NO growth inhibition was recorded at lowest concentration of Nso i.e. 0.1% against *T. versicolor*, similar to control. Mean surface coverage of 82.73, 56.77 and 23.9% was observed in plates containing 0.2, 0.3 and 0.4% of Nso respectively. Highest concentration of Nso (0.5%) checked the growth of the test fungus completely, showing high fungicidal activity.

Similarly Nso (0.5%) against *O. placentus* recorded 100% growth inhibition, as against 83.02% at 0.4%. Growth inhibition of 56.90 and 31.34% of the test fungus was observed when fumigated with 0.3 and 0.2% of Nso, whereas 100% growth was observed at 0.1% concentration of neem oil and in control. At highest concentration (0.5%), Nso showed fungicidal activity against *O. placentus*. Statistical analysis of data revealed that null hypothesis is rejected at 0.05 significance level, as the activity shown by the various concentrations of Nso were found to be significantly different from each other against brown and white rot.

Soil block bioassay results showed that both the test fungi cause more than 50% weight loss in both woods. Soft wood *(P. roxburghii)* and hard wood (*P. deltoids)* blocks fumigated with concentrations (0.3, 0.9, 1.9, 2.9, and 3.9%) of Nso and tested for toxicity against wood decaying fungi i.e. *T. versicolor* and *O. placentus* by soil block bioassay revealed retentions of 74.76, 224.29, 473.51, 722.73 and 971.95 gm/ m^3 in fumigated test blocks, respectively.

Soft wood (chir) blocks fumigated with 0.3, 0.9, 1.9, 2.9, and 3.9% concentrations of Nso on *T. versicolor,* recorded mean weight loss of 20.62, 17.49, 13.32, 8.91 and 5.76%, respectively against. 50.73% in control block. Nso was found effective at all concentrations against *O. placentus*. Chir blocks fumigated with 0.3% and 9% concentration of Nso recorded weight loss of 25.13 and 20.35%, respectively. Blocks fumigated with 1.9%, 2.9% and 3.9% concentration of Nso, recorded mean weight loss of 17.25**,** 11.73 and 7.66%, respectively, as compared to 53.87% mean weight loss in control blocks. Hard wood (poplar) blocks fumigated with 3.9% concentration of Nso, subjected to *T. versicolor* recorded minimum a mean weight loss of 7.10% against 11.74, 13.86, 19.84 and 22.45% at 2.9, 1.9, 0.9 and 0.3% concentration, respectively and 53.11% in the control. Fumigated blocks of poplar subjected to *O. placentus* at 0.3, 0.9, 1.9, 2.9 and 3.9% concentration of Nso, recorded mean weight loss of 27.55, 22.43, 18.55, 12.74 and 10.38%, respectively as against 57.64% in the control.

Weight loss caused by *T. versicolor* and *O. placentus* in test blocks of *P. roxburghii* and *P. deltoides*, fumigated with different concentrations of Nso were statistically analyzed at 5% significance level. It was found that, mean weight loss (%) caused in poplar and chir blocks fumigated with various concentrations of Nso was different so null hypothesis was rejected at 5% significance level. It is inferred from statistical analysis that the extent of deterioration caused by *T. versicolor* and *O. placentus* in both wood species was significantly different and *O. placentus* caused more weight loss as compared to *T. versicolor.*

Faster decay of hardwoods than that of soft woods by white rot fungi is reported in earlier studies. It may be partially explained by the effect of the different amounts and different types of lignin composed of almost entirely of quaiacylpropyl (G) units in soft wood along with in addition to G units in

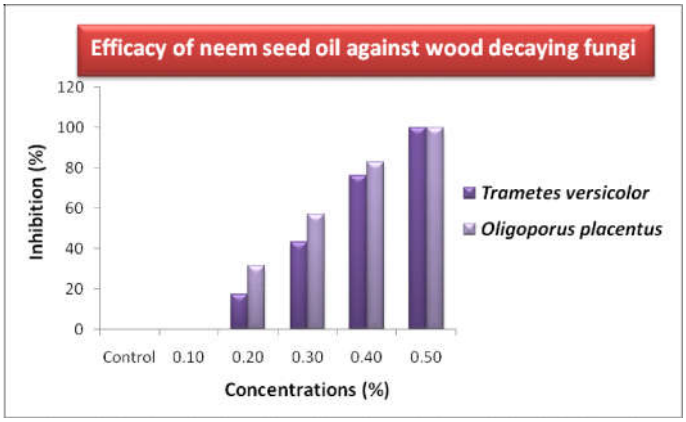

Fig. 1

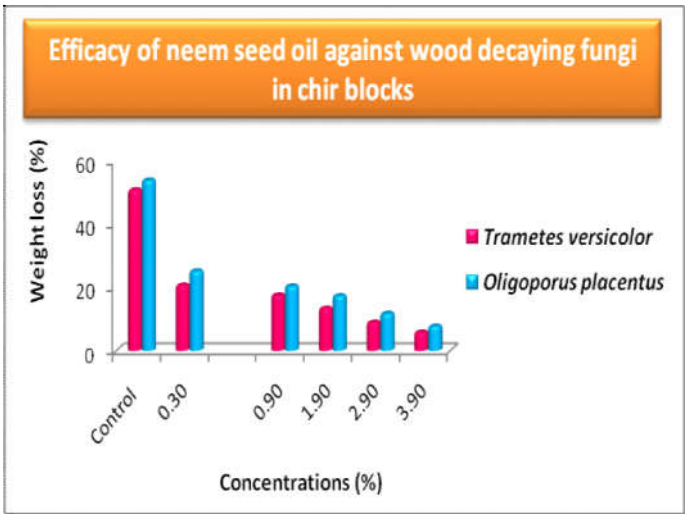

Fig. 2

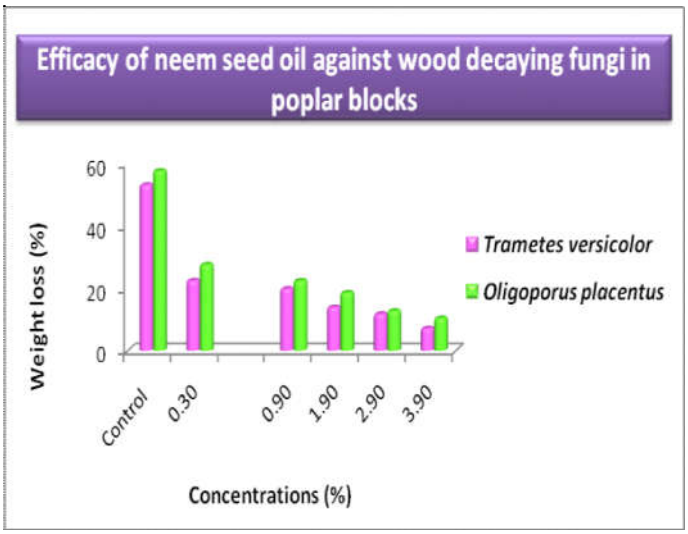

Fig. 3

hard work numerous syringylpropyl (S) unit. A study addresses the influence of lignin type on decay by the white rot fungus *T. versicolor* by using a number of woods with a wide range of S:G ratios and different lignin type distributions. The results of the study are consistent with the general premise that lignin concentration and lignin type affect the decay resistance of wood **(Llewellyn *et al.*, 1994)**.

Results revealed that *T. versicolor* causes less weight loss in *P. roxburghii* as compared to *P. deltoides*. This finding is also in conformity with the findings of **Melecion and Morrell (2009)** who reported that *T. versicolor* causes less weight loss in soft wood as compared to hard wood. This is probably due to the inability of the fungus in causing substantial degradation of coniferous components and the tendency of fungus to be hyper active on hardwoods.

The antifungal activity of Nso may be due to the sulfur present in it, also in conformity with the findings of **Miller and Morrell (1990)** who observed that various decomposition products of NaMDC provide some protection of wood near the application point, but only volatile products and the sulfur in non volatile products, play a major role in protecting wood away from the point of application and play an important role in long term wood protection. Sulfur was present only at low levels in cellulose mixtures. Similarly **Zahora and Morrell (1988)** also studied the decomposition of methylisothiocyanate (MIC) in blocks of Douglas fir heart wood. It was found that elemental sulfur was formed and showed fungal toxicity. No study was reported so far on the activity of Nso as fumigant against wood decaying fungi.

It was thus concluded that neem seed oil (Nso) provided maximum protection to soft and hard wood blocks from both the wood decaying i.e. white and brown rot fungi at all concentrations of Nso tested, The maximum being 82% at highest concentration (3.9%), and was therefore recommended for use as an effective protection tool which is safer to the environment as well as the workers also than synthetic compounds and would be more acceptable to consumers. Further work on chemical components produced during fumigation from Nso may be characterized and their activity ascertained for wood protection. Residual effect may be studied for different time intervals to assess its efficacy.

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Integrated management of early blight of potato caused by *Alternaria solani*

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ABSTRACT

The field experiment to manage early blight of potato (*Alternaria solani*), a world wide disease of potato crop, through integrated use of bio-control agents, botanicals and fungicidal treatments viz. mancozeb (0.25%), copper oxychloride (0.3%), hexaconazole (0.05%), azoxystrobin (0.2%), *A. niger* - V (0.4%), *A. niger* - V + sticker (0.4% + 0.1%) revealed that azoxystrobin was found the most effective treatment in two successive years. Among the bioagents, *A. niger* with sticker gave satisfactory results in reducing the disease incidence and was found statistically at par with azoxystrobin.

Key world: *Solanum tuberosum, Alternaria solani, Aspergillus niger*, Azoxystrobin, Bioagents, Hexaconazole

Early blight of potato caused by *Alternaria solani* is a major disease pest of potato crop which ranks fourth as food crop in the world. It causes leaf spots on potato that later gets covered with a deep greenish-blue growth of the fungus. Lowest leaves are attacked first and progresses upward in the next few days. The disease can occur over a wide range of climatic conditions and can be very destructive if left uncontrolled, often resulting in complete defoliation of plants. In contrast to the name, it rarely develops early, but usually appears on mature foliage. In India, the disease is prevalent throughout the country but is potentially destructive in few pockets, where environmental conditions are hot and humid, especially the sub-mountains and plateau region of Madhya Pradesh and Maharashtra causing losses upto 40%. Effective management of this disease requires implementation of an integrated disease management approach. Under high disease pressure, single practice for disease management is not efficient, so integration of all the possible management practices viz., use of cultural practices, resistant cultivars, bioagents and foliar fungicides (Wharton and Kirk, 2007) is required to achieve economic yield of good quality potato crop.

The present investigation was therefore carried over to evaluate the integrated use of bio agents and fungicides with different active ingredients for management of *A. solani* in potato field.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of CPRI Modipuram, Meerut during 1999-2000, and 2000-2001 crop season in randomized block design with three replications using 'Kufari - Jwala' variety of potato. Seven different treatments viz., mancozeb (0.25%), copper oxychloride (0.3%), hexaconazole (0.05%), azoxystrobin (0.2%), *A. niger* - V (0.4%), *A. niger* - V + sticker (0.4% + 0.1%), and the control were tested. The plot size was 4-3 m, and spacing was 60-20 cm. Sowing of potato tubers was done in September. Recommended dose of fertilizers was applied and the first spray was given immediately after the initial appearance of disease symptoms. All the fungicides were sprayed at 10 days interval. Control plots were sprayed with same volume of water and after three sprayings of fungicides and bio-agents at 10 days interval 20 plants / plot were selected randomly. The data on disease severity were recorded using 0-4 rating scale (Reifchnedeider *et al.*, 1984). First observation on disease severity was recorded before the beginning of first spray of fungicides, and subsequently before each spray and finally 10 days after last spray. Yield increase over control was also recorded. The data was statistically analyzed using simple Randomized Block Design (RBD).

RESULTS AND DISCUSSION

The data revealed that all the fungicides and bioagents used for the management of the disease significantly reduced

Table 1. Effect of different treatment on disease incidence and yield.

Treatments	1999-2000			2000-01		
	Doses (%)	Leaf blight incidence (%)	Total yield (kg plot^{-1})	Leaf blight incidence (%)	Total yield (kg plot^{-1})	Mean PDI of two Years
Mancozeb	0.25	17.5	18.2	18.3	17.5	17.9
Copper oxychloride	0.2	18.56	16.3	19.6	15.8	19.08
Hexaconazole	0.05	18.23	17.7	19.2	16.1	18.715
Azoxystrobin	0.2	12.96	20.4	13.1	20.3	13.03
Aspergillus niger	0.4	18.2	16.9	19.1	16.2	18.65
Aspergillus niger + sticker	0.4 + 0.1	14.45	19.6	14.2	20.1	14.325
Control	0	31	13.2	37	11.2	34
Pooled C.D.(P=0.05)			2.96284			

the disease incidence during both the years of experimentation. Among the treatments, azoxystrobin performed best with 12.96 and 13.10% in two successive years respectively (Tables 1). This was statistically at par with bio-agent, *A. niger* along with sticker being 14.45 and 14.2 %, respectively. It was also found that when *A. niger* was used alone, the disease incidence was 18.2 and 16.2 %, respectively for the two successive years. This suggest that a sticker must be used to achieve good results. According to Datar and Mayee (Datar and Mayee, 1985) and Rajgopal and Vidhyasekaran (Rajgopal and Vidhyasekaran, 1983) mancozeb controlled disease incidence of tomato. Our results where the disease incidence was observed to be 17.5 and 17.5 %, respectively for the two successive years was similar to earlier findings. It was statistically at par with copper oxychloride, hexaconazole and *A. niger*. Combination of systemic fungicides like metalaxyl + mancozeb, ridomil + acrobit was economical and more effective in the management of early blight of potato than the repeated sprays of a single fungicide (Aslam *et al.,* 2003; Choulwar, A.B and V.V. Datar 1994)

Data presented in Table 1 indicated maximum yield under azoxystrobin treatment (20.4 and 20.3 kg plot^{-1}) which was stastically at par with *A. niger* with sticker (19.6 and 20.1 kg plot^{-1}), respectively for the two successive years followed by mancozeb (18.2 and 17.5 kg plot^{-1}) which was stastically at par with hexaconazole, copper oxychloride and *A. niger* alone during the year 1999-2000 and 2000-2001 as compared to control (13.2 and 11.2 kg plot^{-1}).

In overall field experimentation, azoxystrobin proved most effective in managing the disease therefore, it can be recommended. Many workers (Dahman and Staub, 1992; Mathur *et al.,* 1971; Prasad and Naik, 2003; Singh, 1971) reported mancozeb and difenoconazole as most effective fungicide for the management of early blight, and maximum fruit yield. In our findings also mancozeb recorded significant disease management and increased yield.

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Bio-efficacy of anti-nemic plants against root-knot nematode in medicinal coleus

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ABSTRACT

The effect of growing nematode antagonistic crops such as sunhemp, mustard, marigold, castor, onion and cowpea as intercrop and their biomass incorporation during earthing up in medicinal coleus, *Coleus forskohlii* cultivation, evaluated against the root-knot nematode, *Meloidogyne incognita* under glasshouse and field conditions, revealed that all the tested plants reduced *M. incognita* population and increased the root tuber yield. Among antagonistic plants tested, marigold was found significantly superior in reducing the nematode population in soil, gall formation in roots and increased the root tuber yield followed by sunhemp, cowpea, mustard, onion and castor. Marigold treatment reduced *M. incognita* populations by 43.3 -59.6 % in soil and recorded least gall index of 2.2–3.0 in medicinal coleus plants. Marigold inter cultivation increased root tuber yield of medicinal coleus by 35.6 % under glasshouse condition and 15.0 % under field condition.

Key words: Medicinal coleus, root-knot nematode, antagonistic plants.

Medicinal coleus, *Coleus forskohlii* (Willd.) Briq. is cultivated as an important medicinal plant in India, Nepal, Sri Lanka, Africa, Burma and Thailand. The diterpenoid, forskolin found in the root tubers of *Coleus forskohlii*, which has a number of medicinal uses especially for obesity and blood pressure control, is in great demand in Japan, USA and many European countries. The growing demand for forskolin in international trade has led many farmers to go for its commercial cultivation in India. Root tubers, the economic part of this crop, is highly prone to infestation by root-knot nematode, *Meloidogyne incognita*. Severely infected plants often fail to produce root tubers leading to yield reduction upto 86% (Senthamarai *et al*., 2006). Chemical nematicides do control these to a certain extent, however their applications in cultivation of medicinal plants are strictly restricted as they are reported to alter the active principles and medicinal properties. This led to search for alternative methods of nematode control. Among various eco-friendly strategies available for nematode management, use of antagonistic plants is one the of thrust idea needed to be exploited for field level application. Numerous experiments have since shown that various antagonistic plant species when interplanted with the crop or used as a soil amendment can effectively control nematodes on various crops (Rice, 1983). Hence, sunhemp, mustard, marigold, castor, onion and cowpea as intercultural crop were evaluated for the management of root-knot nematode on medicinal coleus under glass house and field condition.

MATERIALS AND METHODS

A pot culture experiment in a completely randomized block design was carried out at Regional Research Station, Aruppukottai, Tamil Nadu, India during January-May 2006. *Meloidogyne incognita* populations used in glass house study were isolated from medicinal coleus plants at farmer's field and pure cultures were maintained on tomato cv. Co1. Egg masses of *M. incognita* picked from tomato roots were allowed to hatch in a beaker of distilled water and the hatched juveniles (J2) were used for inoculation. Medicinal coleus (cv. Local) terminal stem cuttings of 10 cm length were used in the glass house and field tests. Pots measuring 15 cm in diameter were filled with 5 kg heat sterilized loam: sand mix and medicinal coleus stem cutting were planted @ one pot^{-1}. The seeds of sunnhemp, onion, mustard, castor and cowpea were sown and thinned to one pot^{-1} after germination. For marigold, instead of seed sowing, fifteen day old seedling was planted. Control plants without any inter crops were inoculated with the nematode alone. Ten days after planting (DAP), second stage juveniles (J_2) of *M. incognita* @ 5000 pot^{-1} (Pi) suspended in 10ml of water were inoculated. Treatments were arranged in a completely randomized design with four replications. Plants were

watered when necessary and fertilized biweekly by adding 5g of calcium ammonium nitrates. Sixty days after planting the antagonistic plants from each pot were uprooted and cut into 5- 10 cm pieces and incorporated in the same pots. The experiment was terminated 180 DAP. Observations on nematode populations in soil, root gall index and root tuber yield were recorded. J_2 population density in soil from each replicate was determined from 100 cm^3 rhizosphere soil on 60 and 120 days after planting (DAP) by Cobb's decanting and sieving technique followed by modified Baermann's funnel technique (Southey, 1986). On 180 DAP, the soil from each pot was thoroughly mixed and J2 population density assessed from 100 cm^3. The plants were uprooted 180 DAP and root tuber weight was recorded. Root-gall index was assessed on a 0-5 scale: 0 = no galls; 1 = 5 galls; 2 = 6.20 small galls; 3 = >20 galls homogeneously distributed in the root system; 4 = reduced and deformed root system with some larger galls; 5 = completely deformed root system with few but large galls (Di Vito *et al*., 1979).The number of eggs g^{-1} of root was estimated using the sodium hypochlorite method (Huussey and Barker, 1973). Egg density in roots was calculated by multiplying the number of eggs in 1 g root by the total volume of soil. The sum of the eggs calculated root $system^{-1}$ and J_2 population density estimated in the soil pot^{-1} was considered as the final population (Pf). The reproduction factor (Rf) was calculated by the formula Rf = Pf/Pi

Simultaneously, a field experiment with identical treatments was also conducted during January – May 2006 in a farmer field with natural infestation of *M. incognita* at Dintugal, Tamil Nadu. Randomized blocks design was adopted with seven treatments (as indicated in Table 2) replicated four times. Ridges and furrows formed within plots and stem cuttings were planted in spacing of 60 x 45 cm on one side of the ridges. The plot size was 5 x 4 m^2 with 70 plants $plot^{-1}$. Each plot was separated by 0.5 m wide raised bunds and each replicate was separated leaving 0.5 m space between each bund. After planting on the same day the seeds of sunnhemp, onion, mustard, castor and cowpea were sown (for marigold fifteen day old seedlings were planted) in between medicinal coleus plants on the other side of the ridges. Standard agronomic practices were followed for raising the crop. During earthing up (60 DAP) all the intercultural plants were uprooted and cut into 5-10 cm pieces and incorporated around medicinal coleus plants. The nematode population density in each plot was determined at planting (Pi) and on 60, 120, 180 DAP. Each sample consisting of 10 cores, randomly collected at a depth of 15-20 cm in the rhizosphere of plants, pooled together into a composite sample from which 100 cm^3 sub-sample was collected by coning and quartering. from Samples processed for extraction of nematodes by Cobb's sieving and decanting technique, followed by modified Baermann funnel technique. The plants were carefully uprooted and root gall index, number of eggs g^{-1} of root and root tuber yield were recorded. For the purpose of comparing the treatments, the sum of J2 form 100 cm^3 soil and eggs g^{-1} of root was considered as final population density (Pf). All the data collected were analyzed using analysis of variance and means separated with Duncan's Multiple Range Test following Panse and Sukhatme (1989).

RESULTS AND DISCUSSION

Pot experiment

The results of pot culture experiment revealed that inter-cultivation with sunhemp, mustard, marigold, castor, onion and cowpea in medicinal coleus significantly reduced *M. incognita* and increased the root tuber yield (Table 1). However, their efficiency in reduction of *M. incognita* ranged from 15.7 - 56.9 % than control. Maximum reduction of *M. incognita* population was recorded in marigold treatment. Growing marigold and its incorporation reduced *M. incognita* population density by 56.9 %. The gall index was also least (3.0) in marigold treatment compared to control plants which recorded a maximum of 4.6. The number of eggs g^{-1} of root were also significantly less in marigold treatment. The reproduction factor for nematode alone on medicinal coleus was 25.2 versus 7.2 for plants grown in marigold treated pots. Marigold intercultivation also increased root tuber yield of medicinal coleus by 35.6 % by production of heavier root tubers (225 g $plant^{-1}$) than other treatments. The next best plant was sunhemp which recorded 39.4 % reduction of nematode population and 21.6 % increase of yield over control. Onion and mustard were the least effective plants in checking the nematode populations.

Results of the field experiment were similar to those observed under the pot culture experiment. Perusal of data presented in Table 2 revealed that marigold intercropping reduced nematode population by 43.3 %. This treatment significantly restrited the number of eggs g^{-1} of roots and thereby the reproduction factor as compared to other treatments and control. The reduction of nematode population in turn resulted least gall index (2.2) in this treatment which was significantly lesser than other treatments. Accordingly, the root tuber yield was significantly greater in marigold treatment (23.6 kg $plot^{-1}$) with 15.0 % increase over the control. The next best treatment was sunhemp which recorded 28.0 % reduction of nematode population. The nematode population recorded in the treatments with intercropping of castor and onion was 278 and 272 / 100 cm^3 soil which was on par with control.

Table 1: Effect of antagonistic crops on root-knot nematode and yield in medicinal coleus under pot culture condition

Treatments	Nematode population 100 cm^3 $soil^{-1}$	Gall index	Eggs g $root^{-1}$	Rf	Root tuber yield (kg $plot^{-1}$)
	180 DAP				
Marigold	370 a (56.9)	3.0 a	436 a	7.2 a	225 d (35.6)
Sunhemp	520 b (39.4)	3.6 b	862 b	10.8 b	185 bc (21.6)
Onion	723 e (15.7)	4.0 bc	1598 c	16.0 c	155 a (6.4)
Mustard	691 d (19.5)	4.0 bc	1576 c	16.1 c	161 a (9.9)
Castor	612 c (28.7)	3.6 b	1652 c	16.8 c	170 ab (14.7)
Cowpea	622 c (27.5)	3.6 b	1624 c	16.2 c	175 ab (17.1)
Control	858 f	4.6 d	2236 d	25.2 d	145 a
SEd	13.3	0.21	116.9	1.4	8.2
CD (p=0.05)	28.6	0.43	242.6	2.6	18.6

Figures in the parentheses are percent increase/decrease over control
DAP = Days after planting
Rf = Reproduction factor
Data are means of four replicates. Means followed by the same letter are not significantly different at P<0.05 according to Duncan's multiple range test.

Table 2: Effect of antagonistic crops on root-knot nematode and yield in medicinal coleus under field condition

Treatments	Nematode population 100 cm^3 $soil^{-1}$		Gall index	Eggs g $root^{-1}$	Rf	Root tuber yield (kg $plot^{-1}$)
	At planting	At harvest				
Marigold	96	162 a (43.3)	2.2 a	416 a	6.0 a	23.62 c (15.0)
Sunhemp	92	206 b (28.0)	2.8 b	612 ba	8.8 b	22.14 b (8.0)
Onion	98	272 cd (4.9)	3.6 c	1082 c	13.8 cd	20.84 a (1.0)
Mustard	102	256 c (10.5)	3.3 bc	828 b	10.6 bc	21.36 a (4.0)
Castor	104	278 cd (2.8)	3.6 c	1042 cb	12.6 c	21.62 ab (5.0)
Cowpea	93	212 b (25.9)	3.0 b	802 b	10.9 bc	21.86 b (6.0)
Control	98	286 d	3.9 cd	2008 d	23.4 e	20.46 a
SEd	NS	10.8	0.22	116.9	0.9	0.41
CD (p=0.05)	NS	22.6	0.46	242.6	2.1	0.91

Figures in the parentheses are percent increase/decrease over control
Rf = Reproduction factor
Data are means of four replicates. Means followed by the same letter are not significantly different at P<0.05 according to Duncan's multiple range test.

It is apparent that growing of marigold, sunhemp, cowpea, mustard, onion and castor as intercrops and incorporation of their biomass during earthing up in medicinal coleus resulted in a general reduction in the population of *M. incognita* which might be attributed to antagonistic principles or trap crop principles and amendments of their green plant materials. The antagonistic principles of marigold (Siddiqui & Alam, 1987), sunhemp (Fassuliotis & Skucas, 1969), cowpea (Barrons, 1939), mustard (Potter *et al*., 1998), Onion (Tada *et al*., 1998) and Castor (Rich *et al*., 1989) have been reported earlier. Soil amendment with their green plant material may also be attributed to reduction in nematode population by the increased microbial population and nematophagus fungi (Mankau & Das, 1969; Tomerlin & Smart, 1969) or acumumulation of nitrates and ammonia in soil (Singh & Sitaramiah, 1973) or acumumulation of carbon dioxide in high amounts within first week of decomposition of organic amendments (Datt *et al*., 1996). All the mechanisms working together may be responsible for the reduction in *M. incognita*. Among the various antagonistic plants studied, marigold proved most effective and gave consistently better results of nematode reduction and root tuber yield production. Similar results also reported by Kumar *et al*. (2005) who observed that marigold was found significantly superior in reducing *M. incognita* population when grown as intercrop than mustard. Interculture of marigold with other susceptible crops is known to suppress population of several economically important nematodes (Ijani & Mmbaga, 1988). The significant nematicidal efficacy of marigold is inferred as they are known to releases biologically active toxic principles like á-terthienyl and 5-(3-buten-1-yny) -2,2′ – bithieny from roots (Uhlenbroek & Bijloo (1958), generation of singlet oxygen by photoactivated á-terthienyl (Gommers & Bakker, 1988), dodecanoic acid, myristic acid, palmitic acid and steric acid from flowers (Debprasad *et al*., 2000). Above ground plant parts of marigold have also been found toxic to nematodes (Siddiqui & Alam, 1988). The reasons for improvement in nematode control in marigold treatment in the present study can be surmised as early penetration and development of *M. incognita* deterred by the nematicidal principles of root exudates which will be enhanced further by the release of toxic principles by incorporation of their foliage.

It is thus concluded that growing of marigold as an inter crop in the medicinal coleus, *C. forskohlii* is most effective in reducing root knot nematode, *M. incognita* infestation and increasing the root tuber produciton.

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SHORT COMMUNICATION

Feeding potential of Staphylinid predator (*Oligota sp*.) on two spotted spider mite, *Tetranychus urticae* infesting apple (*Malus domestica* Borkh) in Kashmir

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Key works: Mite pests, Apple, Oligota, Predation, Biological control

The harmful effects of chemical pesticides on natural bio-agents, their rising costs and control failures have resulted in increasing need for ecofriendly and sustainable alternatives like biological control. A number of success stories of biological control have been reported in India, the control of sugarcane wooly aphid through use of predators in Southern states is the latest one. Review of literature reveals that many predators and parasites for example coleopteran beetles, predatory bugs, hymenopterous/braconid wasps etc. are available which have proved quite effective in bringing down the insect/mite pest populations attacking various crops to a tolerable levels. The coleopteran predators, belonging to families Coccinellidae and Staphylinidae are pre-dominant predators of phytophagous mites on apple in Kashmir. Oligota is a specialized mite predator feeding voraciously on these mites. Since, Govt. of India encourages establishment of biocontrol laboratories by the industry, the facility and opportunity was utilized in the conduct of present experiment.

Immature stages of *Oligota sp*. were collected from mite infested leaves of apple trees during early summer. They were reared on two-spotted spider mite (*T. urticae*) in the laboratory. The adults and larvae were fed in separate containers. The predatory potential was studied by rearing 3 larvae in three sets on leaf disc assemblies in petridishes. In each set, counted number of TSSM motile stages and eggs were supplied as food for the predator at regular intervals. The number of mite eggs, nymphs and adults consumed by staphylinid larvae/grub/adult/day singly was counted everyday and recorded.

The beetle appeared as an important predator feeding voraciously on two spotted mites. A grub consumed upto 20 mites day^{-1} while an adult showed predation of upto 10 mites day^{-1}. Each predator consumed upto 490-568.5 mites during its life cycle. Duration of larvae and grub period was of 1-2 weeks and the pupal stage lasted for 1-2 weeks. Life cycle was completed in 3-4 weeks. In England, *Oligota flavicornis* completes its life cycle in about 28 days as reported by Jeppson *et al*., 1975, which coincides with the present findings. Moutia (1958) also reported Oligota as important predator of *T. macfarlanei* Baker and Pritchard infesting vegetable crops in Mauritius. From India Mukerjee *et al*., (1981) observed high population of Oligota during the peak infestation period of spider mites on vegetables in West Bengal and recorded the predator feeding voraciously on these mites. Similarly, Puttaswamy and ChannaBasavanna (1981) found *Oligota oviformus* among the regulatory factors of *T. ludeni* Zacher infesting ornamentals and vegetable crops in Karnataka. Their findings fall in line with the results of current studies.

Table. Feeding potential of Staphylinid predator *Oligota sp*.

Stages of predator	Number of TSSM consumed by single predator		
	Eggs	Motile stages	Total
Larva	*44 ± 18.50	16.45± 8	60.45
Grub	65.25 ± 23.25	255 ±45	320.25
Adult	25.33 ± 6.50	85.40 ±24	110.75
Total	134.60 48.25	356.85 ± 77	491.45

*Each figure is the mean of nine observations

An adult Female

Predator Feeding on mites

It was thus concluded that staphylinid beetle, *Oligota sp*. as a potential predator, can suitably be included in the IPM strategy of spider mites.

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SHORT COMMUNICATION

Seasonal activity of major insect pests of tomato and their occurrence influenced by weather parameters*

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Tomato, *Lycopersicon esculentrum* Mill is one of the most popular and nutritious vegetable crop. Its plants are severely damaged by various insects pests among which the jassid (*Amposca devastans* Distant) and white fly (*Bemacia tabaci* Jeen) are the major ones. Jassids suck sap from leaves causing shortning, puckring and curling of leaves resulting stunded growth of plants, which spread further through white fly (Yawalker 1980). Tomato fruit borer, *Helicoverpa armigera* Hubner is a serious pest of tomato in India and causes around 22 to 88 % fruit damage (Singh and Narang, 1990; Tewari and Krishna Moorthy, 1984). Application of pesticides to save the fruit directly affects the consumers. This necessitated generation of informations on seasonal activity of key insect pests to evolve effective and timely management strategy.

Seasonal incidence of major insect pests of tomato was studied at Fruit Research Station, Entkhedi during the year 2007 – 08 and 2008 – 09 in Rabi and Kharif season on tomato JT-99. Kharif season crop was designated as first crop (July to Oct – Nov) and second crop for rabi season (Jan to April – May) of tomato. Observation was recorded at fortnightly interval as detailed below for major pests. Five plants plot^{-1} were selected at randomly for recording the incidence of leaf minor at weekly intervals. Actual mines leaf^{-1} were counted from upper, middle and lower leaf in all three leaves plant^{-1}. Infestation of tomato fruit borer *Helicoverpa armigera* was observed on per cent fruit damage (number) basis at every picking at weekly intervals. Number of healthy and damaged fruits were counted to calculate per cent fruit damage. White fly population was recorded by using split catch (height – 60 cm, diameter 45 cm, one side of which was provided with a glass pan). It was kept facing the sun. The population of white flies was counted from two randomly selected spots plot^{-1} replications^{-1}. The total number of plants and the number infested by the leaf curl virus were counted from the two central rows of the each plots to calculate the extent of its occurrence.

The observations on jasisid nymph and adults was recorded at weekly intervals form upper, middle and lower leaves from five randomly selected plants plots^{-1}. Weather data were recorded to correlate the influence of weather parameters on the occurrence and damage caused by insect pests.

Incidence of leafminer ranged from 3.85 to 5.79 mines plant^{-1}. The infestation level was almost consistent from first fortnight of July to the second fortnight of December. Its incidence was not influenced by maximum temperature, minimum temperature, relative humidity, and rainfall in first and second crop. The incidence of leafminer in second crop, started right from the transplantion and reached to its highest activity during first fortnight of March (6.63 mines plant^{-1}). Beyond first fortnight of March, the activity started declining that reached to its minimum (0.06 mines plant^{-1}) in the second fortnight of April (Table 1 & 2). Fruitborer, *Helicoverpa armigera* infestation was relatively less as compared to the second crop. The maximum per cent fruit damage (2.88%) was recorded in the first fortnight of November as compared to 22.12% in second fortnight of April. The per cent fruit damage was negatively correlated with the minimum temperature (r = -0.924), relative humidity (r = -0.627) and (r = -0.940) and rainfall (r = 0.783), respectively. In second crop, per cent fruit damage ranged from 6.75 % in first fortnight of March to 22.17% in second fortnight of April. The incidence of fruitborer started with the fruiting of the crop and continued till the ripening of the fruits. Per cent fruit damage was positively correlated with the maximum (r = 0.783), and minimum temperatures (r = 0.637) and negatively with the maximum relative humidity and (r = -0.826), respectively, while the rainfall and minimum relative humidity does not influence the per cent fruit borer in tomato (Table 1 & 2).

Incidence of whitefly in the first crop appeared just after the transplantation within a fortnight. The infestation

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Table 1: Seasonal activity of major insect pests of tomato in the first crop.

Month	Leafminer[1]	Percent fruit damage by Fruitborer[2]	Whitfly[3]	Jassid[4]
July--I	0.66	0.0	2.7	0.82
II	1.54	0.0	2.71	3.36
August--I	4.80	0.0	1.23	4.99
II	5.25	0.0	1.68	6.65
September--I	5.02	0.0	4.60	8.20
II	5.50	0.26	5.01	8.65
0ctober--I	5.79	1.26	6.02	9.15
II	5.08	2.16	4.68	9.12
November--I	4.06	2.88	3.37	3.18
II	5.31	1.93	2.37	3.14
December--I	4.65	2.22	1.62	2.26
II	5.25	2.46	1.22	1.98

Table 2: Seasonal activity of major insect pests of tomato in the second crop

Month	Leafminer[1]	Percent fruit damage by fruitborer[2]	Whitfly[3]	Jassid[4]
January--I	2.63	0.00	0.00	1.60
II	3.42	0.00	0.00	1.01
February--I	2.80	0.00	3.04	0.15
II	5.87	0.00	4.33	0.27
March--I	6.63	6.75	7.07	5.37
II	1.94	11.14	6.11	5.88
April--I	0.66	16.83	4.07	6.43
II	0.06	22.17	6.41	6.81
May--I	0.00	18.29	5.47	0.00
II	0.00	0.00	6.29	0.00
June--I	0.00	0.00	3.28	0.00
II	0.00	0.00	3.64	0.00

[1]Mean population plant^{-1}, [2]Mean percent fruit damage by fruit borer, [3]Mean population plant^{-1} cage^{-1}, [4]Mean population plant^{-1}

decreased in first and second fortnight of August (1.23 and 1.68 whitefly plant^{-1} cage^{-1}). It again increased in the month of September and reached to its highest level (6.02 plant^{-1} cage^{-1}) in first fortnight of October followed by a decline in the month of November and December. It was positively correlated with the maximum temperature (r = 0.807). It could not correlate with the minimum temperature (r = 0.243) maximum relative humidity (r = -0.392) the minimum relative humidity (r = -0.146) and rainfall (r = 0.003). In second crop the incidence of whitefly appeared in the first and a month after transplantation of the crop. Four distinct population peaks during first and second fortnight of March and second fortnight of April and May were observed. Occurrence of leaf curl disease in tomato increased with the increase in whitefly infestation in tomato (r = 0.862) (Table 3).

Jassid population level was relatively low (0.82 plant^{-1} in first fortnight of July to 4.99 plant^{-1} in the first fortnight of August). Population buildup of jassid reached to its peak level in the month of October (9.15 plant^{-1}) followed by decline in the month of November and December. Correlation study between the incidence of jassid and the weather parameter revealed that the infestation of jassid was not influenced by the weather factor. The population of jassid was consistantly higher in the month of March and April. Incidence of jassid was not influenced by the weather parameters except the maximum relative humidity (r = -0.638).

Table 3: Correlation between weather parameters and occurrence of insect pests in first and second crop of tomato

Weather parameter	Values of correlation coefficient							
	Leafminer[1]		Percent fruit damage by Fruitborer[2]		Whitfly[3]		Jassid[4]	
	I crop	II crop	I crop	II crop	I crop	II crop	I crop	II crop
Maximum temperature	0.085	-0.255	-0.290	0.783	0.003	0.646	0.085	0.484
Minimum temperature	-0.412	-0.534	-0.924	0.637	0.807	0.482	0.310	0.290
Relative Humidity (Max.)	0.033	0.039	-0.627	-0.826	0.243	-0.413	-0.125	-0.638
Relative Humidity (Mini.)	-0.458	-0.271	-0.940	-0.525	-0.392	-0.215	-0.027	-0.479
Relative Humidity (Mean.)	-0.376	-0.027	-0.930	-0.702	-0.146	-0.681	-0.051	-0.505
Rainfall	-0.513	-0.474	-0.783	-0.310	-0.211	-0.023	-0.058	-0.386

[1]Mean population plant^{-1}, [2]Mean percent fruit damage by fruit borer, [3]Mean population plant^{-1} cage^{-1}, [4]Mean population plant^{-1}

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SHORT COMMUNICATION

Efficacy of certain neem formulations and biopesticides against S*podoptera litura* (Fabr.)

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Key words: *Spodoptera litura*, neemarin, vanguard, multineem, *B. basiana* and biolep

Spodoptera litura Fabricius (Lepidoptera: Noctuidae) is an economically important polyphagous defoliator insect pest of pulses, oilseeds and millets in India. Its management has therefore always been a point of anxiety among scientists provoking for evalvement of effective control measures (Baitha 2000). One such development in this direction is by using microbs viz., virus, bacteria and fungi and the botanical pesticides derived from neem, chrysanthemum, karanj, and citronella oil, separately and in mixed formulations tested against different instars of *S. litura* under laboratory conditions (Viji and Bhagat 2001). Keeping this in view the present investigation was undertaken.

MATERIALS AND METHODS

Collection of test insect

The eggs and larvae of *Spodoptera litura,* collected from castor fields of C.S. Azad University of Agriculture and Technology, Kanpur, were brought to the laboratory and reared till adult emergence. Males and females in 1:1 ratio were kept in glass chimneys containing the plastic strips (20 x 10 cm) and folded card sheets for mating and egg laying. The eggs laid in clusters covered by brown cottony material on the plastic and paper strips, were collected the next day with the help of No. 4 camel hair brush and fixed on seperate paper with diluted gum. These mass cultured eggs, after drying, were transferred in some small plastic bags for hatching and further readings.

The second instar (3 days old) larvae from the plastic bags were shifted to clean glass tubes containing fresh tender castor leaves and covered with cotton plugs to develop to the third instar stage to be employed for the treatment. These larvae, after starving for few hours were fed with treated leaves of seven different formulations i.e neemarin, vanguard and multineem at 0.5, 1.0, & 1.5% concentrations, Biolep at 0.5, 1.0, & 2.0 % concentrations and *Beauveria bassiana* at 2, 3, & 4 g lt^{-1}. The larval mortality at mean value of different biopesticides concentrations in three replications was recorded after 48, 72, 96, 120 &144 hrs of treatment.

RESULTS AND DISSCUSION

Data (Table 1) revealed that *B .bassiana,* vanguard, neemarin & multineem provided 18.8, 17.7, 13.3 & 10.00% average mortality, respectively of third instar *S. litura* larvae after 48 hrs of treatment. This finding is in accordance with that of Rahman and Kanaujia (2003).

At 72 hrs of treatment, *B. bassiana* and Vanguard showed average mortality of 25.5% that were non-significant among themselves. Neemarin, multineem and Biolep recorded 17.77, 11.1 and 12.22% average larval mortality, respectively. Dhawan and Samwat (1993) found 100% larval mortality when tested for 72 hrs of treatment.

The data pertaining to mortality percentage of *S. litura* larvae after 96 hrs revealed. 36.6 and 31.1% average mortality through *B. bassiana* and Biolep while Vanguard, neemarin and multineem registered 34.4, 20.0 and 16.6% average mortality respectively.

B. bassiana and biolep at 2, 3 and 4gm lit^{-1} recorded 44.4 and 46.6% mortality respectively at 120 hrs of treatment which is slightly higher than vanguard (43.3%) Neemarin and multineem showed 21.1 and 20.0% mortality. Mathura *et al.,* (1994) found a minimum time of 48 hrs to initiate the kill and a maximum of 120 hrs was required to induce 89.99% mortality of 0.5% concentration of different biopesticides formulations.

Data revealed that concentrations of neem formulations recorded significant mortality of *Spodoptera litura* larvae after 144 hrs of treatment. Vanguard and multineem 43.3 and 25.5% mortality, respectively while, biolep and *B. basiana* recorded 47.7 and 48.8% of larval mortality respectively.

*A part of the M.sc (Ag.) thesis submitted by K.Rahul Viswakarma

According to Malathi and Sriramulu (2000) *S. litura* larvae died after 72 hrs of treatment by biopesticides however, present investigation reveals its effectiveness on third instar larvae of *S. litura* at 144 hrs.

The study thus concludes that all the botanicals are equally effective in causing *S. litura* larval mortality and hence may be used as an alternative of synthetic chemical insecticides in the management of *Spodoptera litura* and prevent the chances of developing resistance to pesticides in target insects and undesirable residues.

Table 1: Effect of biopesticides on ***Spodoptera litura*** larvae.

Insecticides	**Av. larvael mortality (%) in concentrations after**				
	48hrs	**72hrs**	**96hrs**	**120hrs**	**144hrs**
Neemarin	13.30	17.77	20.00	21.10	22.20
	(20.00)	(24.75)	(26.23)	(27.13)	(27.87)
Vanguard	17.70	25.50	34.40	43.30	43.30
	(24.75)	(30.25)	(35.88)	(41.09)	(41.09)
Multineem	10.00	11.10	16.60	20.00	25.50
	(14.83)	(16.88)	(23.45)	(26.00)	(30.18)
Biolep	6.60	12.20	31.10	44.40	47.70
	(11.14)	(20.07)	(33.81)	(41.76)	(43.69)
Beauveria	18.80	25.50	36.60	46.60	48.80
bassiana	(24.11)	(30.18)	(37.16)	(43.07)	(44.35)
Mean	30.63	34.28	41.42	46.82	49.36
	(31.33)	(35.41)	(40.61)	(43.93)	(54.61)
SEd, C/T	6.90	5.33	4.71	4.48	3.89
CD (P = 0.05)	19.67	15.21	13.44	12.77	11.09

* Figures in parenthesis are original values.

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