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Date:

Place: Jabalpur

Dr. Moni Thomas
Major Advisor

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(Student)

Declaration and Undertaking by the Candidate

I, Brajesh Kumar Namdev S/o Late Shri Makhan Lal Namdev Certify the work embodied in thesis entitled **"Study on the performance of *Aghani* crop of *kusmi* lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition"** is my own first hand bonafide work carried out by me under the guidance of Dr. Moni Thomas, Senior Scientist at Department of Entomology, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur and place during 2013-2014.

The matter embodied in the thesis has not been submitted for the award of any other degree / diploma. Due credit has been made to all the assistance and help.

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CERTIFICATE-I

This is to certify that the thesis entitled ***“*****Study on the performance of *****Aghani***** crop of *****kusmi***** lac on nutrient managed *****Zizyphus mauritiana***** under heavy rainfall condition*****”*** *submitted in partial fulfilment of the requirement for the degree of* ***MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)*** *of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by* ***Mr. Brajesh Kumar Namdev*** *under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instructions.*

All the assistance and help received during the course of the investigation has been acknowledged by him.

……………………………..

Place: Jabalpur **Dr. Moni Thomas**

Date: Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE

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CERTIFICAT E - II

This is to certify that the thesis entitled “Study on the performance of Aghani crop of kusmi lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition submitted by Mr. Brajesh Kumar Namdev to the Jawaharlal Nehru Krishi Vishwa Vidlyaaya, Jabalpur in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE In Agriculture in the Department of Entomology has been, after evaluation, approved by the External Examiner and by the Student’s Advisory Committee after an oral examination of the same.

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Place: Jabalpur **Dr. Moni Thomas**

Date: Chairman of the Advisory Committee

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Study on the Performance of *Aghani* Crop of *Kusmi* Lac on Nutrient Managed *Zizyphus mauritiana* Under Heavy Rainfall Condition

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

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In

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By

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2014

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Symbol	Abbreviation	Stands for
@		At the rate of
/		Slash/oblique/virgule
_		Dash
±		Plus or minus
%		Percentage
^{0}C		Degree centigrade
	CD	Critical difference
	SEm ±	Standard error of mean
	NS	Non significant
	EC	Emulsifiable Concentrate
	WP	Weltable Powder
	CHC	Cartap hydrochloride
	BLI	Broodlac inoculation
	Kg	Kilogram
	g	gram
	mg	Milligram
	M	Metre
	Cm	Centimetre
	L	Litre
	ml	Mililitre
	Temp	Temperature
	i.e.	In reference to; that is

INTRODUCTION

Nutrients play an important role in the plant growth is widely acknowledged (Oskarsson et al., 2006; Dianda et al., 2009). Mineral nutrition status is known to influence factors such as growth and yield of crop plants by affecting changes in growth pattern, plant morphology, anatomy, and particularly chemical composition. Thickness of epidermal cells, degree of lignifications, sugar concentrations, amino acid content in phloem sap, and levels of defensive compounds are all influenced by nutritional status of the plant (Marschner, 1995).

The plants provide nutrients to herbivorous insects an increase in the nutrient content of the plant is likely to increase its acceptability to pest populations (Scriber, 1984., McGuinness, 1987). Plant nutrient status have a positive effect on population dynamics, which contribute to higher survival rates, longer adult longevity and reproductive periods (Bi et al., 2001).

The Indian lac insect, *Kerria lacca* (Kerr) belongs to order- Hemiptera, suborder- Homoptera, super family- Coccoidae and family- Lacciferidae. *K. lacca* with its piercing and sucking mouth parts sucks plant sap (Colton, 1984). Lac insects are plant sap feeders (Sharma et al., 2006; Singh et al., 2009) therefore thrive well only on certain plant species known as lac hosts. More than 400 lac hosts have been recorded throughout the world (Kapur, 1962, Sharma et al., 1997). *Palash* (*Butea monosperma*), *Ber* (*Zizyphus mauritiana*) and *Kusum (Schleichera oleosa*) are the most common hosts commercial for lac production in India (Roonwal, 1962; Pal, 2009). There are two crops of *Kusmi* strain *Jethwi* harvested in June/July and *Aghani* in January/February. In case of *Rangeeni, Katki is* harvested in October/November and *Baishakhi* in April/May. *Katki* and *Baishakhi* are the main crop contributing about 90 % of Lac production in India (Singh, 2006).

Poor plant nutritional status of host tree of lac insect can have adverse effects on the performance and fitness of the insect. Phloem feeders adversely affect both growth and amino- nitrogen profile of their host plants

(Cook and Denno, 1994). Insect-plant relationship is may be affected by the application of micro or macro nutrients to crop plants (Wellings and Dixon, 1987).

Phloem sap is an important source of insects of the order Hemiptera (Douglas, 2003). Unlike huge investment input in cash crops. Viz. cotton, sugarcane, vegetables, citrus, there is no or minimum investment in lac cash crops of wide industrial application. Lac production also provides livelihood to 3 - 4 million Lac growers (Rao and Singh, 1990), especially forest dependent and rainfed farmers (Ogle and Thomas, 2006). It is a subsidiary source of income for rainfed farmers mainly in parts of Jharkhand, West Bengal, Madhya Pradesh, Chhattisgarh, Maharashtra, Andhra Pradesh (Jaiswal et al., 2004, Ogle and Thomas, 2006; Ramani et al., 2010).

Application of nutrients to plant not only increase its growth but also phloem feeder is an established scientific fact (Embden 1973). Therefore any application of nutrients to the host tree of lac insect is likely, it increase the growth of the tree and lac productivity. There is a need to validate this agreement, as any positive results will not only conserve the host there, but also economical benefit the lac growers generally disadvantaged group.

Therefore, the present research entitled **Study on the performance of *Aghani* crop of *Kusmi* lac on nutrient managed *Z. mauritiana* under heavy rainfall condition** with below mentioned objectives is planned

i. Impact of rainfall on lac insect settlement.

ii. Impact of nutrient management on lac production.

REVIEW OF LITERATURE

The scientific literatures scanned for the present work **Study on the performance of *Aghani* crop of *kusmi* lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition** is reviewed under appropriate sub heads for better understanding.

2.1 Lac general

Colton (1984) reported that lac insect, *Kerria lacca* is a valuable gift of nature to mankind. *K lacca* is a scale insect belonging to order- Hemiptera, suborder- Homoptera, super family Coccoidea and family Lacciferidae. It possesses piercing and sucking type of mouth parts which and sucks plant sap, in the process the insect secrets resinous substance from its three pair of highly specialize lac glands.

Lac insects are plant sap feeders (Sharma et al., 2006; Singh et al., 2009) therefore thrive well only on certain plant species known as lac hosts. More than 400 lac hosts have been observed to carry lac insects throughout the world (Kapur, 1962, Sharma et al., 1997). *Palash* (*Butea monosperma*), *Ber* (*Zizyphus mauritiana*) and *Kusum* (*S. oleosa*) are the most common hosts commercial for lac production in India (Roonwal, 1962; Pal, 2009).

Ramani (2011) reported that there are 12 lac producing states in India. *viz.* Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Uttar Pradesh and West Bengal.

Ogle and Thomas (2006) reported that India is the largest producer of lac, has a share of 62% of the world production of 44,000 metric tons. The country earned a foreign exchange worth Rs. 15,262 lakhs.

Jaiswal and Dwivedi (2005) recommended four key steps for systematic lac cultivation - pruning of host trees, infestation (inoculation) of the host trees with lac insects, removal of used up broodlac (lac insect seed) sticks and crop harvesting. This is apart from the application of insecticides/fungicides for pest/disease control, grouping of trees, and other tips for proper maintenance of lac culture.

2.2 Nutrient management

It is widely accepted that nutrients play an important role in the plant growth (Oskarsson et al., 2006; Dianda et al., 2009), and have recorded positive response of NPK fertilization to wheat crop growth (Berg and Hamid, 1976).

Nori et al. (2012) reported that nitrogen is the most critical element for plant growth, yield and quality of the products in crops .

Bungard et al. (1999) reported that nitrogen comprises seven percent of total dry matter of plants and is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments.

Ragothama (1999) reported that phosphorus the second most important macronutrient next to nitrogen is required for plant growth.

Vance et al. (2003) in a study reported that potasium has an important role in photosynthesis, respiration, energy generation, nucleic acid biosynthesis and as an integral component of several plant structures such as phospholipids.

Yoshida (1981) reported that potassium is an essential element for the growth of plant and takes part in various physiological processes.

Lal et al. (2003) reported that the growth, yield and quality parameters of *Z. mauritiana* improved significantly with added nitrogen, while application of phosphorus influenced all the parameters significantly except plant height, spread and fruit acidity. Potash application caused very little or no effect on growth and yield parameters, They applied four levels of N (0, 250, 500 and 750g per plant) in combination with three levels each of P_2O_5 (0, 250 and 500g per plant) and K_2O (0, 50 and 100g per plant) were applied to ten-year-old plants.Thus basal dose of different nutrients were applied to improve the growth of *Z. mauritiana* for increasing the lac production.

Paul et al. (2012) reported that 100g N, 250g P and 75g K per *Z. mauritiana* plant highest lac yield in *Z. mauritiana* with fertilizer application and manual treatment.

Marschner (1995) reported that mineral nutrition status is known to influence factors such as growth and yield of crop plants by affecting changes in growth pattern, plant morphology and anatomy, and particularly chemical composition. For example, thickness of epidermal cells, degree of lignifications, sugar concentrations, amino acid content in phloem sap, and levels of defensive compounds are all influenced by nutritional status of the plant, and in turn either affect or are presumed to affect resistance to insects

2.3 Nutrient and insect

Wellings and Dixon (1987) repoted that phloem feeders adversely affect both growth and amino- nitrogen profile of their host plants.

Cook and Denno (1994) reported that poor plant nutrition can have adverse effects on the performance and fitness of sap feeders.

Embden (1973) reported that essential amino acids in the plant sap are essential for growth and reproduction of aphids.

Klingauf (1987) reported that numerous studies have shown that variation in dietary concentrations of amino acids and sucrose affects aphid growth, survival, and reproduction.

Cottam (1985) reported that phloem-feeding aphids, whitefly or scale insects have all been charged with reducing the vigor of their host plants plants must defend themselves from attack by a vast range of pests and pathogens, including fungi, bacteria, viruses, nematodes, and herbivorous insects.

Increasing evidence suggests that mineral nutrients plays a critical role in plant stress resistance have been reported by (Kant and Kafafi, 2002; Cakmak, 2005; Amtmann et al., 2008; Romheld and Kirkby, 2010)

Teetes (1980) as well as Listinger (1993) have observed that earlier studies indicate that plants with sufficient nutrients are stronger, healthier, and in general better able to compensate for pest damage than those under nutritional deficiencies.

The plant nutrient status positive effects on population dynamics, which contribute to higher survival rates, longer adult longevity and reproductive periods (Bi et al., 2001), shorter pre-oviposition period (Metcalfe, 1970), greater rate of eggs laid per day (Minkenberg et al.,1990 and Nevo and Coll, 2001) and fecundity (Metcalfe, 1970, Nevo and Coll, 2001) of herbivores, are attributed to the increasing of the soluble protein content and specific free amino acids to change the morphology of host plant (Nevo and Coll, 2001) and high population densities (Cisneros, 2001; Jansson and Smilowitz,1986; Liu and Wang,1989; Su et al., 2003).

Slansky and Scriber (1985) reported that the feeding for survival and development of immature herbivores is the first step in all physiological activities, while oviposition is considered as the life end of female adults.

Scriber (1984) and Mc Guinness (1987) reported that the plants provide nutrients to herbivorous insects; an increase in the nutrient content of the plant is likely to increase its acceptability to pest populations.

Abro et al. (2004) reported that the insect-plant relationship may be affected by the application of micro/ macro nutrients to crop plants.

Huberand and Thompson (2007) reported that nutrient deficient plants are weak and vulnerable to incidences of plant disease and insect pest attack.

Marschner (1995) reported that nutrition of plants has a substantial impact on the predisposition of plants to be attacked or affected by pests and diseases. By affecting the growth pattern, the anatomy and morphology and particularly the chemical composition, the nutrition of plants may contribute either to an increase or decrease of the resistance and/or tolerance to pests and diseases.

Marschner (1995) and Patriquin et al. (1995) reported the mineral nutrition status is known to influence factors such as growth and yield of crop plants by affecting changes in growth pattern, plant morphology and anatomy, and particularly chemical composition. For example, thickness of epidermal cells, degree of lignifications, sugar concentrations, amino acid content in phloem sap, and levels of defensive compounds are all influenced by nutritional status of the plant, and in turn either affect or are presumed to affect resistance to insects.

Douglas (2003) studied phloem sap is an extreme food source that is used as the dominant or sole diet of very few animals, specifically insects of the order Hemiptera, including aphids, whitefly, plant hoppers and some pentatomid bugs.

Phloem sap contains two macronutrients, amino acids and sugars (usually sucrose). Although concentrations of these chemicals in phloem sap have been measured in many plants (Becker, 1973; Zimmerman and Ziegler, 1975), their variability within individual plants has been investigated in only two species: *Sallacutifolia* and *Lupinusalbus*

The response of phloem-feeding insects to phloem sugars is physiologically complex, involving nutritional, osmoregulatory and behavioral components. Phloem sugars are the principal carbon source and respiratory fuel for these insects (Rhodes et al., 1996 and Febvay et al., 1999).

2.4 Nitrogen and insect

Ge et al. (2003) reported that fertilizer application, especially nitrogen fertilizer, results in serious insect herbivores occurrence resistance.

Chen et al. (2008) reported that the plant nutritional quality and plant defenses that directly act on herbivores are altered by N fertilization, and herbivorous insects can distinguish between plants receiving different N applications.

Bhinde (1993) low nitrogen contents in the plants enhance the resistance of plants against pests, but high nitrogen contents cause vigorous growth along with consequent decrease in resistance against pests.

Bi et al. (2001) reported that increased nitrogen fertilizer application is positively correlated with the population of both adults and nymphs of *B. argentifolia.*

Phelan et al. (1996) reported that changing the preference of insects by optimal plant nutritional requirement via altering the fertilizer level of a soil.

Hu et al. (1983) reported that nitrogen fertilization also significantly increased the populations of WBPH, GLH and small brown planthopper

Ebert (1996) reported that nitrogen is taken up by plants in two different forms, nitrate or ammonium. The amino acid compositions were different among plants with different nitrogen treatments, and amino acid content and carbohydrate-to-amino acid ratios are linked to changes in aphid development.

Coulibaly (1990) was reported that the increasing application of nitrogen fertilizer reduced the fiber content in sugarcane and resulted in increased damage by the stem borer.

LU et al. (2007) reported that nitrogen is one of the most important factors in development of herbivore populations. The application of nitrogen fertilizer in plants can normally increase herbivore feeding preference, food consumption, survival, growth, reproduction, and population density

Bi et al. (2001) and Ge et al. (2003) reported that more fertilizer application, especially nitrogen (N) fertilizer, the more serious insect herbivores occurrence and crop damage from these insects by reducing plant resistance.

Prudic et al. (2005) reported that plant nutritional quality and plant defenses that directly act on herbivores are altered by nitrogen fertilization, and herbivorous insects can distinguish between plants receiving different nitrogen applications.

2.5 Phosphorous and insect

Skinner and Cohen (1994) reported that higher phosphorous levels are associated with higher insect levels.

Jansson and Ekbom (2002) found that as P fertilizer levels increased, aphid (*Macrosiphum euphorbiae*) development time shortened, and the adult lifespan and number of offspring increased.

2.6 Potassium and insect

Potassium (K) has been considered a key component of plant nutrition that significantly influences crop growth and some pests infestation. Potassium fertilizer is negatively associated with occurrence of *Aphis glycines* (Myers and Gratton, 2006), leafhoppers and mites (Parihar and Upadhyay, 2001). Increased K levels in foliage can reduce insect pressure (Walter and DiFonzo, 2007).

Amtmann et al. (2008) provide a potential mechanism to explain the relationship between K deficiency and increased insect attack. K deficiency results in reduced synthesis of proteins, starch, and cellulose, and increased accumulation of lower molecular weight compounds such as amino acids, nitrate, soluble sugars, and organic acids. These lower weight molecular compounds are more easily utilized as nutrient sources by sucking insects. Thus in other words, K deficiency on it's own may not correlate with higher insect attack, but the subsequent impact of K deficiency on plants, makes plants more readily attacked by sucking insects. This is better explained by (Walter and DiFonzo, 2007) who reported that low K fertility was associated with high foliar levels of the amino acid serine and higher aphid infestations****

Subramanaian and Balasubramanaian (1976) was reported that potassium induced changes in rice plant had profound effect on insect host interactions. Increase in potassium in rice plant caused reduction in the feeding rate of brown planthopper *Nilaparvata lugens* (Vaithillingan et al.,1976) and rate of population build up of *N. lugens* and green leafhopper, *Nephotettix sp*.

Vaithillingan and Baskaran, (1983) reported that increase K level led to accumulation of more phenols which probably contributed to increase insect resistance in some rice cultivars.

2.7 Impact of rainfall

Suppression of aphid population during high rainfall period was reported by (Patel et al.*,*1997). Decline the population of sucking insects in July and further increase from January up to March was respectively (Senapati and Mohanty,1980).

Lac crop is vulnerable to both biotic and abiotic stress (Sharma et al., 1997; Bhagat and Mishra, 2002; Jaiswal et al., 2008).

Patel et al*.* (1997) reported that high rainfall during July influences lac insect settlement. Suppression of aphid population during high rainfall period.

Meteorological factors play an important role in the population fluctuation of sucking insect pests (Gogoi et al., 2000; Murugan and Uthamasamy, 2001; Panicker and Patel, 2001)

Senapati and Mohanty (1980) reported that population of sucking insects showed decline in July and further increase from January up to March.

Earlier studies have determined the environmental limits of organisms, usually with respect to abiotic factors, such as temperature, irradiance, water availability, and to specific nutrients or toxins. These data provide both vital information for studies of physiological mechanism and robust explanations for the ecology of many taxa (Spicer and Gaston, 1999; Hochachka and Somero, 2002).

Changes in rainfall patterns, frequent droughts and floods, increased intensity and frequency of cold waves, outbreaks of insect pests and diseases area affecting profoundly many biological systems (IPCC, 2007) and lac sub-sector is also equally affected.

Li et al. (1992) reported that the different weather factors like temperature, relative humidity were found to have positive association with thrips population on cotton.

2.8 Major operation of lac production

2.8.1 Inoculation

Timely availability of pest free and quality broodlac is the most important for lac culture (Singh, 2010), especially in July for rainy season (Kumar and Das, 2012).

Approximately 4 kg *Kusmi* broodlac was required for inoculation an average *Kusum* tree, 1.5 kg for *Z. mauritiana* tree and 750g to 1.00 kg broodlac for *B. monosperma* tree (Srivastava ,2011), while (Kumar and Das, 2011) reported that 20g-30g broodlac is required per metre succulent branch. Depending upon the type and size of the lac host tree the broodlac quantity differs.

Bhagirath (2013) and Janghel (2013) reported that the quantity of broodlac used an *Z. mauritiana* and *B. monosperma* varied from 500g to 700g per plant.

2.8.2 Shifting

Shifting process is use for efficient use broodlac was first time carried out by (Khobragade, 2012). Since then shifting has become popular and the operation followed by (Janghel and Bhagirath, 2013).

2.8.3 *Phunki* removal

Phunki removal after three weeks of BLI was suggested by (Sharma and Jaiswal, 2011)

Khobragade (2012), Janghel (2013) and Bhagirath (2013) reported that *Phunki* removal is a labour intensive operation, but the scraped lac provides them a cash income after 30 of BLI.

2.9 Survival of lac insect

Bhagirath (2013) reported that survival of lac insect from BLI to harvesting was 22 to 27 percent in *Aghani* crop *Kusmi* lac while it varied from 27 to 32 percent in *Katki* crop on *B. monosperma* (Janghel,2013) and *Baisakhi* crop on *Z. mauritiana* was 21 to 25 percent (Kunal, 2013).

2.10 Yield of raw lac

According to Mishra et al., (1999) in *F. semialata* the live cell weight and *Phunki* (dry) cell weight on varied from 13.16 to 38.33 mg and 8.00 to 19.00 mg respectively, whereas on *F. macrophylla* it were from 16.83 to 31.67 mg and 9.33 to 18.83 mg. Thus the yield varies from host to host.

Bhagirath (2013) reported that the mean fresh weight (g) of 100 mature lac cells was 4.88g in *Kusmi* lac and 3.38g in case of *Rangeeni* lac, while In the present study it varied from 6.14 to 8.02g in various treatment

Bhagirath (2013) reported that the mean dry weight of 100 cells was 4.66g in case of *Kusmi* lac and 2.63g in case of *Rangeeni* lac.

According to Ghosal (2013), potassium application could bring an appreciable amount of reduction in the dry matter per cent of inoculable shoots. The lesser the dry matter per cent, the more the shoot will be succulent. Therefore, it can be stated that, inoculable shoot become more succulent due to potassium application, which is supposed to contribute to higher lac production. Similar result has been reported by (Abayomi, 1987) in sugarcane. According to (Zengin et al., 2009) increased succulence could be due to increased water uptake on potassium applied of plant.

MATERIAL AND METHODS

The present research work entitled **Study on the performance of *Aghani* crop of *kusmi* lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition** at Dhapara village, Barghat Block, Seoni District, Madhya Pradesh was carried from May 2013 to February 2014.

3.1 Location of study area

3.1.1 Seoni district

Geographically Seoni district is located in the southern part of Madhya Pradesh between $21^0 35'$ and $22^0 58'$ N latitudes and $79^0 12'$ and $80^0 18'$ E longitudes. The district bordered by Jabalpur, Narsinghpur and Mandla districts in north, Balaghat in east and Chhindwara in west and southern boundary of the district lies in just a position to Nagpur (Maharashtra). National Highway -7 connecting Kanyakumari to Kashmir passes through the southern part of the district. A fair weather road connects the major towns in the district. Chhindwara, Balaghat, Katangi and Nainpur (Fig. 3.1) are some of important nearby towns. The narrow guage railway line Chhindwara-Nainpur passes through Seoni. The consumption centres are Seoni, Lakhnadon, Barghat, Chhapara, Dhuma, Kanhiwara and Keolari. The foodgrains, vegetables, fruits, minor forest products, and timber find major markets in Nagpur and Jabalpur and in the consumption centres within the district.

Geologically, the area forms a part of Maikal range of northern and eastern parts of Satpura Hills tending N-S, NE-SW and E-W. The highest topographic elevation in the district is 756 m above mean sea level in Seoni-Lakhanadon plateau region and the lowest is 430m above mean sea level in the plains of Wainganga-Hirri River.

Agro-climatically, the district lies in the Zone IV- Kymore Plateau and Satpura Hill Zone of Madhya Pradesh. Seoni district forms a part of the hills and plateau of the Satpura range of mountains. Major part of the landscape is undulating and rocky with thin layer of soil cover. The portion of the land used for agricultural purpose is 43.22 per cent of the total land cover of which only

11.93 per cent has assured irrigation and hence are double cropped. The rest of the agricultural land is totally rainfed and produces only one crop a year.

3.1.2 Barghat block

Barghat is one among the 8 Blocks of the Seoni district and has 142 villages (136 Revenue villages, 4 Forest villages and 2 uninhabited villages). It has a geographical area of 53,924.09 ha of which 44,218.70 ha is a cultivated area. The area under irrigation is 4,536.63 ha (10.25 %) area while 39,682.07 ha is unirrigated (89.75%).

3.1.3 Dhapara village

Dhapara village has a geographical area of 397.08 ha, of which 338.17 ha is under cultivation while 22.20 ha, 6.50 ha and 27.75 ha are uncultivated under river and ponds. The population of the village is 1885 (Table-1).

Figure 3.1 Map of seoni district

Table 1. Information of Dhapara village

S. No.	Particulars	ha/no./q
1.	Geographical area	397.08
2.	Total cultivated area	338.17
3.	Under forest area	81.82
4.	Area under Rivers and Ponds	23.14
5.	Number of households	377
6.	Populations	3683
	a. Male	1840
	b. Female	1843
7.	Literacy	
	a. Literate	2149
	b. illiterate	1534
8.	Total number of Lac growers	153
9.	Estimate number	
	Ber trees	5642
	Palash trees	20770
10.	Estimate annual lac production (q)	
	a. *Katki crop*	20
	b. *Baisakhi crop*	69

3.2.1 Experimental details

The study was planned under RBD, with six replications and four treatments as mentioned in (Table – 2).

Table 2. Details of the Experiment

Host trees		*Ber* (*Z. mauritiana*)
Design		R.B.D.
Number of Replications		6
Number of treatments		4
Number of *Z. mauritiana*trees per treatment		12
Total number of *Z.mauritiana* trees per replication		2
Treatment details (basal application of fertilizers per *Z. mauritiana* tree)		
T_1	Application of Nitrogen (Urea 220g)	
T_2	Application of Nitrogen (Urea 220g) and Phosphorus (SSP 1560g)	
T_3	Application of Nitrogen(Urea 220g), Phosphorous (SSP 1560g) and Potassium (MoP 125g)	
T_4	Control i.e. no use of fertilizers (Lac growers practice)	

3.2.2 Criteria for selection of

a. Lac growers:

Lac growers having *Z mauritiana* trees in their field and willing to participate in the research were selected for the study. The marking of the selected trees was done in month of May 2013.

b. Trees:

Z mauritiana trees which are over five years old, healthy, pruned and possessing sufficient succulent branches were selected for the study.

3.3 Operations

There were the following nine major operations during the experiment (Table-3).

Table 3. Details of major operation

S. no.	Operations	Period
1	Selection of plant and its marking	Last week of May
2	Soil sample collection	June 2013,November, 2013 and January, 2014
3	Application of fertilizers	19-20th June, 2013
4	Broodlac inoculation	16-17thJuly, 2013
5	Shifting of broodlac inoculated	23rdJuly, 2013
6	*Phunki* removal	6th August, 2013
7	Spraying of pesticide	25-26th August, 2013
8	Harvesting of sticklac	9-10th January, 2014
9	Scraping of raw lac	25th January to 6th February 2014

3.3.1 Fertilizers application

All the marked *Z mauritiana* tree except control (T_4) were applied with basal dose of fertilizer as per treatment (Table- 2) one month before Broodlac inoculation.

3.3.2 Broodlac inoculation

The process of Brood lac inoculation had following three operations

a. **Brood inoculation:** Healthy Broodlac weighing 300 to 600 g were used for inoculation per *Z. mauritiana* tree. Depending on the size of the tree, the brood lac were divided into three to six bundles (each with 100g per bundle) and inoculated between 16th to17th July, 2013.

b. **Shifting:** The Broodlac bundles were shifted carefullyafter 5 to 6 days of its inoculation to those branches of the same *Z mauritiana* tree which have less larval settlement. This was to ensure uniform distribution of the brood on all tree branches where there was no or insufficient lac larval settlement.

c. ***Phunki* removal:** Larvae (crawlers) of lac insect from Broodlac settled on the tree in three weeks from the date of its inoculation. Once the crawlers leave the broodlac and settle on the twigs of the host, the remains of the Broodlac bundle is called *Phunki*. *Phunki* is in fact sticklac. *Phunki* usually consists of predators, was removed after 21 days of Broodlac inoculation and scrapped to recover raw lac, and in this process the predators are removed.

3.3.3 Spraying of pesticides

Application of pesticides for predator management is an essential process in the Lac production.

a. **Equipment and items:** The spraying operations were carried by a Sprayer. Plastic bucket, drum, face mask, sun glasses and soap were other items that were used during the spraying operations.

b. **Preparation of pesticides solution:** The solution of pesticides were prepared by adding its desired quantity (1g of Cartap hydrochloride per litre of water + 1g Mancozeb per litre of water) in a small container followed by brisk stirring with a piece of stick. This concentrate solution was further diluted with clear water to make the spray solution.

c. **Spraying:** Spraying of pesticides with a Foot sprayer required two persons. One operated peddle of the Foot sprayer while other holding the lance of the sprayer sprayed the solution on the *Z. mauritiana* tree.

d. **Spraying schedule:** Spraying of the pesticides was done on 25th to 26thAugust, 2013.

3.3.4 Harvesting of sticklac

At maturity the sticklac was harvested on 9th and 10th of January 2014 for estimation of lac yield.

3.3.5 Scraping of raw lac

After harvesting of sticklac its scraping was done between 25thJanuary to 6th February 2014.

3.4 Observations were recorded from

Three randomly selected lac insect settled branches per *Z. mauritiana* tree, at five fixed spots of 2.5 sq cm per branch. The observations recorded following schedule mentioned in the (Table -4).

Table 4. Details of observations and its schedule

S. no.	Observation	Scale	Period
A. Pre-harvest			
a.	Larval settlement count	Lac insect/2.5 sq. cm succulent branch*	30 days after BLI**
B. Post-harvest			
a.	Ratio of insect settlement to harvest	Lac insect/2.5 sq. cm branch sticklac	August 2013-January 2014
b.	Raw lac production	Weight(g) of raw lac /foot of sticklac	January 2014
c.	Ratio of fresh raw lac to dry raw lac	Weight(g) loss after shady drying	January 2014
d.	Mean cell weight	Weight(g) of 100 cell	January 2014
e.	No. of sticklac/plant	In number	January 2014
f.	Lac yield/plant	Kg/plant	January 2014
g.	Cost of Fertilizers application	Per tree	February 2014
h.	Cost of pesticide application	Per tree	February 2014

* 3 branch / plan; **BLI- Broodlac inoculation

3.5 Statistical Analysis

Data recorded on various aspects were tabulated and subjected to statistical analysis by using the techniques of analysis of variance (Panse and Sukhatme, 1967). Treatment significance was tested by '*F*' test. If '*F*' test express the significant difference between the treatment mean values tested with critical difference (CD) at 5% level of significance was computed.

Table 5. Analysis of Variance

Sources of variance	***df***	**S.S.**	**M.S.S**	***F Cal***	***F Tab***
Replications	(r-1)	SSR	VR	-	
Treatments	(t-1)	SST	VT	VT / VE	*F* at 5% (t-1), (r-1) (t-1)
Errors	(r-1) (t-1)	SSE	VE		
Total	(r.t-1)				

where

r = number of replications

t = number of treatments

VR= replication mean sum of square

VT=treatment mean sum of square

VE= error mean sum of square

The significance among different treatment means was judged by critical difference (CD) at 5% level of significance for comparison among the treatments, the marginal means of each treatment was considered. The following formula was used for various estimations.

i. Standard error of mean

$$S.\ Em \pm = \sqrt{\frac{E.\ ms}{r}}$$

ii. Critical difference (CD) = SEm x √ 2 x t 0.05

where,

Ems	=	error mean sum of square
t	=	'*t*' value at 5 % level at error *d.f.*
r	=	number of replication

RESULTS

The present research work **Study on the performance of *Aghani* crop of *kusmi* lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition** was conducted from May 2013 to February 2014 at Dhapara village, Barghat Block, Seoni District, MP. The study was carried out on 48 well pruned and over five year old *Z. mauritiana* trees in farmers field. The Broodlac inoculation to harvest were timely carried during the study. The results of the present study are discussed below.

4.1 Nutrient application

The nutrient application were done in *Z. mauritiana* from 19th June to 20th June 2013. The Nitrogen, Phosphorus and Potash was applied through basal application of Urea, SSP and MoP respectively (Table-6). The nutrient in different treatments were in T_1-N (Urea 220g), T_2 - N (Urea 220g) and P (SSP 1560g),T_3 - N (Urea 220g), P (SSP 1560g) and K (MoP 125g) and T_4 - Control i.e. no use of fertilizers (Lac growers practice).

4.2 Broodlac inoculation

The Brood lac inoculation (BLI).of *kusmi* broodlac was done from 16th July to 17th July 2013 (Table-6) on *Z. mauritiana* trees. The mean BLI per plant varied from 400g to 500g per plant, depending on the size of host trees. There was no significant difference among the different treatments.

4.3 Shifting

Shifting was done on seven days after BLI i.e. 23rd July 2013 to ensure uniform distribution of the brood on all the of *Z. mauritiana* branches, where there was no or insufficient lac larval settlement.

4.4 *Phunki* removal

Phunki was removed 21 days after BLI i.e. from 6th August to 7th August 2013. The mean weight of *phunki* lac was 242.08g, 261.08g, 271.25g and 232.50g respectively in case of T_1, T_2, T_3 and T_4 (Table-7). There was no significant difference in the mean weight of *phunki* among four treatments.

4.5 Scrap lac from *Phunki*

Phunki was scrapped to obtain raw lac from it. The mean weight (g) of the raw lac obtained after scraping of *phunki* was 142.91g, 151.25g, 164.58g and 140.83g respectively among T_1, T_2, T_3, and T_4. There was no significant difference among the raw lac from Phunki the raw lac from *phunki* (Table-8)

Table 6. Basal application of fertilizers per *Z. mauritiana* tree

T_1	Application of Nitrogen (Urea 220g)
T_2	Application of Nitrogen (Urea 220g) + Phosphorus (SSP 1560g)
T_3	Application of Nitrogen(Urea 220g) + Phosphorous (SSP 1560g) + Potassium (MoP 125g)
T_4	Control i.e. no use of fertilizers (Lac growers practice)

Table 7. Mean brood inoculation (g) per plant

Replications	**Mean brood inoculation (g) per plant**			
	Treatments			
	T_1	**T_2**	**T_3**	**T_4**
R_1	400	400	500	450
R_2	400	450	400	400
R_3	450	500	400	400
R_4	400	400	400	400
R_5	450	450	450	450
R_6	400	400	450	400
Mean	**416.66**	**433.33**	**433.33**	**416.67**
SEm±13.26	CD at 5% NS			

Table 8. Mean weight of *phunki* (g) per plant

Replications	Mean weight of *phunki* (g) per plant			
	Treatments			
	T_1	T_2	T_3	T_4
R_1	245.0	277.5	285.0	205.0
R_2	252.5	275.0	247.5	215.0
R_3	235.0	302.5	237.5	235.0
R_4	242.5	247.5	252.5	237.5
R_5	232.5	231.5	350.0	247.5
R_6	245.0	232.5	255.o	255.0
Mean	**242.08**	**261.08**	**271.25**	**232.5**
SEm±12.36	CD at 5% NS			

Table-9 Mean weight of scrap lac from *phunki* (g) per plant

Replications	Mean weight of scrap lac from *phunki (g)* per plant			
	Treatments			
	T_1	T_2	T_3	T_4
R_1	152.5	167.5	172.5	122.5
R_2	147.5	167.5	152.5	125.0
R_3	140.0	170.0	140.0	147.5
R_4	137.5	150.0	145.0	137.5
R_5	137.5	130.0	215.0	150.0
R_6	142.5	122.5	162.5	162.5
Mean	**142.91**	**151.25**	**164.58**	**140.83**
SEm ± 8.62	CD at 5% NS			

4.6 Population density of *Kusmi* lac

The mean larval settlement count of *Kusmi* lac insect was observed per 2.5 sq. cm of the succulent branches after BLI till the harvest i.e. at 30, 45, 60, 70, 90, 110, 151,172 days of BLI (Table -9).

Impact of rainfall

The Broodlac inoculation was carried out on the 16^{th} July to 17^{th} July 2013. The crawlers (larvae of *K. lacca)* crawls from the Broodlac bundles to succulents branches for next 20 days. Heavy rainfall accured immediately after the BLI. The precipitation was 46, 48, 16, 17, 16, 10 and 25 mm from 18^{th} July to 24^{th} July 2013. There were 27 rainy days between 15^{th} July to 15^{th} August 2013, and total rainfall during the period was 506mm. Continuous rain washed away the crawlers in motion. It was observed that plants which had less leaves and few branches were more affected.

30 days after BLI

Mean lac insect settlement per 2.5 sq. cm varied from 79.32 to 90.02 in the four treatments T_1, T_2, T_3 and T_4.The mean lac insect count per 2.5sq. cm was highest in T_1 (90.02) followed by T_2(87.63), T_3 (86.07) and T_4 (79.93).There was a significant difference in the mean lac insect settlement among the four treatments. There was more lac insect settled over the control in T_1 (13.48%) followed by T_2 (10.47%) and T_3 (8.50%).

45 days after BLI

The lac insects after secretion of resin over its body grow into individual lac cell. The mean lac cell count per 2.5 sq. cm at 45 days after BLI varied from 51.35 to 64.08 in different treatments. The mean lac cell count was highest in T_1 (64.08) followed by T_2 (59.51), T_3 (54.02) and T_4 (51.35). There was a significant difference among the four treatments. The number of live lac cell was highest over the control in T_1 (24.79%) followed by T_2 (15.89%) and T_3 (5.19%).

60 days after BLI

The mean live lac cell count per 2.5 sq. cm at 60 days after BLI varied from 40.01 to 47.6 in different treatments. The mean live lac cell was highest in T_1 (47.6) followed by T_2 (43.81), T_3 (42.28) and T_4 (40.01). There was a significant difference among in the mean live lac cell count the four treatments. The live lac cell over the control was highest in T_1 (18.97%) followed by T_2 (14.49%) and T_3 (5.67%).

90 days after BLI

The male emerged between 65-75 days after BLI. Winged male lac insect were seen, which were short lived. After the male emergence the remaining live lac cell were that of female lac insects. The mean female lac cell count per 2.5 sq. cm at 90 days after BLI varied from 22.88 to 27.88 in different treatments. The female lac cell count was highest in T_1 (27.88) followed by T_2 (24.76), T_3 (24.53) and T_4 (22.88). There was a significant difference in the live female lac cell among all the treatments. As it is the female that produces lac, therefore its numbers determine the lac productivity. Highest live female lac cell over the control was in T_1 (21.85%) followed by T_2 (8.21%) and T_3 (7.21%).

110 days after BLI

The mean live female lac cell count per 2.5 sq. cm at 110 days after BLI varied from 17.8 to 23.71in different treatments. It was highest in T_3 (23.71) and lowest in case of T_4 (17.8). There was a significant difference in the mean number of live lac cells among the treatments. The live lac cell over control was highest in T_3 (33.20%) followed by T_1 (29.38%) and T_2 (22.47%).

130 days after BLI

The mean live lac cell count per 2.5 sq. cm at 130 days after BLI varied from 16.50 to 20.33 in different treatments. It was highest in T_1 (20.33) followed by T_2 (20.23), T_3 (20.08) and T_4 (16.50).There was a significant difference in the mean number of live lac cell count among the treatments. It was highest over control in T_1 (23.21%) followed by T_2 (22.60%) and T_3 (21.69%).

150 days after BLI

The mean live female lac cell count per 2.5 sq. cm at 150 days after BLI it varied from 16.16 to 19.05 in different treatments. The live lac cell count was highest in T_1 (19.05) followed by T_2 (18.87), T_3 (18.92) and T_4 (16.16). There was a significant difference in number of live cell among the treatments. It was highest over the control in T_1 (17.88%) followed by T_3 (16.77%) and T_2 (16.76%).

172 days after BLI (At harvest)

The *Aghani* crop of *Kusmi* lac matured in the month 1^{st} week of January 2014 . It was harvested from 8^{th}January to 9^{th} January 2014 i.e. 172 days after BLI. The mean lac cell count at harvest/maturity varied from 15.57 to 18.43 per 2.5 sq. cm. The live lac cell count was highest in T_1 (18.43) followed by T_2 (18.03), T_3 (17.41) and T_4 (15.57). There was a significant difference in the mean live lac cell count among different treatments. It was highest in T_1 (18.36%) followed by T_2 (15.79%) and T_3 (11.81%) lac cell over the control. Thus application of fertilizer on their *Kusmi* lac host tree had more number of there lac cells at harvest on comparison to control.

4.7 Transmission loss of lac insects

Transmission loss (TL) defined as the loss in the number of lac insect per 2.5 sq. cm from BLI to harvest. There was a significant loss of insect from BLI to harvest among different treatments (Table-10) as observed from 30 day after BLI to harvest. It was 28.81, 47.04, 69.03, 71.42, 77.42, 78.84 and 79.53 per cent at 30, 45, 60, 90, 110, 130,150 and 172 days in case of T_1. In case of T_2, the TL was 32.08, 47.72, 71.75, 75.13, 76.92, 78.46 and 79.42 per cent at 30, 45, 60, 90, 110, 130, 150 and 172 days respectively. In case of T_3, the TL was 37.24, 50.88, 71.50, 72.46, 76.67, 78.02 and 79.78 per cent at 30, 45, 60, 90, 110, 130, 150 and 170 days respectively. In case of T_4,TL was 35.27, 49.56, 71.15, 77.56, 79.20, 79.32 and 80.37 percent at 30, 45, 60, 90, 110, 130, 150 and 172 days respectively. The highest TL was in case of T_4 (80.37%) followed by T_3 (79.78%), T_1 (79.53%) and T_2 (79.42%). Thus the survival percent of lac insect from BLI to harvest was highest in T_2 (20.58%) followed by T_1 (20.47%), T_3 (20.22%) and T_4 (19.63).

4.8 Sticklac

Branches of the lac host tree with lac encrustation of mature lac insect when ready to harvest is called sticklac. The mean number of sticklac was highest (18) in both T_2 and T_3 (18) followed by T_1 (17.08) and T_4 (13.16). There was a significant difference in the number of sticklac in different treatments.

4.9 Weight of sticklac

The mean weight of sticklac per 30 cm varied from 16.88g to 92.03g (Table-11). The mean weight (g) of sticklac per 30 cm was highest in T_3 (47.34g) followed by T_1 (41.59g), T_2 (35.73g) and T_4 (32.50g). There was no significant difference in the mean weight of sticklac among different treatments.

Table 11. Mean number of Sticklac per plant at harvest

Replications	**Mean number of Sticklac per plant**			
	Treatments			
	T_1	**T_2**	**T_3**	**T_4**
R_1	20.0	15.5	20.0	16.0
R_2	18.0	16.5	16.0	12.5
R_3	15.5	20.5	17.0	12.0
R_4	13.0	16.0	18.0	13.0
R_5	20.0	19.5	23.0	12.5
R_6	16.0	20.0	14.0	13.0
Mean	**17.08**	**18.00**	**18.00**	**13.16**
SEm± 0.95	CD at 5% 2.88			

Table 12. Mean weight of sticklac (g) per 30 cm at harvest

Replications	Mean weight of sticklac (g) per 30 cm			
	Treatments			
	T_1	T_2	T_3	T_4
R_1	36.99	31.02	92.03	25.51
R_2	70.03	47.23	47.51	27.23
R_3	42.71	31.23	16.88	42.14
R_4	29.08	31.36	47.23	36.88
R_5	27.69	41.20	38.06	38.13
R_6	43.04	32.33	42.33	25.10
Mean	**41.59**	**35.73**	**47.33**	**32.50**
SEm± 6.62 CD at 5% NS				

4.10 Mean fresh weight of 100 lac cell

The mean fresh weight (g) of 100 cells of lac insect differed significantly among the treatments. It varied from 5.27 to 8.91g (Table-12). The mean fresh weight of 100 cell of lac insect was highest in T_3 (8.02g) followed by T_1 (7.20g), T_2 (6.89g) and T_4 (6.14g). There was a significant difference among the mean fresh weight (g) of 100 lac cell in all treatments over control. It was highest over control in T_3 (30.61%) followed by T_1 (17.26%) and T_2 (12.21%).

4.11 Mean dry weight of 100 lac cell

The mean dry weight (g) of 100 cell of lac insect differed significantly among the treatments. The mean dry weight of 100 cells varied from 4.25g to 7.84g (Table-13). The mean dry weight of 100 lac cells was highest in T_3 (7.08g) followed by T_1 (6.30g), T_2 (6.01g) and T_4 (5.18g).It was highest over control in T_3 (36.63%) followed by T_1 (21.62%) and T_2 (16.02%).

Table 13. Mean fresh weight (g) of 100 cell of lac insect

Replications	Mean fresh weight (g) of 100 lac cells			
	Treatments			
	T_1	T_2	T_3	T_4
R_1	8.03	5.92	8.91	5.47
R_2	8.03	6.02	8.16	6.22
R_3	8.07	6.59	8.39	5.74
R_4	7.26	7.64	6.69	6.17
R_5	6.53	8.52	8.43	7.33
R_6	5.27	6.69	7.56	5.90
Mean	**7.20**	**6.89**	**8.02**	**6.14**
SEm± 0.37	CD at 5% 1.13			

Table 14. Mean dry weight (g) of 100 cells of lac insect

Replications	Mean dry weight of 100 lac cells			
	Treatments			
	T_1	T_2	T_3	T_4
R_1	6.99	4.98	7.84	4.25
R_2	7.02	5.50	7.10	5.21
R_3	7.42	5.55	7.30	4.85
R_4	5.99	6.61	5.62	5.80
R_5	5.64	7.57	7.90	6.14
R_6	4.72	5.86	6.73	4.82
Mean	**6.30**	**6.01**	**7.08**	**5.18**
SEm± 0.36	CD at 5% 1.11			

4.12 Mean yield of raw lac

The mean yield of raw lac (kg) per plant obtained after harvesting of lac crop was 5.08, 4.54, 5.33 and 3.83 respectively among the treatments T_1, T_2, T_3, and T_4 (Table-14). There was a significant difference in the mean yield of raw lac among all the treatments. Application of fertilizer significantly increased the mean yield of lac per plant over control. It was highest over control in T_3 (39.16%) followed by T_1 (32.63%) and T_2 (18.53%).

Table 15. Mean raw lac yield (kg) per plant

Replications	Mean raw lac yield (kg) per plant			
	Treatments			
	T_1	T_2	T_3	T_4
R_1	4.25	3.75	6.00	2.75
R_2	5.25	4.50	4.50	4.50
R_3	6.00	5.00	5.50	3.50
R_4	5.25	4.50	4.00	4.00
R_5	4.75	4.50	7.00	4.25
R_6	5.00	5.00	5.00	4.00
Mean	**5.08**	**4.54**	**5.33**	**3.83**
SEm± 0.300	CD 5% 0.906			

4.13 Production cost of *Aghani* crop of *Kusmi* lac on Ber (*Z. mauritiana*)

The production cost of *Aghani* lac crop on *Z. mauritiana* tree was highest in case of T_3 (Rs 413.38) followed by T_2 (Rs 395.57), T_1 (Rs393.01), and T_4 (Rs326.65). The mean yield per *Z. mauritiana* was highest in T_3 (5.33kg) followed by T_1 (5.08 kg), T_2 (4.54kg) and it was lowest in T_4 (3.83kg).

Table 16. Production cost of Kusmi lac on Ber (*Z. mauitiana*)

A. Operational cost (Rs) per plant					
Operations	**Cost**	**T_1**	**T_2**	**T_3**	**T_4**
Pruning	Rs 120/24 trees	5.00	5.00	5.00	5.00
Labour @Rs280/18tree for Fertilizer application		40.00	40.00	40.00	0
Inoculation	Rs 120/24 trees	5.00	5.00	5.00	5.00
Phunki removal	Rs 120/48 trees	2.50	2.50	2.50	2.50
Scraping of *Phunki*	Rs 20/kg	2.84 (142.91 g)	3.02 (151.25g)	3.28 (164.58 g)	2.8 (140.83 g)
Labour @Rs 300/48 trees for Pesticide application		6.25	6.25	6.25	6.25
Harvesting	Rs 120/12 trees	10.00	10.00	10.00	10.00
Scraping raw lac	Rs 20/kg	101.60	90.80	106.60	76.60
Sub Total (a)		**173.19**	**162.57**	**178.63**	**108.15**
B. Input cost (Rs) per plant					
Brood	K- 500/kg	208.00	216.50	216.50	208.00
Spray of Pesticide					
CHC 50 SP @Rs 100/100 g		6.00	6.00	6.00	6.00
Dithane M-45 @Rs 30/100 g		4.50	4.50	4.50	4.50
Fertilizer Application					
Cost of Fertilizers		1.32	6.00	7.75	0
Sub Total (b)		**219.82**	**233.00**	**234.75**	**218.50**
C. Total (a+b)		**393.01**	**395.57**	**413.38**	**326.65**
D. Gross Return (Rs) per plant					
Mean yield	Kg	**5.08**	**4.54**	**5.33**	**3.83**
Value @	600/kg	3048.00	**2724.00**	**3198.00**	**2298.00**
Phunki yield	Kg	0.142	0.151	0.164	0.140
Phunki value@	500/kg	70.50	75.50	82.00	70.00
Total		**3118.50**	**2799.50**	**3280.00**	**2368.00**
E. (D - A+B) Net Return (Rs) per *Z. mauritiana* plant					
Gross Return(D)		**3118.50**	**2799.50**	**3280.00**	**2368.00**
Total cost (A)+(B)		**393.01**	**395.57**	**413.38**	**326.65**
Net Profit		**2725.49**	**2403.93**	**2866.62**	**2041.35**

. In the month February 2014 rate of *Kusmi* raw lac was Rs 600 per kg.

*CHC = Cartap hydrochloride

4.14 Net Profit

The net profit was highest in case of T_3 (Rs 2866.62/tree) followed by T_1 (Rs2725.49/tree) and T_2(Rs2403.93/tree) and it was lowest (Rs2041.35/ tree) in case of T_4 (Table-16).

The Cost-Benefit ratio was highest (1:6.83) in T_1 and T_3 followed by T_4 (1:6.14) and it was lowest (1:5.98) in case of T_2 (Table-17).

Table 17. Cost benefit ratio

Treatments	Net profit	Cost	B.C Ratio
T_1	2725.49	393.01	1:6.93
T_2	2403.93	395.57	1:6.07
T_3	2866.62	413.38	1:6.93
T_4	2041.35	326.65	1:6.24

DISCUSSION

Results of the present research work **Study on the performance of *Aghani* crop of *kusmi* lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition,** are discussed below.

5.1 Nutrient application

The basal application of nutrient were done in *Z. mauritiana* from 19th June to 20th June 2013. The Nitrogen, Phosphorus and Potash was applied through basal application of Urea, SSP and MoP respectively. The nutrient in different treatments were in T_1-N (Urea 220g), T_2 - N (Urea 220g) and P (SSP 1560g),T_3 - N (Urea 220g), P (SSP 1560g) and K (MoP 125g) and T_4 - Control i.e. no use of fertilizers (Lac growers practice).

It is widely acknowledged that nutrients play an important role in the plant growth (Oskarsson et al. 2006; Dianda et al. 2009), and have recorded positive response of NPK fertilization to wheat crop growth (Berg and Hamid, 1976). Nitrogen is the most critical element for plant growth, yield and quality of the products in crops (Nori et al., 2012).It comprises seven percent of total dry matter of plants and is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments (Bungard et al., 1999).

Phosphorus- The second most important macronutrient next to nitrogen is required for plant growth (Ragothama, 1999). It has an important role in photosynthesis, respiration, energy generation, nucleic acid biosynthesis and as an integral component of several plant structures such as phospholipids (Vance et al*.,* 2003). Potassium is an essential element for the growth of plant and takes part in various physiological processes (Yoshida, 1981).

The above studies confirm that nutrient management in plants are very important for its growth and production.

Phloem feeding insects adversely affect both growth and amino-nitrogen profile of their host plants (Wellings and Dixon, 1987), while poor plant nutrition can have adverse effects on the performance and fitness of sap feeders (Cook and Denno, 1994).Essential amino acids in the plant sap are essential for growth and reproduction of aphids (Embden, 1973).Numerous studies have shown that variation in dietary concentrations of amino acids and sucrose affects aphid growth, survival, and reproduction (reviewed in Klingauf, 1987).

Thus, the earlier studies confirm that plant nutrients have an impact on the growth and reproduction of phloem feeders.

Paul et al. (2012) reported that 100g N, 250g P and 75g K per *Z. mauritiana* plant highest lac yield in *Z. mauritiana* with fertilizer application and manual treatment.

Lal et al (2003) reported that the growth, yield and quality parameters of *Z. mauritiana* improved significantly with added nitrogen, while application of phosphorus influenced all the parameters significantly except plant height, spread and fruit acidity. Potash application caused very little or no effect on growth and yield parameters, They applied four levels of N (0, 250, 500 and 750g per plant) in combination with three levels each of P_2O_5 (0, 250 and 500g per plant) and K_2O (0, 50 and 100g per plant) were applied to ten-year-old plants.

Thus, basal dose of different nutrients were applied in the present study to improve the growth of *Z. mauritiana* for increasing the lac production.

5.2 Broodlac inoculation

The *Z. mauritiana* trees were inoculated high quality *Kusmi* brood lac from 16th July to 17th July 2013. Depending on the size of host trees. The mean BLI per plant varied from 400g to 500g. There are no significant difference among the treatments.

Timely availability of pest free and quality broodlac is the most important for lac culture (Singh, 2010), especially in July for rainy season (Kumar and Das., 2012).

Approximately 4 kg *Kusmi* broodlac was required for inoculation an average *Kusum* tree, 1.5 kg for *Z. mauritiana* tree and 750g to 1.00 kg broodlac for *B. monosperma* tree Srivastava 2011), while Kumar and Das (2011) reported that 20g-30g broodlac is required per metre succulent branch. Depending upon the type and size of the lac host tree the broodlac quantity differs.

The quantity of broodlac used an *Z. mauritiana* and *B. monosperma* varied from 500g to 700g per plant (Bhagirath ,2013., Janghel, 2013).

The present research work agrees with those of the earlier lac workers in broodlac requirement and inoculation in present study on the *Z. mauritiana* were medium of size, thus the broodlac used varied from 400g to 500g. There was no significant difference in the broodlac inoculation indicates that irrespective of the treatments, the broodlac inoculation was uniform throughout the experiment.

5.3 Shifting

Shifting was done on 7th days after BLI i.e. on 23rd July 2013, to ensure uniform distribution of the brood on all the branches of *Z. mauritiana* where there was no or insufficient lac larval settlement

Shifting process is for efficient use broodlac was first time carried out by Khobragade (2012). Since then shifting has become popular and the operation followed by many workers (Kunal 2013,Janghel, 2013 and Bhagirath, 2013).

5.4 ***Phunki* removal**

Brood sticks with no larvae of *K. lacca* are called *phunki. Phunki* is removed after 21 days of BLI (from 6th August 2013) to obtain raw lac from it and remove the predators harbouring in it. The mean weight of *phunki* lac obtained 21 days after BLI was 242.08g, 261.08g, 271.25g and 232.50g respectively in case of T_1, T_2, T_3 and T_4. There was no significant difference in the mean weight of *phunki* between the treatments.

Phunki is scrapped to obtain raw lac from it. The mean weight (g) of the raw lac obtained after scraping of *phunki* was 142.91g, 151.25g, 164.58g and 140.83g respectively among T_1, T_2, T_3, and T_4. There was no significant difference among the raw lac obtained from *phunki* in different treatments.

Phunki removal after three weeks of BLI was suggested by Sharma and Jaiswal (2011). *Phunki* removal is a cultural and mechanical approach for removal of predators and parasites from the lac production production system. This was followed by earlier workers namely Khobragade (2012), Janghel (2013), and Bhagirath (2013). *Phunki* removal is a labour intensive operation, but the scraped lac provide them a cash income after 30 of BLI.

Non significant difference of the raw lac obtained from *phunki* among different treatments indicates that broodlac used was of high quality. Kunal (2013) also found no significant difference in weight of *phunki* on the same host. But significant difference reported by Bhagirath (2013) was due to impact of insecticide treatment and raw lac obtained from *Kusmi* lac and *Rangeeni* lac.

5.5 Impact of rainfall

The Broodlac inoculation was carried out on the 16th July and 17th July 2013. The crawlers (larvae of *K. lacca)* crawls from the Broodlac bundles to succulent branches for next 20 days. Heavy rainfall occured immediately after the BLI.The precipitation was 46, 48, 16, 17, 16, 10 and 25 mm from 18th July to 24th July 2013 respectively. There were 27 rainy days between 15th July to 15th August 2013, and the total rainfall during the period was 506mm. Continuous rain washed away the crawlers in motion. It was observed that plants which had less leaves and few branches were more affected.

Lac crop is vulnerable to both abiotic and biotic stress (Sharma et al., 1997; Bhagat and Mishra, 2002; Jaiswal et al., 2008)

The survival of lac insect dependent upon many factors such as abiotic (Rainfall, temperature, wind and air currents) and biotic (food, predators and parasite).As the suppression of aphid population during high rainfall period was reported by Patel et al .,(1997). Decline the population of sucking insects in July and further increase from January up to March was respectively Senapati and Mohanty (1980).

Bhagirath (2013) reported that after his study on the *Aghani* crop of *Kusmi* lac on the host of *Z. mauritiana* tree reported that the mean larval settlement of lac larvae per 2.5 sq. cm varied from 62.00 to 111.20 in different treatments, while in *Baisakhi* crop of *Rangeeni* lac varied from 61.40 to 102.60 in the different treatments but there are no significant difference among the treatments.

Comparatively better larval settlement reported by Bhagirath (2013) may be due to the *Aghani (Kusmi)* and *Baisakhi* crop when no rainfall occured during BLI.

Kunal (2013) reported that the mean larval settlement per 2.5 sq cm in *Baisakhi* crop of *Rangeeni* lac on *Z. mauritiana* tree varied from 86.47 to 104.13, but according to Janghel (2013) in *Katki* crop on *B. monosperma* tree it varied from 73.53 to 97.13 in different treatments. Tahir (2014 in his personal communication) informed that the mean larval settlement per 2.5 sq. cm in *Jethwi* crop of *Kusmi* lac on *Z. mauritiana* tree under nutrient managed condition varied from 92.14 to 105.20 this was due to no rainfall during January 2014.

5.6 Population density of *Kusmi* lac

The mean larval settlement count of *Kusmi* lac insect was observed per 2.5 sq. cm of the succulent branches after BLI till the harvest i.e. at 30, 45, 60, 70, 90, 110, 172 days of BLI (at harvest).

30 days after BLI

The mean lac insect settlement per 2.5 sq. cm varied from 79.32 to 90.02 in the four treatments T_1, T_2, T_3 and T_4.The mean lac insect count per 2.5sq. cm was highest in T_1 (90.02) followed by T_2 (87.63), T_3 (86.07) and T_4 (79.93).There was a significant difference in the mean lac insect settlement among the four treatments. There was more lac insect settled over the control in T_1 (13.48%) followed by T_2 (10.47%) and T_3 (8.50%).

In the nitrogen treated *Z. mauritiana* there were 13.48 percent more lac larval settlement over control it is an indication that the nitrogen influence lac larval settlement.

Fertilizer application, especially nitrogen fertilizer, results in serious insect herbivores occurrence resistance (Bi et al., 2001; Ge et al., 2003). Plant nutritional quality and plant defenses that directly act on herbivores are altered by N fertilization, and herbivorous insects can distinguish between plants receiving different N applications (Prudic et al., 2005 and Chen et al., 2008). Low nitrogen contents in the plants enhance the resistance of plants against pests, but high nitrogen contents cause vigorous growth along with consequent decrease in resistance against pests (Bhinde, 1993; Huber and Thompson, 2007).

Increased nitrogen fertilizer application is positively correlated with the population of both adults and nymphs of *B. argentifolia* (Bi et al., 2001). So, there is opportunity of changing the preference of insects by optimal plant nutritional requirement via altering the fertilizer level of a soil (Hendrix et al., 1990; Phelan et al., 1996).

Thus, higher larval settlement of lac insects on *Z. mauritiana* with nitrogen treatments is in agreement with earlier findings.

The second highest larval settlement of lac insect was on *Z. mauritiana* treated with phosphorous. Skinner and Cohen., (1994) reported that higher phosphorous levels are associated with higher insect levels. In an another study Jansson and Ekbom (2002) found that as P fertilizer levels increased, aphid (*Macrosiphum euphorbiae*) development time shortened, and the adult lifespan and number of offspring increased.

In the present study the larval settlement of lac insect was comparatively less in the *Z. mauritiana* treated plants with NPK.

Potassium (K) has been considered a key component of plant nutrition that significantly influences crop growth and some pests infestation. Potassium fertilizer is negatively associated with occurrence of *Aphis glycines* (Myers and Gratton, 2006), leafhoppers and mites (Parihar and Upadhyay, 2001). Increased K levels in foliage can reduce insect pressure (Facknath and Lalljee, 2005; Walter and DiFonzo, 2007). These findings are in agreement with a compilation of studies by the International Potash Institute (cited in Amtmann et al., 2008).

Amtmann et al. (2008) provide a potential mechanism to explain the relationship between K deficiency and increased insect attack. K deficiency results in reduced synthesis of proteins, starch, and cellulose, and increased accumulation of lower molecular weight compounds such as amino acids, nitrate, soluble sugars, and organic acids. These lower weight molecular compounds are more easily utilized as nutrient sources by sucking insects. Thus in other words, K deficiency on it's own may not correlate with higher insect attack, but the subsequent impact of K deficiency on plants, makes plants more readily attacked by sucking insects. This is better explained by Walter and DiFonzo, (2007) who reported that low K fertility was associated with high foliar levels of the amino acid serine and higher aphid infestations. However in the present study the significant difference in the settlement is due to the impact of nutrient management.

Thus, the present findings are in agreement with those of the earlier workers.

45 days after BLI

The lac insects after secretion of resin over its body grow into individual lac cell. The mean lac cell count per 2.5 sq. cm at 45 days after BLI varied from 51.35 to 64.08 in different treatments. The mean lac cell count was highest in T_1 (64.08) followed by T_2 (59.51), T_3 (54.02) and T_4 (51.35). There was a significant difference among the four treatments. The number of live lac cell was highest over the control in T_1 (24.79%) followed by T_2 (15.89%) and T_3 (5.19%).

Bhagirath (2013) reported that the *Aghani* crop of *Kusmi* lac insects after secretion,of resin over its body grow into individual lac cell. The mean lac cell count per 2.5 sq. cm at 45 days after BLI varied from 60.00 to 95.80 in different treatments. There was no significant difference among the treatments.

Janghel (2013) reported that the *Katki* crop of *Rangeeni* lac on *B. monosperna* tree, the mean lac cell count per 2.5 sq. cm at 45 days after BLI varied from 33.00 to 67.33 in different treatments. But there was no significant difference among the treatments. Kunal (2013) reported that the *Baisakhi* crop of *Rangeeni* lac on *Z. mauritiana* tree. The mean lac cell count per 2.5 sq cm at 45 day after BLI varied from 73.80 to 96. But there was a significant difference among the mean lac cell count among the treatments due to the pesticide application.

In earlier studies, there was no significant difference in the mean cell count at 45 days of BLI. The significant difference in the mean cell number in different treatments indicates the impact of nutrient management of *Z. mauritiana.*

The number of lac insect were less in comparison to that reported by Bhagirath (2013) because the reason that first application of pesticides not done after 30 days of BLI, due to continues rains. The infestation of *E. amabilis* cause the severe damage to lac insect.

60 days after BLI

The mean live lac cell count per 2.5 sq. cm at 60 days after BLI varied from 40.01 to 47.6 in different treatments. The mean live lac cell was highest in T_1 (47.6) followed by T_2 (43.81), T_3 (42.28) and T_4 (40.01). There was a significant difference among in the mean live lac cell count the four treatments. The live lac cell over the control was highest in T_1 (18.97%) followed by T_2 (14.49%) and T_3 (5.67%).

Bhagirath (2013) reported that the mean *Kusmi* lac cell count per 2.5 sq. cm at 60 days after BLI varied from 53.20 to 86.60 in different treatments. There was significant difference among in the mean lac cell count the treatments.

The mean *Rangeeni* female lac cell count per 2.5 sq. cm at 60 days after BLI varied from 23.20 to 29.40 in different treatments and there was a no significant difference among the treatments. Janghel (2013) reported that the mean population density at 60 day after BLI from 28.13 to 40.53. There was no significant difference among the treatments. The density of *Kusmi* live lac insect was less compare to the work of Bhagirath (2013).because the infestation of *E. amabilis* have reduce the over all density of live lac cell.

The variation in the mean lac cell count may be due to different treatment treatments, strain and season of the earlier studies. In present work nutrient availability in host *Z. mauritiana* significantly effect more larval settlement of lac insect compare to control.

90 days after

The male emerged between 65-75 days after BLI. Winged male lac insect were seen, which were short lived. After the male emergence the remaining live lac cell were that of female lac insects. The mean female lac cell count per 2.5 sq. cm at 90 days after BLI varied from 22.88 to 27.88 in different treatments. The female lac cell count was highest in T_1 (27.88) followed by T_2 (24.76), T_3 (24.53) and T_4 (22.88). There was a significant difference in the live female lac cell among all the treatments. As it is the female that produces lac, therefore its numbers determine the lac productivity. Highest live female lac cell over the control was in T_1 (21.85%) followed by T_2 (8.21%) and T_3 (7.21%).

Bhagirath (2013) reported that after the male emergence the remaining lac cell was of female lac insects. The mean female *Kusmi* lac cell count per 2.5 sq. cm at 90 days after BLI to declined and it varied from 34.00 to 42.60 in different treatment. there was a significant difference among the treatments.

The mean *Rangeeni* female lac cell count per 2.5 sq. cm at 90 days after BLI continued to decline and it varied from 23.60 to 27.20 in different treatments. There was a significant difference in the mean female lac cell count in different treatments.

Janghel (2013) reported that the mean population density at 90 day after BLI continued to decline and it varied from 19.87 to 30.00. There was a significant difference in the population density of lac insect. After male emergence, 45 to 55 percent in *Kusmi* strain and 35 to 55 percent in *Rangeeni* strain population of lac insect was reduced than compare to insect count after 60 days of BLI in both the study.

There are significant difference among all the treatments after 90 days of BLI. The difference in present study was due to nutrient management of *Z. mauritiana*, while that reported by Bhagirath (2013) was due to application of pesticide.

130 days after BLI

The mean live lac cell count per 2.5 sq. cm at 130 days after BLI varied from 16.50 to 20.33 in different treatments. It was highest in T_1 (20.33) followed by T_2 (20.23), T_3 (20.08) and T_4 (16.50).There was a significant difference in the mean number of live lac cell count among the treatments. It was highest over control in T_1 (23.21%) followed by T_2 (22.60%) and T_3 (21.69%).

Bhagirath (2013) reported that the female lac cell count per 2.5 sq. cm at 130 days after BLI it varied from 31.20 to 37.60 in different treatments. There was a significant difference among the treatments due to the application of pesticide.

In present work nutrient availability in the host *Z. mauritiana* significantly influenced more live cell of lac insect compare to the control.

172 days after BLI (At harvest)

The *Aghani* crop of *Kusmi* lac matured and harvested at 172 days after BLI. The mean lac cell count at harvest/maturity varied from 15.57 to 18.43 per 2.5 sq. cm. The live lac cell count was highest in T_1 (18.43) followed by T_2 (18.03), T_3 (17.41) and T_4 (15.57). There was a significant difference in the mean live lac cell count among different treatments. It was highest in T_1 (18.36%) followed by T_2 (15.79%) and T_3 (11.81%) lac cell over the control.

Bhagirath (2013) reported that *Aghani* crop of *Kusmi* lac crop matured and harvested 151 days after BLI, while *Katki* crop in 110 days. In *Kusmi* the mean lac cell count per 2.5 sq. cm at harvest or maturity varied from 28.40 to 33.80, while in *Rangeeni* it varied from 19.00 to 24.60 in different treatments. There was a significant difference in the mean female lac cell count in different treatments due to the pesticide application.

Kunal (2013) reported that the *Baisakhi* crop matured and harvested after 180 days of BLI. The mean lac cell count per 2.5 sq cm varied from 16.36 to 25.01. There was a significant difference among the mean lac cell count among the treatments due to the application of pesticide..

Janghel (2013) reported that the *Katki* lac crop harvested 110 days after BLI. The mean population density at harvest i.e. at in maturity varied from 19.87 to 29.87. There was a significant difference the population density at harvest among the treatments due to the application of pesticide.

In present research work significant difference among the treatments due to the nutrient application.

5.7 Survival of lac insects

The population density of lac insect per 2.5 sq cm at 30 day after BLI was 90.02, 87.63, 86.07, and 79.32 which reduced to 18.43, 18.03, 17.41 and 15.57 in case of T1, T2, T3 and T4 respectively.

In present study, only 19 to 22 percent lac insect survived from BLI to harvesting, and there was a significant difference among the treatments due to nutrient application

Bhagirath (2013) reported that survival of lac insect from BLI to harvesting was 22 to 27 percent in *Aghani* crop *Kusmi* lac while it varied from 27 to 32 percent in *Katki* crop on *B. monosperma* (Janghel 2013), *Baisakhi* crop on *Z. mauritiana* was 21 to 25 percent (Kunal 2013).

In all the above studies, the survival percent of lac insect varied from 19 to 32 percent irrespective of the season, strain and treatments.In present study it was 19 to 22 percent.

5.8 Sticklac

The mean number of sticklac per plant varied from 12 to 23. The mean number of sticklac was highest in 18 (T_3) followed by 18 (T_2), 17.083 (T_1) and 13.16 (T_4). There was a significant difference in the number of sticklac among different treatments..

In present research work the number of sticklac in the *Z. mauritiana* with nutrient management was more comparison to control. Availability of nutrient may caused more number of sticklac. The quality of food dependent upon the nutrient available on host plant. Thus, settlement of *K. lacca* depends on many reasons other than availability of succulent shoots. Higher density of the lac insect means higher competition for food.

5.9 Weight of sticklac

The mean weight of sticklac per 30 cm varied from 16.88 to 92.03. The mean weight (g) of sticklac per 30 cm was highest 47.33 (T_3) followed by 41.59 (T_1), 35.73 (T_2) and 32.50 (T_4). There was no significant difference in the mean weight of sticklac among different treatments.

Bhagirath (2013) reported a significant difference among in mean weight of sticklac (g) per 30 cm due to the pesticide treatments and *Kusmi* and *Rangeeni* strain.

5.10 Fresh weight of 100 lac cell

The mean fresh weight (g) of 100 cell of lac insect differed significantly among the treatments. The mean weight of 100 mature lac cells varied from 5.24 to 8.91. The mean fresh weight of 100 cell of lac insect was highest (8.02) in case of T_3 followed by T_1 (7.20 g), T_2 (6.89 g) and T_4 (6.14).

According to Mishra et al. (1999) in *F. semialata* the live cell weight and *Phunki* (dry) cell weight on varied from 13.16 to 38.33 mg and 8.00 to 19.00 mg respectively, whereas on *F. macrophylla* it were from 16.83 to 31.67 mg and 9.33 to 18.83 mg. Thus the yield varies from host to host.

Bhagirath (2013) reported that the mean fresh weight (g) of 100 mature lac cells was 4.88g in *Kusmi* lac and 3.38g in case of *Rangeeni* lac, while in the present study it varied from 6.14 to 8.02g in various treatment.

There was a significantly increase the fresh weight of 100 lac cell of *Kusmi* lac, It was highest over control in T_3 (30.61%) followed by T_1 (17.26%) and T_2 (12.21%) due to the nutrient management on *Z. mauritiana.*

5.11 Dry weight of 100 lac cell

The mean dry weight (g) of 100 cell of lac insect differed significantly among the different treatments. The weight of 100 cells varied from 4.25 to 7.90. The mean dry weight of 100 lac cells was highest in T_3 (7.08) followed by T_1 (6.30), T_2 (6.01) and T_4 (5.18).

Bhagirath (2013) reported that the mean dry weight of 100 cell was 4.66g in case of *Kusmi* lac and 2.63g in case of *Rangeeni* lac.

In the present study the weight of 100 cells was more in comparison to control, the increase in the mean dry weight of 100 cell was highest 36.63 percent in T_3 (NPK) followed by 21.62 T_1 (N) and 16.02 percent in T_2 (NP).

This indicate that there was an increase in dry cell weight due to nutrient management. The mean dry cell weight of *Kusmi* lac cell reported by Bhagirath (2013) was varied 3.40g to 4.66g, which is no nutrient management.

5.12 Yield of raw lac

The mean yield (kg) per plant obtained after harvesting of lac crop was 5.08, 4.54, 5.33 and 3.83 respectively among the treatment T_1, T_2, T_3, and T_4. There was a significant difference in the yield of raw lac among all the treatments. There was an increase in the mean yield of lac per *Z. mauritiana* over control. It was highest over control in T_3 (39.16%) followed by T_1 (32.63%) and T_2 (18.53%).

According to Ghosal, (2013) Potassium application could bring an appreciable amount of reduction in the dry matter per cent of inoculable shoots. The lesser the dry matter per cent, the more the shoot will be succulent. Therefore, it can be stated that, inoculable shoot become more succulent due to potassium application, which is supposed to contribute to higher lac production. Similar result has been reported by (Abayomi, 1987) in sugarcane. According to (Zengin et al., 2009) increased succulence could be due to increased water uptake on potassium applied of plant.

In present study the yield of raw lac on *Z. mauritiana* with fertilizer treatment significantly increased oer the control. It may be attributed to the nutrient management of host plant.

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

The present research work entitled **Study on the performance of *Aghani* crop of *kusmi* lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition** at Dhapara village, Barghat Block, Seoni District, Madhya Pradesh was carried from May 2013 to February 2014 in lac growers field with four treatments.

The Nitrogen, Phosphorus and Potash was applied through basal application of Urea, SSP and MoP respectively. The nutrient in different treatments were in T_1-N (Urea 220g), T_2 - N (Urea 220g) and P (SSP 1560g),T_3 - N (Urea 220g), P (SSP 1560g) and K (MoP 125g) and T_4 - Control i.e. no use of fertilizers (Lac growers practice).

6.1.1 Nutrient management

Nutrient management in plants are very important for its growth and production and plant nutrients have an impact on the growth and reproduction of phloem feeders. Nitrogen is the most important element for plant growth, yield and quality of products. Phosphorus is the second most important macronutrient next to the nitrogen is required for plant growth. Potassium is essential for growth and various physiological processes.

Insect-plant relationship is affected by the application of micro or macro nutrients to crop plants. Nutrient deficient plants remain weak and vulnerable to incidence of plant disease and insect pest attack.

Phloem sap is an extreme food source used as the dominant or sole diet of insects in the order Hemiptera. Essential amino acids in the plant sap are essential for growth and reproduction of sucking insect. The plants provide nutrients to herbivorous insects. Any increase in the nutrient content of the plant is likely to increase its acceptability to pest populations.

Increased nitrogen fertilizer application is positive associated with increase in the population of the sucking insect. Nitrogen is one of the most important factors in development of herbivore populations. The application of nitrogen fertilizer in plants can normally increase herbivore feeding preference, food consumption, survival, growth, reproduction, and population density.

The higher phosphorous levels are associated with higher insect levels. Potassium has been considered a key component of plant nutrition that significantly influences crop growth and some pest infestation. Potassium fertilizer is negatively associated with sap feeders.

6.1.2 Population density of *K. lacca*

The mean brood lac inoculation per *Z. mauritiana* plant ranged from 400g to 500g. As the twigs of lac host trees are cylindrical and narrow, it is practically difficult to mark one square inch area followed by counting of larvae of *K. lacca* which are usually 0.5 mm in size. In the present study 2.5 sq cm was the area to study the lac insect count. It provides comfortable space for accurate Lac insect counting. The mean lac larval settlement per 2.5 sq cm from 30 days after BLI to the harvest of the lac crop showed a significant difference among the four treatments. The mean number of lac larvae per 2.5 sq cm was in T_1 (90.02), T_2 (87.63), T_3 (86.07) and T_4 (79.93) at 30 after BLI. There was more in comparison to lac growers practice (control T_4). There was 13.48 percent more number of larval settlement of lac insect on *Z. mauritiana* treated with Nitrogen (T_1). This was followed by 10.47 percent in ($T_{2)}$ and 8.50 percent in (T_3).There was significant difference due to the nutrient application. Nitrogen is one of the most important factors in development of herbivore populations. The second highest larval settlement of lac insect was on *Z. mauritiana* treated with phosphorous because higher phosphorous levels are associated with higher insect levels. The number of lac insect was less in plants which treated with NPK because potassium fertilizer is negatively associated with occurrence of sap feeders but number of lac insect was more compare to control (no use of fertilizer). Significant difference in the mean lac cell count at harvest that indicates the impact of nutrient management of Z*. mauritiana*. After 172 The mean lac cell count at harvest or maturity the live lac cell count was highest in T_1 (18.43) followed by T_2 (18.03), T_3 (17.41) and T_4 (15.57). There was a significant increase number of live lac cell over the control. It highest in T_1 (18.36%) followed by T_2 (15.79%) and T_3 (11.81%).

6.1.3 Survival of lac insects

The mean population density of lac insect per 2.5 sq cm at 30 day after BLI was 90.02, 87.63, 86.07, and 79.32 which reduced to 18.43, 18.03, 17.41 and 15.57 in case of T_1, T_2, T_3 and T_4 respectively.

In present study, only 19 to 22 percent lac insect survived at the time of harvest.There was a significant difference in the survival percent age of lac insect at haevest due to nutrient application. It was highest in T_1 and lowest in $T_{4.}$

6.1.4 Impact of rainfall

The survival of lac insect dependent upon many factors such as abiotic (Rainfall, temperature, wind and air currents) and biotic (food, predators and parasite). As pesticide application was carried out uniformly, the loss of lac insect due to the incidence of predators and parasites werw minimized.

After the broodlac inoculation the crawlers (larvae of *K. lacca)* crawls from the broodlac bundles to succulent branches for next 20 days. Heavy rainfall occured immediately after the BLI. The precipitation was 46, 48, 16, 17, 16, 10 and 25 mm from BLI to next seven days. There were 27 rainy days immediately after the BLI. The total rainfall during the period was 506mm. Continuous rain washed away the crawlers in motion. It was observed that plants which had less leaves and few branches were more affected.

6.1.5 Sticklac

The mean number of sticklac was highest (18) in both T_2 and T_3 followed by T_1 (17.08) and T_4 (13.16). There was a significant difference in the number of sticklacs among different treatments. The number of sticklac in the *Z. mauritiana* with nutrient management was more comparison to control. Availability of nutrients may resulted in more branches for settlement of lac larvae after BLI, which may resulted in more number of sticklac. The quality of food dependent upon the nutrient available on host plant. Thus, settlement of *K. lacca* depends on many reasons other than availability of succulent shoots. Higher density of the lac insect means higher competition for food.

6.1.6 Fresh weight of 100 lac cell

The mean fresh weight (g) of 100 cell of lac insect differed significantly among the treatments. The mean fresh weight of 100 cell of lac insect was highest (8.02) in case of T_3 followed by T_1 (7.20 g), T_2 (6.89 g) and T_4 (6.14). There was a significantly increase the fresh weight of 100 lac cell of *Kusmi* lac, It was highest over control in T_3 (30.61%) followed by T_1 (17.26%) and T_2 (12.21%) due to the nutrient management on *Z. mauritiana.*

6.1.7 Dry weight of 100 lac cell

The mean dry weight (g) of 100 cell of lac insect differed significantly among the different treatments. The weight of 100 cells varied from 4.25 to 7.90. The mean dry weight of 100 lac cells was highest in T_3 (7.08) followed by T_1 (6.30), T_2 (6.01) and T_4 (5.18).In the present study the weight of 100 cells was more in comparison to control, the increase in the mean dry weight of 100 cell was highest 36.63 percent in T_3 (NPK) followed by 21.62 T_1 (N) and 16.02 percent in T_2 (NP).This indicate that there was an increase in dry cell weight due to nutrient management.

6.1.8 Yield of raw lac

The mean yield (kg) per plant obtained after harvesting of lac crop was 5.08, 4.54, 5.33 and 3.83 respectively among the treatment T_1, T_2, T_3, and T_4. There was a significant difference in the yield of raw lac among all the treatments. There was an increase in the mean yield of lac per *Z. mauritiana* over control. It was highest over control in T_3 (39.16%) followed by T_1 (32.63%) and T_2 (18.53%).

It is interesting to note through the larval settlement 30 days after BLI and survival percent to lac insect (cells) were highest in *Z.mauritiana* treated with N but the dry cell weight as well as the raw lac yield was more in *Z. mauritiana* treated with NPK. It concludes that though the number of cells were less in *Z.mauritiana* with NPK, but weight of 100 lac cells higher, may be due to the higher resin secretion by lac insect due to NPK treatment of its host

The yield of raw lac on *Z. mauritiana* with fertilizer treatment significantly increased over the control. It may be attributed to the nutrient management of host plant.

6.2 Conclusions

I. Nutrient management significantly increase the 18.53 to 39.16 percent of raw lac yield over the control.
II. Nutrient management of host plant improve the plant health.
III. Abiotic factor rainfall affect the lac insect settlement in *Aghani* crop of *Kusmi* lac

6.3 Suggestions for future work

I. Application of amino acid on host *Z. mauritiana* and *Butea monosperma* for lac. production may be studied.
II. Nutrient management of host and its impact on the incidence of predator and parasite of lac insect may be studied.

Table- 9 Transmission loss of lac insect

Rep	Transmission loss of number of lac insects from BLI to harvest (Lac insect per 2.5 sq. cm succulent branch)																															
	30 days after BLI				45 days after BLI				60 days after BLI				90 days after BLI				110 days after BLI				130 days after BLI				150 days after BLI				172 days after BLI (at harvest)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
R_1	88.57	82.93	92.93	75.37	61.4	54.97	64.53	55.13	44.3	42.2	49.77	41.57	27.4	23.1	28.63	24.07	25	20.37	25.07	19.33	22.4	18.83	22.93	17.77	21.2	17.37	20.93	16.87	20.03	16.93	19.53	16.2
R_2	91.83	89.37	81.97	78.87	67.5	60.43	48.03	50.43	46.5	45.13	38.56	40.5	27.26	24.93	22.13	22.8	24.03	23.03	19.7	18.66	20.2	20.43	17.67	17.56	18.86	19.06	21.56	17.23	17.96	18.26	15.8	16.6
R_3	91.77	90.97	83.03	78.93	67.73	62.56	54.06	49.66	48.8	47.3	41.13	39.56	28.56	23.26	22.8	22.1	25.73	24.43	20.26	18.33	18.8	21.8	18.56	16.23	17.53	20.33	16.96	16.1	17.53	19.1	16.8	15.5
R_4	89.73	83.93	84.23	78.83	62.13	57.56	45.55	49	47.66	46.06	36.93	37	26.7	26.03	19.73	21.66	21.6	18.8	23.83	15.63	20.53	20.26	19.16	15.8	19.7	19.1	17.86	15.63	19.2	18.13	17.23	15.03
R_5	84.43	94.7	92.43	83.9	58.83	67.13	58.8	51.5	47.23	51.06	45.5	40.03	28.2	25.76	28.06	24.06	17.1	23.26	31.2	18.23	20.4	21.26	21.43	15.77	19.9	19.36	17.56	15.36	18.73	18.46	17.2	14.8
R_6	93.77	83.9	81.83	80.03	66.9	54.43	53.03	52.36	51.56	43.13	41.8	41.43	29.16	25.46	25.86	22.63	24.73	20.9	22.2	16.6	19.66	18.8	20.76	15.87	17.13	18.03	18.63	15.8	17.13	17.33	17.9	15.3
Mean	90.02	87.63	86.07	79.32	64.08	59.51	54.02	51.35	47.6	45.81	42.28	40.01	27.88	24.76	24.53	22.88	23.03	21.8	23.71	17.8	20.33	20.23	20.08	16.5	19.05	18.87	18.92	16.16	18.43	18.03	17.41	15.57
SE(m)	1.779				2.01				1.34				0.76				1.3				0.56				0.55				0.41			
C.D. at 5%	5.36				6.13				4.08				2.32				3.97				1.73				1.67				1.26			
	Survival of lac insect (%)				71.19	67.92	62.76	64.73	52.96	52.28	49.12	50.44	30.97	28.25	28.5	28.85	25.58	24.87	27.54	22.44	22.58	23.08	23.33	20.8	21.16	21.54	21.98	20.38	20.47	20.58	20.22	19.63
	Transmission loss (%)				28.81	32.08	37.24	35.27	47.04	47.72	50.88	49.56	69.03	71.75	71.5	71.15	71.42	75.13	72.46	77.56	77.42	76.92	76.67	79.2	78.84	78.46	78.02	79.62	79.53	79.42	79.78	80.37

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APPENDICES

Analysis of mean brood inoculation (g)/ *Z mauritiana* plant

Source	d.f	SS	MSS	*F cal*	*Ftab 5%*
Replication	5	7,500			
treatment	3	1,666.66	555.56	0.526	3.28
Error	15	15,833.33	1,055.55		
Total	23	25,000			

SEm = 13.36 CD 5% = NS

Analysis of mean weight of *phunki* (g)/ *Z mauritiana* plant

Source	df	SS	MSS	*F cal*	*Ftab* 5%
Replication	5	1,101.927			
treatment	3	5,588.198	1,862.73	2.031	3.28
Error	15	13,755.365	917.03		
Total	23	20,445.490			

SEm = 12.36 CD 5% = NS

Analysis of mean weight o of scrap lac from *phunki* (g)/ *Z mauritiana* plant

Source	df	SS	MSS	*F cal*	*Ftab* 5%
Replication	5	585.67			
treatment	3	2,090.36	696.78	1.562	3.28
Error	15	6,692.44	446.16		
Total	23	9,368.49			

SEm = 8.62 CD 5% = NS

Analysis of mean number of Sticklac /*Z mauritiana* plant

Source	Df	SS	MSS	*F cal*	*Ftab* 5%
Replication	5	41.47			
treatment	3	95.62	31.87	5.825	3.28
Error	15	82.07	5.47		
Total	23	219.16			

SEm = 0.95 CD 5% = 2.88

Analysis of mean weight of sticklac (g) per30 cm at harvest

Source	df	SS	MSS	*F cal*	*Ftab* 5%
Replication	5	779.96			
treatment	3	774.35	258.11	0.980	3.28
Error	15	3,950.97	263.39		
Total	23	5,505.29			

SEm = 6.62 CD 5% = NS

Analysis of mean fresh weight (g) of 100 lac cells

Source	df	SS	MSS	*F cal*	*Ftab* 5%
Replication	5	3.78			
treatment	3	10.93	3.64	4.285	3.28
Error	15	12.76	0.85		
Total	23	27.48			

SEm = 0.37 CD 5 = 1.13

Analysis of mean dry weight of 100 lac cells after shady drying

Source	df	SS	MSS	*F cal*	*Ftab* 5%
Replication	5	3.51			
treatment	3	11.11	3.70	4.604	3.28
Error	15	12.07	0.80		
Total	23	26.70			

SEm = 0.36 CD 5 = 1.11

Analysis of mean weight of raw lac production (kg) per pant

Source	df	SS	MSS	*F cal*	*Ftab* 5%
Replication	5	2.41			
treatment	3	7.94	2.64	4.885	3.28
Error	15	8.13	0.54		
Total	23	18.49			

SEm = 0.300 CD 5% = 0.906

CURRICULUM VITAE

The author of this thesis **Brajesh Kumar Namdev** S/o Late Shri Makhan Lal Namdev was born on 16th July 1989, at village and Post – Raneh, Teh.- Hatta, Distt.- Damoh (MP).

After graduation, for further study, he got admission in M.Sc. (Ag.) for specialization in Entomology at the College of Agriculture, JNKVV, Jabalpur (M.P), where successfully completed the entire course requirement for Master's degree with an OGPA 7.14 out of 10 point scale in the year 2014.

For the partial fulfillment of the Master's degree carried out thesis work on "Study on the performance of *Aghani* crop of *kusmi* lac on nutrient managed *Zizyphus mauritiana* under heavy rainfall condition" It was successfully conducted by him and being submitted in the form of this thesis.

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