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Impact of organic manures, green leaf manures and micronutrients on natural enemies and energy use efficiency in cotton

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ABSTRACT

The field experiment was carried out at MARS, Dharwad during *kharif* 2010-11 and 2011-12 to study the impact of organic manures, green leaf manures and micronutrients on natural enemies, sucking pest population, energy use efficiency and energy productivity. Among the nutrient management practices, EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDF recorded significantly higher natural enemies population mainly coccinellids, syrphid maggots, *Micromus timidis,* chrysoperla and spiders/plant (0.80, 1.05, 0.88, 0.72, 1.30 and 1.28) over RDF + FYM (0.35, 0.44, 0.44, 0.44, 1.13 and 0.53, respectively). The foliar spray of panchagavya @ 5% recorded significantly higher natural enemies population, viz. coccinellid adults, syrphid maggots, *Micromus timidis,* chrysoperla and spiders/plant (0.67, 0.72, 0.64, 1.27 and 1.04/plant, respectively) over bio-digester @ 20% (0.57, 0.64, 0.57, 1.16 and 0.96, respectively).The combined application of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDF with foliar spray of panchagavya @ 5% recorded significantly higher natural enemies population mainly coccinellid adults, coccinelid grubs, syrphid maggots, *Micromus timidis,* chrysoperla and spiders/plant (0.88, 1.13, 0.92, 0.75, 1.34 and 1.32/plant, respectively) as compared to RDF + FYM (0.25, 0.38, 0.36, 0.31, 0.74 and 0.31/plant, respectively). At 90 DAS, RDF + FYM @ 5 t/ha recorded significantly lower aphids and thrips populations (2.73, 1.42 per 3 leaves) over other nutrient management practices. The integrated application of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDN recorded significantly higher energy use efficiency and energy productivity (2.17 and 0.186 kg/MJ, respectively) over FYM @ 5 t/ha + RDF (2.05 and 0.174 kg/MJ). The combined application of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDN with foliar spray of panchagavya @ 5% recorded significantly higher energy use efficiency and energy productivity (2.27 and 0.194 kg/MJ, respectively) over RDF + FYM.

Key words: Energy use efficiency, Micronutrients, Natural enemies, Organic manure,

Modern agriculture largely depends on the use of fossil fuel based inputs such as chemical fertilizers, pesticides and labour saving energy intensive farm machinery. The applications of such high input intensive technologies have undoubtedly increased the production and labour efficiency, but, there is a growing concern over their adverse effects on soil productivity and environmental quality. The intensive cultivation and monocropping are associated with problems mainly soil fertility degradation, micronutrient deficiencies, poor soil physical condition, soil biological activity and the out break of pest and diseases. All these posing serious threat to our food security and livelihood supporting systems. These problems are mainly due to abandoning the natural and ecological principles. Organic agriculture in the world has emerged as an alternative to the chemicals oriented intensive modern agriculture. Agricultural intensification, through increasing fertilization input within fields and cropland expansion at landscape scales, is considered a key driver of biodiversity loss and the decline of ecosystem services.

Organic agriculture is assumed to achieve more sustainable practices by reducing environmental impacts, such as biodiversity decline, compared to conventional agriculture. The global retail market of organic cotton has increased from 605 million to 4.9 billion in 2012 with an annual growth rate of 3.8% (Anon. 20015). In India, cotton is grown over an area of about 11.3 mha with a total production of 34.42 m bales (Anon. 2015). India ranks fifth in area and third in production of cotton after USA and China. The productivity of cotton is 510 kg of lint/ha which is much lower than the world average of 621 kg/ha.

Among the cotton growing states, Karnataka ranks fifth with an area of 3.90 lakh ha and sixth in production with

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9.0 lakh bales of lint with an average productivity of 392 kg of lint/ha. To sustain the productivity of organic cotton, nutrition and plant protection play a very important role. In this context, to make the organic cotton production more sustained the field studies were carried out to study the nutrient management practices for organic cotton production. In this context, to make the organic cotton production more sustained the field studies were carried out to study the natural enemies and energy use efficiency in organic production system.

MATERIALS AND METHODS

The field experiment was conducted at MARS, Dharwad during 2010-11 and 2011-12 to study the "Impact of organic manures, green leaf manures and micronutrients on natural enemies and energy use efficiency in cotton". The soil of the experiment site was medium deep black, having medium carbon (0.48%) and available NPK (264.70:21.80:285.30 NPK kg/ha). The experiment was laid out in split plot design with three replications. The main plot comprises of three manurial treatments as M_1 : Recommended dose of fertilizer (RDF)(80:40:40 N:P_2O_5:K_2O kg/ha + FYM @5 t/ha), M_2: EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDN M_3: EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF and sub plot consists of five liquid organic manures treatments are L_1 : Foliar application of panchagavya @ 5% at sympodial branching, square, flower and boll development stages, L_2: Foliar application of bio-digester @ 20%, L_3 : Foliar application of cow urine @ 10%, L_4 : Foliar application of vermiwash, L_5 : Foliar application borax @ 0.2% + $MgSO_4$ and one control treatment was T_1: Recommended dose of fertilizer (RDF) (80:40:40 N:P_2O_5:K_2O kg/ha + FYM @ 5 t/ha). As per the treatments the organic manures equivalent to RDN and RDF through farmyard manure, enriched compost (50%), green leaf manure were applied 15 days before sowing and 50% vermicompost was spot applied to the soil before dibbling of cotton seeds and top dressing with remaining 50% of vermicompost was done at 60 DAS. The chemical fertilizers as per the recommended package alone and along with farmyard manure were applied to the check treatments. The seeds were treated with cow urine, *Azospirillum*, phosphate solubalizing bacteria, *Pseudomonas striata, Trichoderma* and cow dung slurry before sowing. The seed of Hybrid cotton DHH-11 was obtained from ARS Dharwad (ARS, Hebballi) and were hand dibbled with two cotton seeds per hill on 12 July 2010 in 1st year and 8 June 2011 in 2nd year. In each plot four plants were selected randomly for the observation of natural enemies and sucking pest population which were recorded on three leaves selected randomly from top, middle and bottom and count were taken at 30 and 60 DAS. The population density of natural enemies which included predatory coccinellids/plant, chrysoperla eggs/plant, spiders/plant, syrphid maggots/plant and *Micromus timidus*/plant were recorded following the same procedure as mentioned in the case of sucking pests.

The energy use efficiency was worked out in terms of kg crop yield (main crop) produced per 1000 MJ energy consumption in the cropping system (Padhi *et al.* 2001, Erdal *et al.* 2009).

$$\text{Energy use efficiency} = \frac{\text{Total energy output (MJ/ha)}}{\text{Total energy input (MJ/ha)}}$$

The energy productivity is ratio of cotton yield to total energy input (Padhi *et al.* 2001, Erdal *et al.* 2009).

$$\text{Energy productivity} = \frac{\text{Cotton yield (kg/ha)}}{\text{Total energy input (MJ/ha)}}$$

RESULTS AND DISCUSSION

The population of natural enemies varied significantly due to nutrient management practices (Table 1 and 2). Pooled data revealed that application of of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDF recorded significantly higher natural enemies population mainly coccinellids adults, syrphid maggots, *Micromus timidis,* chrysoperla and spiders/plant (0.80, 0.88, 0.72, 1.30 and 1.28, respectively) over RDF + FYM (0.35, 0.44, 0.44, 1.13 and 0.53, respectively). This might be due to non application of harmful chemical insecticides in cotton, favourable environment created with application of organic manures and crop diversity related with growing lucerne as intercrop resulted in higher natural enemies population in organic treatments. The population of natural enemies varied significantly due to different foliar spray treatments. The foliar spray of panchagavya @ 5% recorded significantly higher natural enemies population, viz. coccinellid adults, syrphid maggots, *Micromus timidis,* chrysoperla and spiders/plant (0.67, 0.72, 0.64, 1.27 and 1.04/plant, respectively) over bio-digester @ 20% (0.57, 0.64, 0.57, 1.16 and 0.96, respectively). Among the different treatment combinations, combined application of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDF with foliar spray of panchagavya @ 5% recorded significantly higher natural enemies population mainly coccinellid adults, coccinelid grubs (Fig 1), syrphid maggots, *Micromus timidis,*

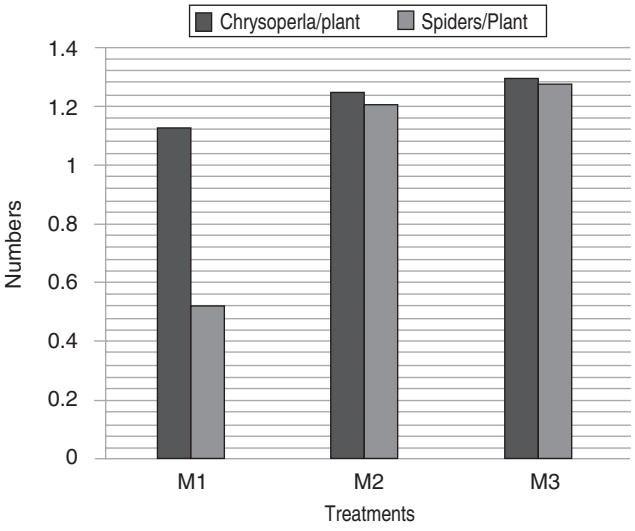

Fig 1 Natural enemies found in different treatments

Table 1 Beneficial organisms found in organic cotton ecosystem as influenced by organic manures, GLM, liquid organic manures and micronutrients

Treatment	2010			2011			Pooled		
	Coccinellid adults/plant	Coccinellid adults/plant	Syrphid maggots/ plant	Coccinellid adults/ palnt	Coccinellid grubs/ plant	Syrphid maggots/ plant	Coccinellid adults/ plant	Coccinellid grubs/ plant	Syrphid maggots/ plant
Organic manure (M)									
M1	0.33c	0.43b	0.47c	0.37c	0.44c	0.42c	0.35c	0.44c	0.44c
M2	0.64b	0.79a	0.73b	0.78b	1.09b	0.77b	0.71b	0.94b	0.75b
M3	0.71a	0.84a	0.89a	0.88a	1.27a	0.86a	0.80a	1.05a	0.88a
SEm±	0.082	0.041	0.082	0.012	0.0163	0.014	0.0082	0.0141	0.0041
Foliar spray of liquid manures + micronutrients (L)									
L1	0.59a	0.75a	0.71a	0.75a	0.98a	0.73a	0.67a	0.87a	0.72a
L2	0.53a	0.63a	0.65a	0.61d	0.87a	0.63b	0.57c	0.75a	0.64b
L3	0.55a	0.66a	0.70a	0.64cd	0.91ab	0.65b	0.60c	0.79a	0.67ab
L4	0.55a	0.69a	0.71a	0.68bc	0.94ab	0.68ab	0.61bc	0.81a	0.69ab
L5	0.58a	0.71a	0.72a	0.71ab	0.97a	0.72a	0.65ab	0.84a	0.72a
SEm ±	0.026	0.061	0.0422	0.018	0.026	0.0183	0.015	0.037	0.0236
Interactions (MXL)									
M1 L1	0.36c	0.47b-d	0.50cd	0.41f	0.48g	0.46f	0.38e	0.47d	0.48e
M1 L2	0.30c	0.38d	0.44d	0.33f	0.40g	0.37fg	0.32ef	0.39d	0.40e
M1 L3	0.31c	0.42d	0.46cd	0.36f	0.42g	0.41fg	0.34e	0.42d	0.43e
M1 L4	0.32c	0.44cd	0.47cd	0.38f	0.45g	0.42f	0.35e	0.44d	0.44e
M1 L5	0.34c	0.45b-d	0.48cd	0.39f	0.46g	0.44f	0.37e	0.46d	0.46e
M2 L1	0.65ab	0.83a	0.72ab	0.84b-d	1.16g	0.81c-e	0.75cd	1.00a-c	0.76cd
M2 L2	0.62b	0.75a-c	0.67ac	0.73e	1.00f	0.71e	0.68d	0.88c	0.69d
M2 L3	0.63ab	0.77ab	0.74ab	0.75de	1.06ef	0.73de	0.69d	0.91bc	0.74cd
M2 L4	0.64ab	0.79a	0.75ab	0.77de	1.09d-f	0.78c-e	0.71cd	0.94a-c	0.77cd
M2 L5	0.65ab	0.82a	0.76ab	0.82c-e	1.15c-e	0.81b-d	0.74cd	0.98a-c	0.79b-d
M3 L1	0.76a	0.95a	0.92a	0.99a	1.30a	0.93a	0.88a	1.13a	0.92a
M3 L2	0.67ab	0.76a-b	0.84ab	0.76de	1.20a-d	0.80c-e	0.72cd	0.98a-c	0.82a-c
M3L3	0.71ab	0.80a	0.88ab	0.81c-e	1.26a-c	0.82b-d	0.76cd	1.03a-c	0.85a-c
M3 L4	0.68ab	0.83a	0.90ab	0.89bc	1.28a-c	0.84a-c	0.78bc	1.06a-c	0.87a-c
M3 L5	0.75ab	0.85a	0.91a	0.93ab	1.29ab	0.91ab	0.84ab	1.07ab	0.91ab
C1	0.27c	0.40d	0.40d	0.23g	0.36g	0.32g	0.25f	0.38d	0.36e
SEm±	0.041	0.10	0.068	0.032	0.041	0.032	0.0258	0.058	0.041

EC- Enriched compost; C- Compost; VC – Vermicompost ; M_1 _ RDF – 80:40:40 NPK kg/ha + FYM @ 5 t/ha ; M_2 - EC (1/3)+ VC(1/3) + GLM (1/3) equi. to RDN ; M_3- EC (1/3)+ VC(1/3) + GLM (1/3) equi.to RDF; L_1- Panchagavvy @ 5%; L_2- Bio-digester @ 20% ; L_3- Cow urine @ 10%; L_4- Vermiwash @ 20%; L_5- borax @ 0.2% + $MgSO_4$ @ 1% ; C_1- RDF – 80:40:40 NPK kg + FYM @ 5 t/ha

Table 2 Beneficial organisms found in organic cotton ecosystem as influenced by organic manures, GLM, liquid organic manures and micronutrients

Treatment	2010			2011			Poooled		
	Chrysoperla/ plant	Spiders/plant	Micromus timidis/plant	Chrysoperla/ plant	Spiders/ plant	Micromus timidis/plant	Chrysoperla/plant	Spiders/Plant	Micromus timidis/plant
Organic Manure (M)									
M1	1.12b	0.52c	0.43c	1.14c	0.55b	0.45b	1.13b	0.53c	0.44b
M2	1.24ab	1.09b	0.62a	1.26b	1.33a	0.71a	1.25a	1.21b	0.67a
M3	1.28a	1.21a	0.66a	1.33a	1.35a	0.77a	1.30a	1.28a	0.72a
SEm±	0.040	0.0082	0.049	0.0082	0.016	0.041	0.023	0.0082	0.029
Foliar spray of liquid manures + micronutrients (L)									
L1	1.26a	0.97a	0.60a	1.29a	1.12a	0.69a	1.27a	1.04a	0.64a
L2	1.13b	0.88a	0.54a	1.19c	1.03d	0.59b	1.16c	0.96c	0.57b
L3	1.20a	0.93a	0.56a	1.22bc	1.06cd	0.62ab	1.21b	1.00bc	0.59ab
L4	1.23a	0.94a	0.58a	1.25ab	1.08bx	0.64ab	1.24ab	1.01ab	0.61ab
L5	1.25a	0.96a	0.58a	1.27a	1.10ab	0.67ab	1.26a	1.03ab	0.63ab
SEm±	0.024	0.028	0.026a	0.015	0.0105	0.029	0.015	0.015	0.021
Interactions (MXL)									
M1 L1	1.18ab	0.55c	0.44b-e	1.19a-c	0.58c	0.49bc	1.19b-d	0.57e	0.47b
M1 L2	0.98cd	0.47cd	0.41de	1.08c	0.50c	0.41cd	1.03e	0.49e	0.41bc
M1 L3	1.10bc	0.50c	0.42c-e	1.11bc	0.54c	0.43cd	1.11de	0.52e	0.43bc
M1 L4	1.16ab	0.51c	0.45b-e	1.15a-c	0.56c	0.44cd	1.15c-e	0.53e	0.45b
M1 L5	1.17ab	0.55c	0.43c-e	1.18a-c	0.58c	0.48b-d	1.17b-d	0.56e	0.45b
M2 L1	1.27ab	1.12ab	0.65a	1.30a-c	1.37ab	0.77a	1.28a-c	1.25a-c	0.71a
M2 L2	1.19ab	1.02b	0.60a-d	1.22a-c	1.29b	0.65ab	1.20a-d	1.16d	0.62a
M2 L3	1.23ab	1.09ab	0.62a-c	1.25a-c	1.30b	0.68a	1.24a-d	1.20cd	0.65a
M2 L4	1.24ab	1.10ab	0.63ab	1.26a-c	1.34ab	0.70a	1.25a-c	1.22b-d	0.67a
M2 L5	1.27ab	1.12ab	0.63ab	1.28a-c	1.35ab	0.75a	1.28a-c	1.24a-d	0.69a
M3 L1	1.32a	1.23a	0.71a	1.37a	1.40a	0.80a	1.34a	1.32a	0.75a
M3 L2	1.22ab	1.16ab	0.62a-c	1.25a-c	1.31b	0.72a	1.24a-d	1.23b-d	0.67a
M3L3	1.27ab	1.21a	0.63ab	1.32ab	1.33ab	0.76a	1.30ab	1.27a-c	0.70a
M3 L4	1.30a	1.22a	0.65a	1.33ab	1.33ab	0.78a	1.31ab	1.28a-c	0.72a
M3 L5	1.31a	1.22a	0.70a	1.36a	1.38ab	0.79a	1.33a	1.30ab	0.75a
C1	0.85d	0.35d	0.33e	0.63d	0.28d	0.30d	0.74f	0.31f	0.31c
SEm±	0.052	0.045	0.061	0.068	0.026	0.058	0.041	0.026	0.041

EC- Enriched compost; C- Compost; VC – Vermicompost ; M_1 _ RDF – 80:40:40 NPK kg/ha + FYM @ 5 t/ha ; M_2 - EC (1/3)+ VC(1/3) + GLM (1/3) equi. to RDN ; M_3- EC (1/3)+ VC(1/3) + GLM (1/3) equi. to RDF; L_1- Panchagavvy @ 5%; L_2- Bio-digester @ 20% ; L_3- Cow urine @ 10%; L_4- Vermiwash @ 20%; L_5- borax @ 0.2% + $MgSO_4$ @ 1% ; C_1- RDF – 80:40:40 NPK kg + FYM @ 5 t/ha.

Table 3 Energy use efficiency and energy productivity of organic cotton production system as influenced by organic manures, GLM, liquid organic manures and micronutrients

Treatment	Energy use efficiency	Energy productivity (kg/MJ)
Organic manure (M)		
M1	2.05b	0.174b
M2	2.17a	0.184a
M3	2.08b	0.186a
SEm±	0.023	0.0012
Foliar spray of liquid manures + micronutrients (L)		
L1	2.17a	0.184a
L2	2.00c	0.169c
L3	2.08b	0.176b
L4	2.09b	0.177b
L5	2.17a	0.184a
SEm±	0.024	0.0022
Interactions (MXL)		
M1 L1	2.14bc	0.181bc
M1 L2	1.97de	0.167de
M1 L3	2.01c-e	0.171c-e
M1 L4	2.05c-e	0.174c-e
M1 L5	2.09cd	0.177c-e
M2 L1	2.27a	0.189a
M2 L2	2.04c-e	0.173c-e
M2 L3	2.14bc	0.182bc
M2 L4	2.14bc	0.182bc
M2 L5	2.29a	0.194a
M3 L1	2.13bc	0.181bc
M3 L2	1.97de	0.167de
M3L3	2.07c-e	0.176cd
M3 L4	2.08cd	0.176cd
M3 L5	2.12bc	0.180cd
C1	1.94e	0.160e
SEm±	0.0408	0.0033

EC- Enriched compost; C- Compost; VC – Vermicompost ; M_1 – RDF – 80:40:40 NPK kg/ha + FYM @ 5 t/ha ; M_2 - EC (1/3)+ VC(1/3) + GLM (1/3) equi. to RDN ; M_3- EC (1/3)+ VC(1/3) + GLM (1/3) equi. to RDF; L_1- Panchagavvy @ 5%; L_2- Bio-digester @ 20% ; L_3- Cow urine @ 10%; L_4- Vermiwash @ 20%;

chrysoperla and spiders/plant (0.88, 1.13, 0.92, 0.75, 1.34 and 1.32/plant, respectively) as compared to RDF + FYM (0.25, 0.38, 0.36, 0.31, 0.74 and 0.31/plant, respectively). Rajashekara Rao *et al.* (2001) reported that the plots receiving vermicomopost @ 3.75 t/ha and neemcake @ 770 kg/ha recorded higher population of natural enemies over plots fertilized with inorganic fertilizers. Gaelle Marliac *et al.* (2015) observed that the higher natural enemies found in organic production system over conventional production system. Agricultural intensification through increasing

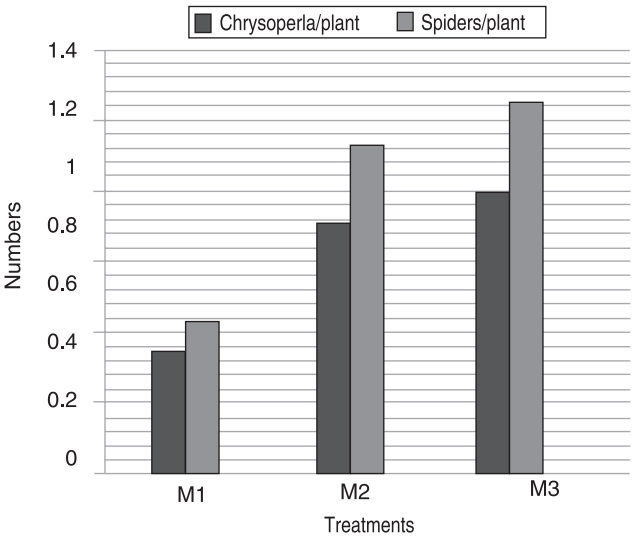

Fig 2 Natural enemies found in different treatments

fertilization input and cropland expansion has caused rapid loss of semi-natural habitats and the subsequent loss of natural enemies of agricultural pests (Zihua *et al.* 2017)

The integrated application of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDN recorded significantly higher energy use efficiency and energy productivity (2.17 and 0.186 kg/MJ, respectively) over FYM @ 5 t/ha + RDF (2.05 and 0.174 kg/MJ). Higher energy use efficiency in organic treatments was mainly due to on farm production and recycling of byproducts and wastes produced in a farming system for production of organic manures as compared to inorganic fertilizers. The foliar spray of panchagavya @ 5% recorded (Table 4) significantly higher energy use efficiency and energy productivity (2.17 and 0.184 kg/MJ, respectively) over foliar spray of bio-digester @ 20% (0.169 kg/MJ) and was on par with borax @ 0.2% + $MgSO_4$ @ 1%. The increase in natural enemy abundance and diversity relies on the presence and permanency of local trophic resources and adequate living conditions provided by cultural practices and the management of resources and/or habitats. Both plant- and detritus-mediated resources are the basis of food webs that comprise predatory trophic levels. Supplementary and/or complementary food (nectar, pollen, honeydew, hosts and prey) and suitable habitats for reproduction, diapause, overwintering, refuge, etc. (Landis *et al.* 2000).

The combined application of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDN with foliar spray of panchagavya @ 5% recorded significantly higher energy use efficiency and energy productivity (2.27and 0.194 kg/MJ, respectively) over RDF + FYM and was on par with EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDN with borax @ 0.2% + $MgSO_4$ @ 1%. Mousavi *et al.* (2010) observed that main energy consumer input in irrigated conditions were electricity (45.3%), chemical fertilizers (28.3%) and diesel fuel (15.2%); also, about 85% of total energy input in rainfed conditions was consumed by chemical fertilizers and diesel as fuel input. Under irrigated and rainfed conditions, the energy use efficiency

was calculated as 1.85 and 3.5 and the energy intensity was found to be 13.54 and 7.13 MJ/kg, respectively. Finally concluded that combined application of EC (1/3) + VC (1/3) + gliricidia GLM (1/3) equivalent to RDN with foliar spray of panchagavya @ 5% recorded higher beneficial natural enemies and higher energy use efficiency.

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