INTRODUCTION

King of spices (pepper account for 37 % of World total spice trade).
Commercial pepper is dried berries of woody perennial evergreen climbing vine.

Production:

- Average yield - 0.425 t/ha.
- Under good management - 1.5 t/ha
- Under research condition – 1.8 – 2.5 t/ha from high yielding cultivars/ selections
- Extent – 31000ha Exports over 12000mt

BASIC CONCEPT OF IPNM

- Limit the unfavorable exploitation of Soil fertility and Plant nutrients.
- Maintenance and possible improvements of soil fertility status.
- Sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner.
- Minimize the possible environmental hazards.
- Minimize cost of production.

IPNM WHY?

- Growing demand and consumption of fertilizer
- High cost
- Unavailability
- Imbalance nutrient contents
- Neither mineral fertilizer nor organic fertilizer alone can achieve the production sustainability
- To minimize possible environmental hazards

NATURE OF SPICES CROPPING SYSTEMS

- Mainly Small holdings with mixed crops
- Large scale plantations of Cinnamon, Pepper, Cardamom
- Sensitivity of investment with price fluctuation
- Except Cinnamon, association of Shade/Support trees
  Agro-forestry ⇨
- Perennial crops with one or two harvests/yr
- Considerable Bio mass inputs from shade/support/companion trees Nutrients, Mulch, OM, Minimize runoff, Microbial activities?

Cropping System -

- Most of the EACs are cultivated as Mixed gardens or Intercropping resembling an Agro-forestry system, except Cinnamon
- Sharing of resources between or among the crops are optimum.
- The systems have Competitive as well as Beneficial effects
- This will enable to go for resource sharing cropping systems such as " Organic farming"

NUTRITION OF PEPPER

- Chemical fertilizers
- Green manure
- Organic manures
- Compost
- Bio fertilizers

Fertilizer management

Early stage of both rainy seasons (2 splits/year)
Ring application –15 cm away from base
In sloping lands – semi circular application only upper side of the base

Fertilizer mixture

1. Urea - 4 (14% N)
2. ERP - 5 (11% P_2O_5)
3. MOP - 3 (14% K_2O)
4. Kieserite - 1 (2 % MgO)

Rate of application

Age	Amount – g/vine/year
1st year	250 g
2nd year	500 g
3rd year & onwards	700 g

Black Pepper: a typical Agroforestry system

- Pepper always grown with a support tree, mainly a legume (Gliricidia, Erythrina etc.)
- Biomass from support/shade tree range from 10-20Mt/yr

A well pruned Pepper field

- Provide adequate sunlight
- Minimize competition
- Supply a large quantity of quality green manure
- Recycle plant nutrient
- Reduce moisture losses
- Minimize disease incidence
- Arrest soil erosion
- Sustain productivity

Effect of pruning intervals on biomass production of *G. sepium* & yield of Pepper (kg/ha/2yr)

Treatment (pruning interval)	Leaf	Tender stems	Hard stems	Pepper yield
Every month	5850^{a}	2105^{a}	-	4538^{a}
Every two month	7960^{ab}	3978^{a}	-	3027^{ab}
Every three month	12765^{bc}	6834^{b}	1480^{a}	2700^{ab}
Every four month	14517^{c}	8577^{b}	7259^{a}	1700^{b}
Every five month	14823^{c}	7041^{b}	17977^{b}	1650^{b}
Every six month	893^{ab}	2357^{a}	14428^{b}	1320^{b}

Gunaratne & Heenkenda (1993)

Total N,P and K in Different Parts of *Gliricidia* kg/ha/24 months

	Leaf			Tender stem			Leaf /Tender stem			Mature stem		
	N	P	K	N	P	K	N	P	K	N	P	K
T1	235	42	193	56	13	116	291	55	309	-	-	-
T2	304	22	205	144	20	183	448	42	388	-	-	-
T3	451	32	290	227	15	151	678	47	441	22	2	24
T4	491	25	306	120	15	124	611	40	430	99	12	122
T5	474	24	240	99	10	87	573	34	327	259	20	232
T6	249	8	126	33	3	29	282	11	155	196	17	189

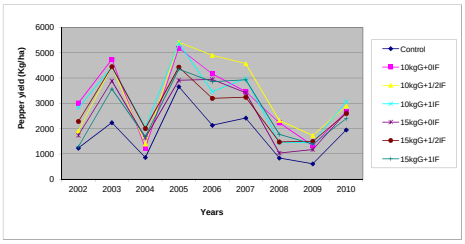
Gunaratne & Heenkenda 1993

Gliricidia mulch – young plants

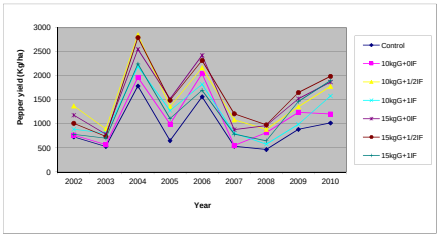
Result in field

Results

Wasanagama



Matale



Impact on Soil Chemical Properties Wasanagama (IBL)

Treatment	Total N %	Exch. K (mg/kg)	Exch. P (mg/kg)	Exch. Mg (mg/kg)	O.C. %
Control	0.18	246.0	4.99	257.3	0.99
10GM 0 Fert.	0.30	499.0	6.62	321.0	1.19
10GM ½ Fert.	0.23	588.7	8.77	211.7	1.20
10GM 1 Fert.	0.29	843.7	14.02	391.3	1.30
15GM 0 Fert.	0.29	684.0	10.10	278.3	1.50
15GM ½ Fert.	0.23	688.7	8.88	306.7	1.59
15GM 1 Fert.	0.36	867.3	11.46	357.3	1.49
LSD (*P=0.05*)	0.16	227.8	4.25	152.8	0.56
CV%	36.91	20.29	20.29	28.32	23.76

Impact on Soil Chemical Properties Matale

Treatment	Total N %	Exch. K (mg/kg)	Exch. P (mg/kg)	Exch. Mg (mg/kg)	O.C %
Control	0.16	301	7.0	487	1.08
10GM 0 Fert.	0.23	505	11.0	584	1.81
10GM ½ Fert.	0.28	558	12.0	586	1.83
10GM 1 Fert.	0.27	545	11.7	557	2.09
15GM 0 Fert.	0.22	492	8.7	559	2.80
15GM ½ Fert.	0.26	545	15.5	585	2.05
15GM 1 Fert.	0.25	644	17.0	600	1.81
LSD (*P=0.05*)	0.02	204	4.0	111	0.19
CV%	5.83	30.81	21.55	11.08	5.17

Impact on Soil Chemical Properties Etulgama

Treatment	Total N %	Exch. K (mg/kg)	Exch. P (mg/kg)	Exch. Mg (mg/kg)	O.C %
Control	0.29	60	1.8	96.6	2.17
10GM 0 Fert.	0.35	225	5.2	339.0	2.90
10GM ½ Fert.	0.33	244	10.5	364.0	2.88
10GM 1 Fert.	0.34	460	12.6	348.0	2.55
15GM 0 Fert.	0.32	274	10.0	336.2	4.20
15GM ½ Fert.	0.34	609	15.0	334.7	2.87
15GM 1 Fert.	0.34	468	17.7	438.4	2.68
LSD(P=0.05)	0.049	264.71	6.59	121.33	1. 08
CV%	8.48	46.53	39.14	21.15	21.16

Effect on weed growth – Grasses

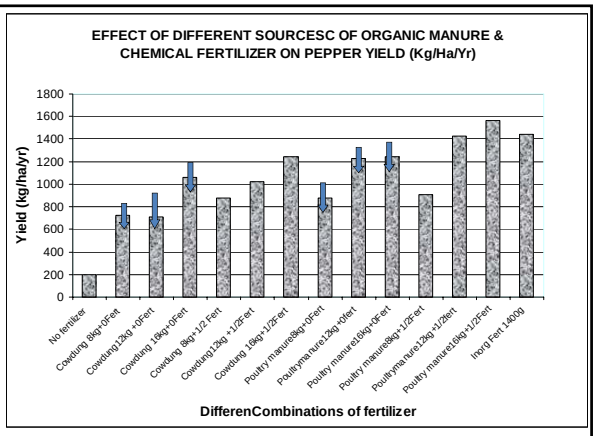
Treatment	Count 1		Count 2	
	Count	Dry Wt.(g /m^2)	Count	Dry Wt. (g /m^2)
Control	45.33	17.08	46.67	15.85
10GM 0Fert	16.33	5.34	28.67	9.27
10GM ½ Fert	21.33	4.17	30.33	5.41
10GM 1Fert	23.00	10.6	22.00	13.02
15GM 0Fert	26.50	7.34	28.67	7.74
15GM ½ Fert	27.33	11.04	14.00	8.05
15GM 1Fert	23.33	9.31	22.00	8.16
Significance	**	**	**	**
LSD P=0.05)	25.77	8.38	18.88	7.32
CV%	23	26	31	28

Effect on Weed Growth Broad Laves

Treatment	Count 1		Count 2	
	Count	Dry Wt.(g/m²)	Count	Dry Wt.(g/m²)
Control	71.00	21.11	38.66	29.09
10GM 0Fert	17.33	4.40	19.67	5.90
10GM ½ Fert.	13.67	11.89	16.33	10.72
10GM 1Fert	27.00	20.83	13.33	9.07
15GM 0Fert	13.67	6.93	12.33	5.08
15GM ½ Fert	8.00	7.31	8.67	0.66
15GM 1Fert	6.67	15.86	16.67	8.20
Significance	***	***	**	**
LSD (*P=0.05*)	20.73	11.01	19.23	9.32
CV%	26	31	28	24

Use of Animal Waste/Organic Manures in Pepper

- Cattle manure (8,12,16 kg/vine/year)
- Poultry manure (8,12,16 kg/vine/year)



What can be Used for Organic Crop Production?

- Litter, Crop residues or Pruned biomass, animal waste and compost as a source of plant nutrients
- Biomass as a soil amendments to minimize soil degradation & to control soil borne pathogens
- Overall sustainability of the system due to diverse income; reduce risk

Mechanism towards "Organic Farming"

-Shade regulation in Pepper

Preparation of Compost

Training on Organic fertilizer Production

Experiments in Farmers Fields……

Experiments in Farmers Fields……

Experiments in Farmers Fields……

Preparation and Application of Treatments

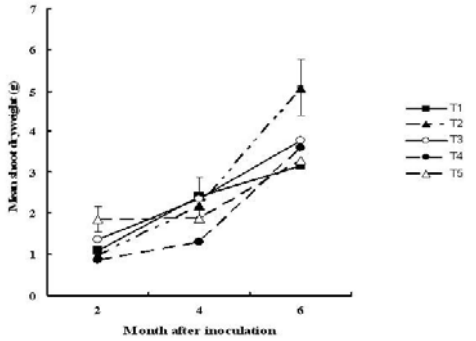
Vermi-compost

Bio Fertilizers

Use of Arbascular Mycorrhiza in Pepper (Glomus mosseae

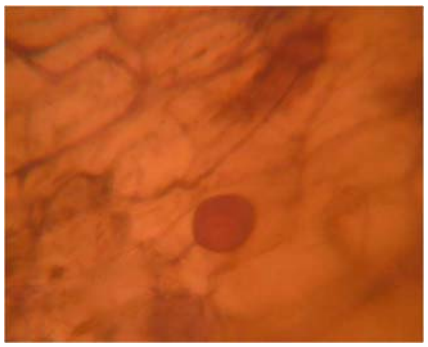
Treatment code	Inoculum Level (g)	Quantity of potting mixture (g/pot)	Mean number of spores/ pot	Mean VAM Spore Density (No. of spores/g of potting mixture)
T1	25	875	265	0.3
T2	75	825	795	0.88
T3	150	750	1590	1.77
T4	300	600	3180	3.53
T5-Control	0	900	0	0

Effect of VAM Inoculation on Mean Shoot Biomass of Black Pepper with Time after Inoculation, Vertical Bar Indicates LSD at 0.05 Probability



Stained Black Pepper Root Segment at 2nd Month after Inoculation Showing Fungal Hyphae in Root Tissues

Stained Black Pepper Root Segment at 4th Month after Inoculation Showing Vesicle Formation (Indicated by an arrow) within Root Tissues



Latest Approach on Soil Fertility Management for Pepper

- Use of Integrated approach using Mineral, Organic & Bio fertilizers, based on quantified research data.
- Recycling of crop wastes and shade tree loppings to provide nutrient and to improve soil chemical, physical & biological properties.
- Use of local fertilizer sources to the extent possible (ERP, Dolomite etc.)
- Development of site specific fertilizer recommendations based on on-farm data and soil analytical data.

Disease in Black Pepper

Slow wilt disease in Black Pepper –

- **Proper soil conservation, Incorporate organic matter to the soil, Make soil mounds to encourage root development, soil moisture conservation.**
- **Control mealy bugs *etc*.**
- **Make soil mounds at the base of the plant, Add *Gliricidia* leaves or any organic matter to the plant.**

Quick wilt Disease in Black Pepper –

- **Cultural – Improve drainage, pruning, remove & destroy infected plants.**
- **Biological - Use of Antagonistics fungi such as *Trichoderma* sp.**
- **Resistant cultivars –Select resistant/Tolerant cultivars from local germplasm.**
- **Use cuttings only from healthy mother plants.**
- **Abiotic – Incorporate organic matter to the soil, Make soil mounds to encourage root development, soil moisture preservation.**

Prevent Nursery Diseases by Solarization of the Potting Mixture

- Re use the wasted potting mixture
- Good root system
- Good plant growth Cheap, safe & simple

The Organic spices & beverage crop production

- Export Agriculture Crops have a growing demand for "Organic products"
- Potential exist due to high biomass found within the system & low pest and disease incidence

- **What DEA has done to promote Organic farming?**
- 1998 – introduction of Organic farming Promotion scheme
  - Technology Development & Dissemination (Organic fertilizer, Bio/Organic pesticides, GAP, Record keeping etc.)
  - Assist to get the certification
  - Market linkage & promotion

Over 100 organic villages were established and 48 of them got the certification

What else needed?

- Certification process and Marketing system should be streamlined to be benefited the **Producer**.
- Post Harvest handling should pay more attention.
- Market promotion in developed world should be strengthened.