SELINUS UNIVERSITY
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EFFECT OF ORGANIC FARMING ON CABBAGE CROP ECOLOGY WITH REFERENCE TO PRODUCTIVITY, BIODIVERSITY AND SOIL PROPERTIES IN ILAM, NEPAL

by YOGENDRA MAN SHRESHTA

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CHAPTER ONE

INTRODUCTION

The chapter covers the basic background information of the study. The chapter has different sub-sections. The main sub-sections are: general background, statement of research problem, significance, research objective, hypothesis,

1.1 General Background

Nepal is a land-locked, Himalayan country bordered with China to the north and India to east, south and west. It is a developing country with an agriculture based economy (GC *et al.,* 2018; Adhikari, 2015). Farming is the main economic activity, where two third of the total population are engaged in agriculture (GC *et al*. 2018; MoAD, 2015). Agriculture sector accounts 29.52% of gross domestic product (GDP) in Nepal (IIDS, 2018). A high proportion of households in Nepal depend on agriculture for the generation of livelihood (MoAD, 2012). Previously agriculture in Nepal was based predominantly on local input. But since 1960s, the introduction of so called modern agriculture has increased the external inputs, especially the uses of agro-chemicals. The several studies showed that the modern agriculture has increased crop yields but also posed severe environmental problems (Pimental *et al*. 1995). In Nepal too, the ever increasing use of agro-chemicals has been leading environment toward degradation, and the aftermaths are the low agricultural productivity, soil degradation, loss of agro-biodiversity, pest outbreak, human health hazard etc. This situation implies that the sustainability of agriculture in Nepal is seriously threatened. In recent years farmers have been realizing the bad impact of agro-chemicals, and have been trying hard to introduce alternative system that is sustainable, and suitable in local condition (NCDC, 2005). In such context, sustainable agriculture system like organic farming is one of the best alternatives that can be adopted by farmers. Sustainable agriculture would ideally produce good crop yields with minimal impact on ecological factors such as soil fertility, biodiversity, and total environment (Tilman, 1999; Mader *et al.* 2002).

Organic farming is a sustainable approach to agriculture in which the aim is to create integrated, environmentally and economically sustainable agricultural production systems (Mc Cann et al., 1997; Conacher and Conacher, 1998; Lampkin and Measures, 1999). It relies on self-regulating ecological and biological processes and interactions to sustain productivity and reduce environmental degradation.

Over the last few decades, consumer pressures and Governments policy initiatives have stimulated a rapid growth in organic farming. Organic farming is now being challenged by the need for further expansion and development to meet the increase in demand for organic food and growing concerns for the environment. To satisfy the consumer, therefore, the relationships between production and environmental concern must be balanced. The aims of organic farming are not just to minimize environmental impact and optimize production, but to combine these two concerns (Birgitte et al., 2001). It is well-suited for small scale farmers (University of Copenhagen, 2006). Under conditions of low natural productivity and low external inputs, well managed organic farming can even increase yields compared to conventional agriculture (Ramesh et al., 2005, Badgley et al., 2007). Farmers involved in intensive agricultural production activities may also benefit from including organic methods such as green manure cultivation using legumes because these can reduce their input costs (IFAD, 2005), while producing food which can be considered to be safer for farmers, consumers, and the environment.

The practice of using organic manure to sustain the agricultural production is age old (Sherchan and Gurung, 1996). Organic manure is traditional source of plant nutrients, which is the most readily available to the farmers (Gaur *et al.*, 1995). Soil organic matter (SOM) gives positive impact to over all soil properties such as water infiltration rates, water holding capacity, nutrient cycling, pesticides adsorption (Stevenson, 1994; Campbell *et. al*., 1996; Francioso *et al*., 2000; Wander and Yang, 2000), soil flora, and fauna (Frieben and Kopke, 1995; Fraser et al., 1988; Piffiner and Luka, 2007; Feber et al. 1998). Production potential of organic farming is also satisfactory. Studies of organic and/or alternative (low input/sustainable) systems report yields comparable to conventional systems in cabbage (Shrestha, 2008) maize (Pimentel et al., 2005), apples (Reganold et al., 2001), tomatoes (Clark et al., 1999) and soybeans (Pimentel et al., 2005, Smolik and Dobbs, 1991 and Stanhill, 1990) and in some cases higher than the modern farming (Jenkinson, 1994; Rodale Institute, 1999), and this might be the result of positive impact of organic farming to the soil properties and environment.

Despite the potential environmental benefits of organic farming, it has been criticized as low-yielding and less efficient than conventional agriculture in its use of land and resources (Tilman et al., 2002; Trewavas, 2004). Several yield trial comparisons between organic and conventional farming systems have shown significantly lower yields for organic systems (Ryan et al., 2004 and Stanhill, 1990). Thus, the major challenge of organic farming systems is to maintain high yields and excellent quality utilizing farming practices that have acceptable environmental impacts (Tilman et al., 2002). In this context, use of *Nasabike* manure and agri-medicine can be the effective solution in mitigating the challenges in organic farming.

Nasabike manure (locally prepared bio fertilizer) and *Nasabike* agri-medicine (locally prepared botanical pesticide) are the innovation of Namsaling Community Development Centre (NCDC), Ilam. Both the *Nasabike* manure and *Nasabike* agri-medicine are recently introduced after 10 years of farmer's field evaluation in Ilam. They have been found very useful innovation, for converting chemical farming into organic. Farmers have been using the same widely in Ilam, Nepal as well as in the hill districts of Sri Lnaka (PESA, 2005). The *Nasabike* manure, prepared from rice bran, oilcake, topsoil, compost and cattle urine, is found very effective for all types of crop and can be used for alternative to chemical fertilizers. Similarly, *Nasabike* agri-medicine, prepared from 14-15 locally available plants having pesticidal properties fermented with cattle urine, is found effective for managing insect pest and diseases, which repeal, and/or kill many insect pests and avoid diseases as well as improve plant health. (NCDC, 2003, 2005). The research conducted on cabbage in 2008 showed that *Nasabike* manure if applied in combination with *Nasabike* agri-medicine can produce result almost similar with chemical farming. Besides, organically produced cabbage has good quality as compared to that of chemically produced (Shrestha, 2008). However, the ecological impact of the *Nasabike* manure and agri-medicine is yet to be known. Therefore, this research proposal has been developed to study the influence of *Nasabike* manure and agri-medicine on cabbage, carrot, and tomato crop ecology with reference to productivity, biodiversity and soil properties in Ilam, Nepal.

1.2 Statement of the problems

Vegetable farming is one of the proven cash crops for the farmers of Ilam. Farmers have been producing varied vegetable crops both seasonal and off season and delivering to the local market as well as exporting to the nearby Indian market. For commercial production of vegetables farmers have been using chemical fertilizers, pesticides, and plant growth regulators in higher dose than that of the recommendation. The negative impact of chemical has been resulting in several agriculture and environment related problem and above all the unsustainability of agriculture. The fertilizer, pesticides are external inputs and the farmers have to buy every time they intend to use. Thus, the cost of chemicals, transportation and application has increased the production cost and sometimes they cannot cover even the production cost from the sale of produce.

The polluted environment, pesticide and fertilizer contaminated drinking water and pesticide residue in food has been resulting in poor human health along with several skin, respiratory, cardiac, fertility related diseases in the farmers as well as consumers.

After experiencing the negative impact of agro-chemicals, the importance of organic agriculture is being realized not only by farmers who have been using chemical fertilizer and pesticides for the last four decades but also by the policy makers, intellectuals and sensitive citizens (Bhat, 2009). Realizing the same, all stakeholders have been exerting efforts to promote organic farming since 1990s, however, organic farming is still in the early stages in Nepal. One of the main reasons behind the slow growth of organic agriculture is obviously lacking knowledge of farmers and extension workers regarding effective alternatives to agro-chemicals.

There are several agricultural by-products, after some manipulation those can be used to improve soil fertility and productivity in organic farming. At the same time there are several plants having pesticidal properties and by using the same the diseases and insect pests of agricultural crops can be managed effectively through organic approach. *Nasabike* manure and *Nasabike* Agri-medicine are those organic product that can be prepared locally by farmers on their own.

Nasabike manure and *Nasabike* Agri-medicine, introduced by NCDC in Ilam are widely used alternatives to agro-chemicals. The farmers have been using the same for organic vegetable production and they are satisfied by the result but there has been limited information regarding the response of the same to yield and quality of produce. Similarly, they are supposed to beneficial to environment but no research has been conducted to find the effect of the same on crop ecology.

1.3 Significance of the Research

Until 1960s, the agriculture in Nepal was truly organic but by passing of time, the practices changed more towards inorganic which is a direct threat to agriculture productivity, environmental quality and human health (Paudyal, 2010).

Organic Agriculture basically focuses on environmental issues, human health, and food security and above all the sustainability of agriculture. It has several positive contributions toward environmental protection, conservation of resources, improved food quality, improve health status etc. Organic farming helps increase the quality of soil, water, air and biodiversity. Practices of organic farming like crop rotations, inter-cropping, ecological pest management, organic and bio fertilizers and minimum tillage encourage soil, fauna and flora, improving soil properties and creating sustainable soil systems. Besides, Organic agriculture contributes to address the greenhouse effect and global warming through its ability to sequester carbon in the soil which finally makes the clean air (IFOAM, 2015). In conclusion, organic farming always promotes environmentally sound, socially just and economically viable agriculture system thereby ensuring agriculture sustainability.

The so called modern agriculture, because of extensive use of agro-chemicals has several negative impacts on environment including soil, water and other natural resources as well as on the human health because of the heavy use of chemicals. Its impact has been leading agriculture toward unsustainability. This is absolutely undesirable situation as our future generation may have to suffer largely because of unsustainable agriculture and its aftermath. Therefore, today's need is to introduce the appropriate agriculture technology that is sustainable from economic, ecological and social perspectives. In this context the proposed study will be much helpful because it identifies the influence of the both *Nasabike* manure and Agri-medicine on overall crop productivity and ecology. Though, farmers are using the same and they are satisfied too but there is no research finding to prove that these are much effective for organic farming and in such situation this study will prove the same and generate authentic findings.

The findings of the study will be useful for the planner and policy makers to formulate the plan and policy for the promotion of organic agriculture. The agriculture technician, extension workers, and farmers will be aware about the effect of organic manures and organic practices on crop ecology and its role in sustainability of agriculture thereby replicating the technology in wider areas. The study, as an authentic research, will be useful for researchers for further study of organic farming.

1.4 Goal and objective

Goal

To ensure agriculture sustainability from economic, ecological and social perspective.

Objectives

The objectives of this research is to find the effect of organic farming on cabbage crop ecology in Ilam with specific objectives-

1. Find the influence of *Nasabike* manure and agri-medicine as organic inputs in yield and quality of cabbage in 3 agro ecological zones of Ilam.
2. Study the weed population, density, and diversity, under chemical and organic plots.
3. Study the important phyco-chemical properties of soil in chemical and organic plots.

1.5 Hypothesis

- **H0:** Crop ecology does not differ between organic and chemical farming. **(H_0:$\mu_1 = \mu_2$).**
- **H1:** Crop ecology differs between organic and chemical farming **(H_1:$\mu_1 \neq \mu_2$).**

CHAPTER TWO

LITERATURE REVIEW

This chapter includes the literatures regarding the various aspects of organic agriculture reviewed during the study. It gives the gist regarding definition of organic agriculture, its status in Nepal, its production potentiality, its effect to soil, bio-diversity, pests etc. as well as about the input used in study. The chapter covers the literatures from academic, practitioners and government to gather the knowledge on research problem as well as to justify the rational of this study.

2.1 Definition of Organic Agriculture

There are many explanations and definitions for organic agriculture but all converge to state that it is a system that relies on ecosystem management rather than external agricultural inputs. Organic agriculture is the holistic approach for producing safe food for human consumption, domestic animal consumption as well as for protecting natural resources and overall environment from negative impact of agro-chemical, thereby achieving agricultural sustainability in the long run.

"Organic agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity, and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved." (IFOAM, 2007).

Similarly Gafsi et al. defines organic agriculture as “Organic farming is defined as a form of agriculture, which do not use chemical inputs in its production process, and enhancing the biological and ecological processes to promote soil fertility and good health of animals and plants (Gafsi, Le, & Mouchet, 2010)”. It involves complete view and it depends on ecological processes, biodiversity as well as cycles adapted to local circumstances rather than the use of external inputs with adverse effects. It is aiming at promotion of fair relationship and a qualitative life for all related components.

Codex Alimentarius Commission, the international food standard body established by the Food and Agriculture Organisation of the United Nations (FAO) and the World Health Organisation (WHO), describes organic agriculture in great detail: 'Organic agriculture is a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system.' (Sligh and Christman 2003).

Organic agriculture is practised in most countries of the World and the extent has continued to expand as more producers have realized that organic production is often a legitimate and economically viable alternative enterprise (Creamer 2003). As organic agriculture is an approach, its technology and practices differ from place to place and in the same way the definition also differs, however it has common principle accepted globally. Common definitions often focus on what organics lacks; the prohibition of most synthetic inputs is a central aspect of the practice of organics. However, organics is not simply a return to the past (Lampkin, 2002).

Organics combines conventional farming knowledge with current scientific understandings of crop alternation, composting, green manure, multiple cropping and other techniques to create a system that relies on minimal outside inputs to keep up soil fertility, and is therefore different from many notions of traditional agriculture. Although the relationship between traditional agriculture and modern notions of organic agriculture has received little attention in the literature (UNESCAP, 2002), recent studies have attempted to bridge the divide between modern organic and traditional agriculture by highlighting the ecological benefits of traditional systems and the relative ease with which traditional small-scale farmers can convert to a certified organic system (Altieri, 2002).

2.2 Organic Agriculture Development in Nepal

Until 1960s almost all farming in Nepal was undertaken in traditional way using organic inputs produced in household level. From 1965 government encouraged the use of high yielding crop varieties, chemical fertilizers and pesticides to increase crop productivity in order to meet the food requirement of ever increasing population. In the beginning bags of chemical fertilizers were distributed freely to the farmers. Similarly, use of pesticides and other agrochemicals were also promoted to the farmers through trainings, demonstration and other communication means. Gradually use of agrochemicals increased in the country. Average consumption of agrochemicals is still low as compared to other south Asian countries, however unbalanced use of agrochemical is widespread in the areas where commercial production of crops has already started.

The organic agriculture is a very common word in Nepalese agriculture sector. Over a century, traditional farmers in hills and mountains have been following the farming practice, which is similar to organic farming. However, many of them have no idea that their traditional practice is called organic agriculture (Tamang et al. 2011). From 1980s, after realizing the negative impact of overuse/misuse of agrochemicals to environment, natural resources and human health, NGO sectors initiated movement towards organic agriculture. During 1980s and 1990s several NGOs like Institute for Sustainable Agriculture, Nepal (INSAN), Nepal Community Support Group (NECOS), Jajarkot Permaculture Program, Lotus Land Agriculture Farm, Community Welfare and Development Society (CWDS), HASERA Agriculture Farm, Nepal Permaculture Group (NPG), Ecological Services Centre (ECOSCENTRE), Organic Nepal etc. started organic agriculture program in different part of Nepal. Similarly, Organic agriculture was first appeared as one of the priority sectors of Nepal Government since the 10th Five Years Plan (2003-2008).

2.3 Status of Organic Agriculture in Nepal

Organic agriculture appeared as one of the importance sectors in Nepalese agriculture for the first time in the 10th Five Year plan (2003-2008). Now many institutions, individuals and farmers are rigorously engaging in this field. There are various local organic practices; some were practiced from the past and some innovating new practices by farmers themselves learning by doing. At present, some organic products such as coffee, tea, honey, large cardamom, ginger etc are exported to international market (Bhatta et.al., 2009).

According to Tamang et al. (2011), numerous institutes and individuals think that organic movement in the context of Nepal is quite slow in progress because of lacking clear vision of the government and one-sided information flow from the different developmental projects. Similarly, government past policy and programs, agriculture production particularly organic productions are never grasped in the perspective of the food (Bhatta et al. 2009). The national agriculture policy 2061 BS clearly stated that the promotion of organic agriculture is only for export. The policy and program guided it from the promotion of business and emphasis has been given for earning more money but never seen from the own food and health" (Tamang, et.al., 2011). Hence, the literatures show that organic farming is limited in the only export oriented supplies such as coffee, tea, large cardamom, ginger etc and in a certain group of farmers.

Local farmers knowingly or unknowingly have been practicing organic agriculture and have invented various organic techniques but we have not acknowledged them for their contribution. Nepalese organic products reach the standard for the Nepalese market but competing with the international market is too hard. Because of the complicated certification process, marketing of organic product within our own country is more effective than competing with the international market. Due to the lack of accredited laboratory facility, several cases of return of the certified organic products (honey) had been seen in the recent past. Great possibility of organic farming exists because still many places are organic by default, far from the modern technologies and chemical fertilizers. Many of the farmers in Nepal face problems that the organic products are not perfect in shape, size and colour as compared to products produced by the use of agrochemicals. So they are always in fear that consumer give priority to the appearance of product rather than the way of production and nutrient content of the product. They think that organic products are expensive and unaffordable. At village level the local seeds are being replaced by the hybrid and other high yielding varieties especially vegetables.

It is believed that Nepalese farmers are more committed for the organic farming compared to other south Asian countries. But these days particularly youth are distracting from the agriculture field. Only few farmers are convinced that organic agriculture is possible and the organic pesticides and fertilizers can also contribute in better production as compared to the chemical inputs. Organic farming never became a priority area of research organizations like National Agricultural Research Council (NARC) and National Agricultural Research and Development Fund (NARDF). There are limited and scattered researches on organic farming, which are not properly documented and thus repeated on the limited issues.

2.4 Production potentiality of organic farming.

Many researchers have proved that yield potentiality of organic farming system is not that much differs from that of conventional and in some cases the yield potential was found better than that of conventional farming. Studies of organic and/or alternative (low input/sustainable) systems report yields comparable to conventional systems in cabbage (Shrestha, 2008) maize (Pimentel et al., 2005), apples (Reganold et al., 2001), tomatoes (Clark et al., 1999) and soybeans (Pimentel et al., 2005, Smolik and Dobbs, 1991 and Stanhill, 1990) and in some cases higher than the modern farming (Jenkinson, 1994; Rodale Institute, 1999), and this might be the result of positive impact of organic farming to the soil properties and environment.

2.5 Soil fertility in Organic farming

A comparison of soil characteristics during a 15-year period found that soil fertility was enhanced in the organic systems, while it decreased considerably in the conventional system. Nitrogen content and organic matter levels in the soil increased markedly in the manure—fertilized organic system and declined in the conventional system. Moreover, the conventional system had the highest environmental impact, where 60% more nitrate was leached into the groundwater over a 5 year period than in the organic systems (Drinkwater, 1998).

The Soybean production systems trials show that improving the quality of the soil through organic practices can mean the difference between a harvest or hardship in times of drought (Rodale Institute, 1999). Organic practices encourage the soil to hold on to moisture more efficiently than conventionally managed soil. The higher content of organic matter also makes organic soil less compact so that root systems can penetrate more deeply to find moisture. Organic matter is not only a natural form of fertilizer but also the support of soil life, soil structure (pore system), plant metabolism and crop production. Organic matter is the basis of soil productivity. Jenkinson (1994) stated that soil organic matter and nitrogen levels, increased by 120% over 150 years in the organic plots, compared with only 20% increase in chemically fertilized plots. Organic manures slowly release significant amounts of nitrogen and phosphorus (Muse 1993, Zibilske 1987, Eghball 2001). In addition to supplying plant nutrients, organic manure has been shown to increase the level of soil organic matter, enhance root development, improve the germination rate of seeds, and increases the water-holding capacity of soil (Muse 1993, Zibilske 1987). Applied organic materials promote biological activity in the soil, as well as a favorable nutrient exchange capacity, water balance, organic matter content and soil structure (Muse 1993, Zibilske 1987).

The findings of various researches regarding leaching of N, have shown less leaching of N in organic farming. However, the findings are not directly comparable because of differences in methodology, soil type, climate, and the over-representation of dairy farms, etc. In general, the results show that nitrate leaching in organic farming is very low - from 8 to 34 kg N ha^{-1} yr^{-1} (Eltun, 1995; Granstedt, 1992; Nolte and Werner, 1994; Philipps et al., 1995; Stopes and Philipps, 1992; Watson et al., 1993; van der Werff et al., 1995; Younie and Watson, 1992). The leaching of N in organic farming in Denmark was found from 27 to 40 kg N ha^{-1} yr^{-1} (Kristensen et al., 1994; Magid and Kolster, 1995). Similarly, the accumulation of P in the soil and the risk of leaching can be minimized by following organic rather than conventional principles. Nevertheless, organic farming carries a high risk of P leaching in particular situations, for example, fields receiving or producing sources of organic matter (animal manure, green manure, catch crops, clover-grass, etc.) that raise the mobility of P in the soil (Johnston, 1998).

2.6 Weed diversity in organic farming

Various studies have shown higher weed abundance and species richness in fields under organic management, regardless of the arable crop being grown e.g. mean number of weed species in both margins and cereal fields was more than twice as high under organic management (Frieben and Kopke, 1995); density of non-crop flora in conventional cereal fields was around a third of that in organic fields (Hald, 1999). These differences were greater for broad-leaved weed species such as Fabaceae, Brassicaceae and Polygonaceae, than grasses, which tended to show less variation between organic and conventional fields (Hald, 1999; Kay and Gregory, 1998; and Moreby et al., 1994), suggesting that broad-leaved species are less able to tolerate the intensive weed control measures and denser crop swards of herbicide-treated, heavily fertilised conventional arable fields (Hyvonen et al., 2003; Kay and Gregory, 1998; Kay and Gregory, 1999; Moreby et al., 1994; and Rydberg and Milberg, 2000).

2.7 Diversity of soil micro-organism in organic farming

Overall, differences in microbial (bacteria and fungi) communities between organic and conventional systems are limited (Foissner, 1992; Girvan et al., 2003;

Shannon et al., 2002; Wander et al., 1995; and Yeates et al., 1997). However, there was evidence of a general trend towards elevated bacterial (Bossio et al., 1998; Fraser et al., 1988; Gunapala and Scow, 1998; Mader et al., 1995; and Scow et al., 1994) and fungal (Fraser et al., 1988; Shannon et al., 2002; and Yeates et al., 1997) abundance/activity under organic systems; Fraser et al. (1988) reported a microbial biomass 10–26% greater under organic management. Application of animal (and green) manures on organic farms was cited as the principal factor, providing a significantly greater input of organic carbon, thereby bolstering (in particular) bacterial populations (Fraser et al., 1988 and Gunapala and Scow, 1998).

Arbuscular mychrrhizal fungi (AMF) species present in natural ecosystems are maintained under organic farming but severely depressed under conventional farming, indicating a potentially severe loss of ecosystem function under conventional farming (Oehl et al., 2004). Some studies found only small differences in AMF community between organic and conventional farming (Land and Schonbeck 1991; Kurle and Pfleger 1996; Franke-Snyder et al. 2001) but various studies have reported very low species composition in more intensively managed agricultural land use systems (Sieverding 1989; Douds et al. 1993; Johnson and Pfleger 1992; An et al. 1993; Galvez et al. 2001; Jansa et al. 2002; Oehl et al. 2003).

2.8 Earthworm population in soil under organic farming

Several studies have indicated a general trend for higher earthworm abundance under organic management. The mean biomass, abundance and species richness of earthworms found higher in the organic fields (Pfiffner and Luka, 2007). Brown (1999) reported higher earthworm abundance (almost twice the density) and species diversity, both in-field and within grass margins, in organic than conventional fields. Similarly, Gerhardt (1997); Brooks et al. (1995); Liebig and Doran (1999); and Berry and Karlen (1993) reported that organic sites held larger and more active earthworm populations, whilst Pfiffner and Mader (1997) found a higher number of earthworm species, a higher density (up to two times) under organic, regardless of crop type within the rotation. Reganold et al. (1993) meanwhile reported densities as high as 175 earthworms m^{-2} in biodynamic soils in comparison to only 21 m^{-2} in conventional. As in the case of soil microbes, such differences are likely to result primarily from the use of farmyard (and green) manures in organic systems which provide an important food resource (Berry and Karlen, 1993; Brooks et al., 1995; Gerhardt, 1997; and Pfiffner and Mader, 1997). Prohibition of pesticide use may also benefit earthworms, which occur close to the soil surface and so are most at risk of exposure (Pfiffner and Mader, 1997).

2.9 Diversity and population of surface active spider in organic farming

Feber et al. (1998) compared surface-active spider communities in wheat fields and found that abundance and species richness were generally greater in organic than conventional fields, but significantly so at only one of three paired sites. Spider communities as a whole differed between the two management systems. This observation was supported by Basedow (1998), who reported a higher diversity and widely differing community structure under organic management, but little difference in abundance. Booij and Noorlander (1992), Moreby et al. (1994), Reddersen (1997), Pfiffner and Luka (2003) and Pfiffner and Niggli (1996) all reported a higher abundance of spiders under organic management (up to twice as many spiders on organic (Pfiffner and Niggli, 1996)), although differences were not always statistically significant across studies and years.

2.10 Diversity of insect in organic farming

Several studies have reported higher abundance, greater species richness of carabids on organically managed fields (Booij and Noorlander, 1992; Carcamo et al., 1995; Clark, 1999; Dritschilo and Wanner, 1980; Hokkanen and Holopainen, 1986; Irmler, 2003; Kromp, 1989; Kromp, 1990; O'Sullivan and Gormally, 2002; Pfiffner and Luka, 2003; Pfiffner and Niggli, 1996; and Reddersen, 1997), while some studies have indicated the reverse (Armstrong, 1995; Moreby et al., 1994; Weibull et al., 2003; and Younie and Armstrong, 1995). Organically managed fields contain a greater abundance and diversity of arthropods than conventionally managed fields (Berry et al., 1996; Brooks et al., 1995; Letourneau and Goldstein, 2001; and Reddersen, 1997). However, there were clear differences in response between taxonomic groups. Aphids and their natural predators tended to be more abundant in conventional fields, where more abundant food resources are provided by heavily fertilised, faster growing crops (Moreby et al., 1994 and Reddersen, 1997), groups such as Acari (mites), Formicidae (ants) and Heteroptera (true bugs) tended to show the reverse i.e. less in organic farms (Moreby, 1996; Reddersen, 1997; and Yeates et al., 1997). Feber et al. (1997) recorded a significantly higher total abundance of butterflies on organic than conventional farms, but in contrast, Weibull et al. (2000) found no significant difference in single species abundance, species richness between farming systems.

2.11 Organic farming and plant disease

Organic amendments are considered a potentially useful option because there is a long history of research showing that losses caused by plant-parasitic nematodes can be reduced by adding organic matter to soil (Akhtar and Malik 2000). Soil borne pathogens and root disease are also generally lower in organic than in conventional systems (Van Bruggen, 1995). Another reason organic amendments are evaluated is that microbial suppression of *Pythium* is enhanced by adding plant residues, compost or other organic materials to soil (Hoitink and Boehm 1999). The amendment of cultivated soils with organic material has been suggested to increase the general suppressiveness of the soil pathogens resulting from competition (Bailey and Lazarovitz, 2003). There was an effective control of *Pythium* and *Phytophthora* root rot of cucumber by the application of composts (Hoitink *et. al.*, 1997). Varughese and Padmakumari (1993) found the minimum disease occurrence by *Helminthosporim oryzae* in the organic manure treatments whereas it was very high in the inorganic fertilizer treatments. They suggested organic saved fungicide application. Certain ecological adaptations of the pathogen determine which type of changes will suppress or enhance it (Yin *et. al.*, 2004).

2.12 *Nasabike* manure and agri-medicine

Nasabike manure and fertilizer were found very effective for the quality production of vegetable, flower, and tea in different VDCs of Ilam. The foliar application of *Nasabike* agri-medicine in tea plantation in Kolbung VDC during the period of March to May (2004) induced each flossing 20 days prior than that of chemical tea farming, and the incidence of leaf rust was decreased by 50 % (NCDC, 2005)

Nasabike manure and agri-medicine applied in Gladiolus, Cabbage, Glorisa, Sugandhawal gave very good result in Gorkhe VDC of Ilam. In Gorkhe VDC the cabbage productivity of the Demonstration plot with the application of *Nasabike* manure and agri-medicine was 37.027 tonnes/ha which was similar to the production of chemical plot (37.210), and the market quality and appearance was found better in organic production as compared to chemical production. The gladiolus flower produced by using the *Nasabike* manure and fertilizer were very healthy with long and robust stalk, the buds range were 13-18 and the cut flower remained fresh up to 25 days, 6 days more as compared to 19 days in chemically grown flower. Similar result was found in Ilam Municipality 3 where the productivity of cabbage in *Nasabike* manure and agri-medicine applied field was 39.460 tonnes/ha, and the demand for the produce was high in the local market of Ilam during 2004 and 2005. (NCDC, 2005). The yield of cabbage from *Nasabike* manure and agri-medicine treated plot was almost similar with that of chemically produced, and the storage performance, weight loss, dry matter content of cabbage was superior in organically produced (Shrestha, 2008).

Nasabike manure and agri-medicine are true organic and these are safe to environment and human health. These are proved as the best alternatives to agro-chemicals. It is sustainable technology as the ingredients are locally available and farmers can prepare the same on their own. The farmers of Kagalle, Sri Lanka are satisfied as they finally have got the alternatives to chemicals for the production of organic vegetable with bumper harvest. (PESA bulletin 2, 2005).

CHAPTER THREE

MATERIALS AND METHODS

This chapter explains about the process of data collection. This chapter covers the research approach, research design, data collection, reliability and validity of data analysis plan. This chapter guides the whole process of data collection and analysis.

3.1 Locations

The research was conducted in Ilam district of Nepal. It is the easternmost hill district of Nepal and is bordered by the Indian state of West Bengal in the east and by Jhapa, a Nepal terai district, in the south. In the north and west is another hill district of Nepal, Panchthar. The district, with a geographical area of 1,717 km^2, the district is divided into 10 administrative units viz. 4 Municipalities and 6 Rural Municipalities. The district has 4 clear geographical divisions: a tropical region bordering with the Terai in the south below 500 m asl, subtropical region ranging from from 500-1,000 m, a temperate region in the middle of the district with altitude ranging between 1,000-2,000 m asl and a sub alpine region with altitude above 2,000 m asl. The lowest altitude is 240 m asl at Danabari, south Ilam and the highest is the 3535 m asl at Sandakpur, north Ilam. The average annual rainfall of the district is 250 cm and more than 80% precipitation occurs during June to September.

Ilam municipality was selected to conduct the research. It is one of four urban municipalities of Ilam District. It also acts as the headquarters of Ilam District.

Geographically it lies in the hill region which is mostly known as Mahabharata range. It is also one of the important towns in Province No. 1 and one of the major places in Nepal for tea-production. It is famous for tea production, and diverse agricultural economy. It is one of the major horticultural crop production areas of Nepal. The total area of the municipality is 173.32 km^2 and it is divided into 12 wards.

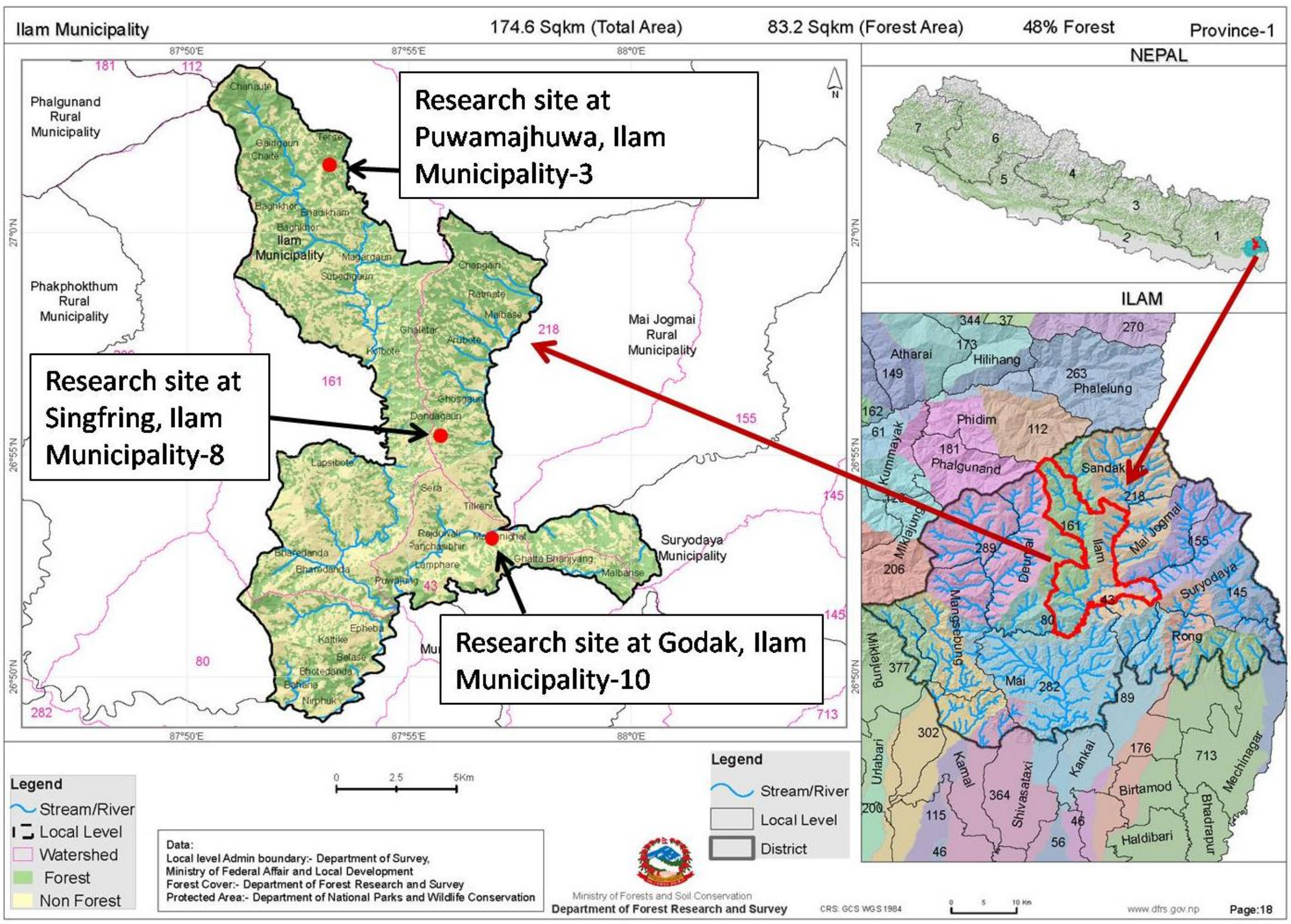

Fig 1. Map of Ilam Municipality showing research site

3.2 Description of research site

Multi-location trial was conducted in three wards of Ilam Municipality representing 3 agro-ecological zones of Ilam Municipality. The selected site for trial are Puwamajhuwa at ward No. 3, Singfring at ward No. 8, and Godak at ward No. 10 representing high hill, mid hill, and foot hill respectively.

3.2.1 Puwamajhuwa, Ilam Municipality- 3

The area lies to the northern part of Ilam district bordered with Panchthar district. The coordinate of the research site is N 27^{o}01’05” and E 087^{o}51’22.9”. The area represents high hill with temperate climate and elevation is 2,275 m asl. The area receives frost and sometimes snow during winter. Temperature ranges from minimum 0°C to maximum 26°C. Rainfall is normally high as compared to other research sites. Soil is clay loam with high pH and low organic matter content.

Table 1. Physico-chemical properties of soil of research site at Puwamajhuwa, Ilam Municipality-3

OM (%)	Total N (%)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	pH	Sand (%)	Silt (%)	Clay (%)	Soil texture
7.93	0.27	82.00	1522.67	5.23	19.3	22.4	58.3	Clay

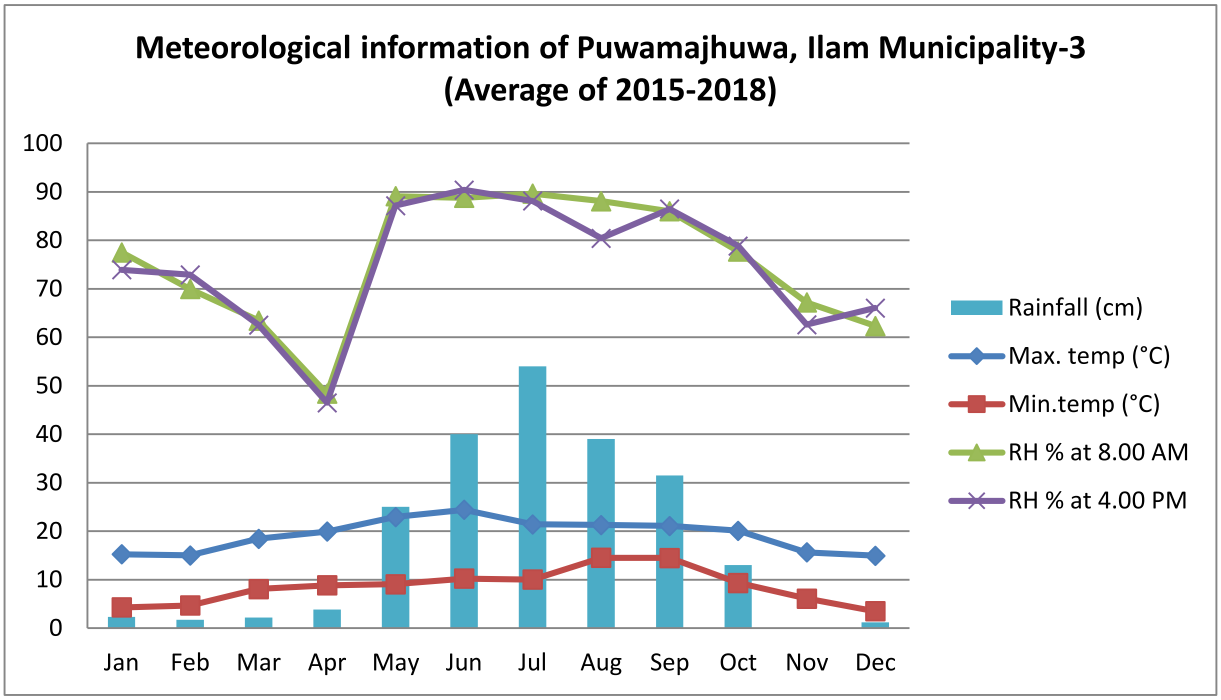

Fig 2. Meteorological information recorded at research site, Puwamajhuwa during 2015-2018.

3.2.2 Singfring, Ilam Municipality- 8

The area lies at the center part of Ilam Municipality. The coordinate of research site is N 26°55'53" and E 087°55'51". It represents mid hill with mild climate throughout year. The elevation of the research site is 1,166 m asl. Soil is sandy loam

Table 2. Physico-chemical properties of soil of research site at Singfring, Ilam Municipality-8

OM (%)	Total N (%)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	pH	Sand (%)	Silt (%)	Clay (%)	Soil texture
5.17	0.19	168.67	600.00	5.17	59.6	19.5	20.9	Sandy loam

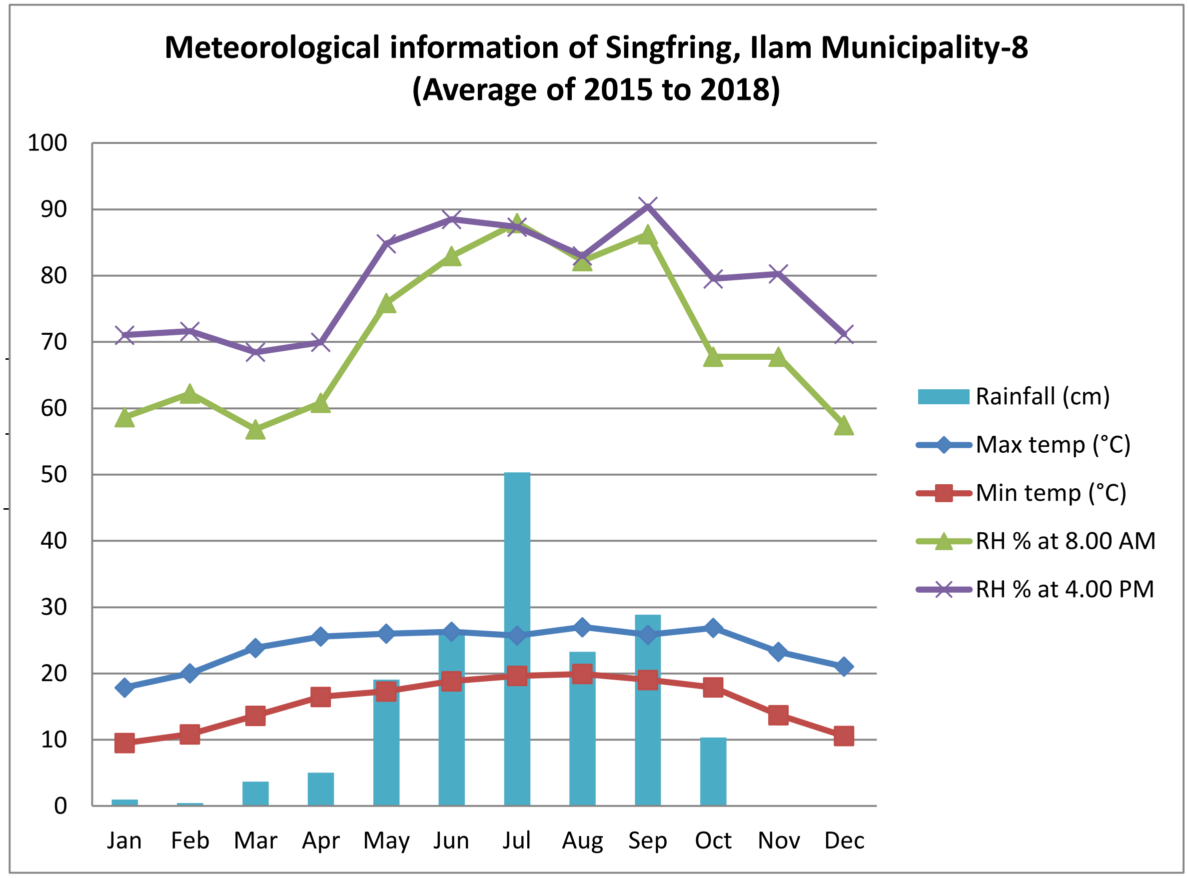

Fig 3. Meteorological information recorded at research site, Singfring during 2015-2018.

3.2.3 Godak, Ilam Municipality- 10

The area lies to the south of Ilam Municipality. The coordinate of research site is N 26°53'12.7" and E 087°56'32.7". It represents warm subtropical climate. The altitude of research site is 495 m asl. Soil of research site is clay loam.

Table 3. Physico-chemical properties of soil of research site at Godak, Ilam Municipality-10

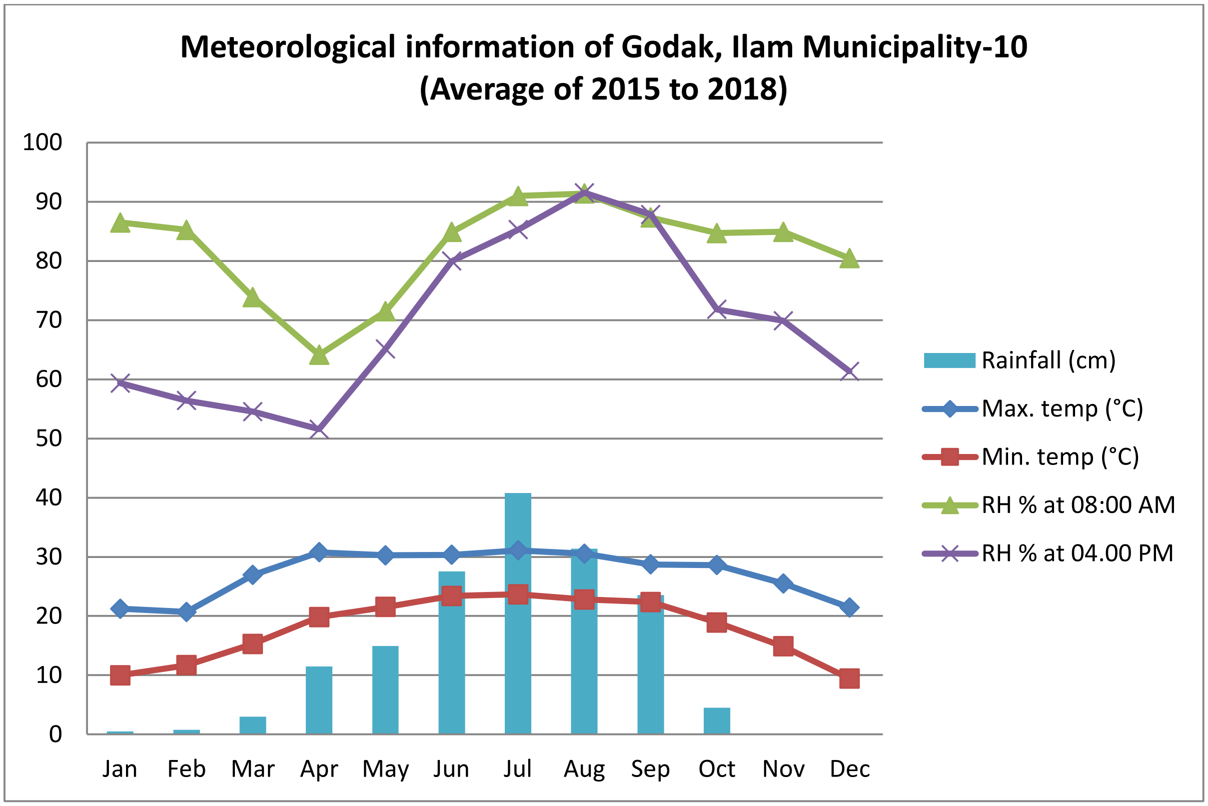

Fig 4. Meteorological information recorded at research site, Godak during 2015-2018.

3.3 Experimental design

In each site, the experiment was laid out in two factor factorial Randomized Completely Block Design with three replications. There were 9 treatment combination consisting of three type of fertilization methods (*Nasabike* manure, chemical fertilizer and Farm yard manure (FYM)) and three types of plant protection measures (*Nasabike* agri-medicine, chemical pesticide and traditional method of pest control). Three digit random numbers was used from the random table and the treatments were adjusted on ascending order of the random numbers using the rules of randomization in each replication. The experiment was conducted in three replications. In each replication 9 plots were prepared for 9 treatments, thus there were altogether 27 plots in 3 replications in each location. Individual net plot area comprised of 2.5 m X 2 m area with 25 plants. Total nine plants excluding the border plants were used for data recording. In each location, net experimental area was 135m^2 while the gross field area was 294 m^2. Treatment combination and layout plan are presented in the table and figure, respectively.

3.4 Treatments details

The treatments combination of fertilizer (*Nasabike* manure, chemical fertilizer and FYM) and pesticide (*Nasabike* agri-medicine chemical pesticide and traditional method) were used as two different factors in the experiment.

Fertilizers

- Chemical fertilizer - NPK 120:60:30 kg ha^{-1} (3 split dose of N Basal:20 DAT:40 DAT)
- *Nasabike* manure - 5 mt ha^{-1} (2 split dose Basal and 20 DAT)
- Farm yard manure (FYM) - 20 mt ha^{-1} (single application as Basal)

Plant protection measures

- Chemical pesticide
  - Malathion (5%) 20 kg/ha during land preparation
  - Soil drenching by Cyperin-10 (Cypermethrin @ 1.5ml/lt) 2 times before transplanting

- Two spraying of Malathion @ 2ml/lt of water (for cabbage butterfly, and DBM)
- Two spraying of Rogor @ 2ml/lt of water at an interval of 15 days (for aphids)

- *Nasabike* agri-medicine: Five percent solution (50ml/ l of water), spraying at the interval of 15 days
- Traditional method as per the pest infestation

Table 4. Different types of fertilization and pesticides used as treatment

SN	Factos	Symbol
	Factor 1 (Fa) : Fertilizer	
1	*Nasabike* manure	A1
2	Chemical fertilizer	A2
3	Farm yard manure (FYM)	A3
	Factor 2 (Fb) : Plant protection measures	
1	*Nasabike* agri-medicine	B1
2	Chemical pesticide	B2
3	Traditional method	B3

3.5 Treatment combination

The combination of fertilizers and pesticides as treatments are presented in table 5.

Table 5. Treatment combinations of fertilizers and pesticides for the field experiment

Treatment	Combinations	Symbol
T1	*Nasabike* manure + *Nasabike* agri-medicine	**A1B1**
T2	Chemical fertilizer + *Nasabike* agri-medicine	**A2B1**
T3	Farm yard manure + *Nasabike* agri-medicine	**A3B1**
T4	*Nasabike* manure + Chemical pesticide	**A1B2**

T5	Chemical fertilizer + Chemical pesticide	**A2B2**
T6	Farm yard manure + Chemical pesticide	**A3B2**
T7	*Nasabike* manure + Traditional method	**A1B3**
T8	Chemical fertilizer + Traditional method	**A2B3**
T9	Farm yard manure + Traditional method	**A3B3**

3.6 Field lay out

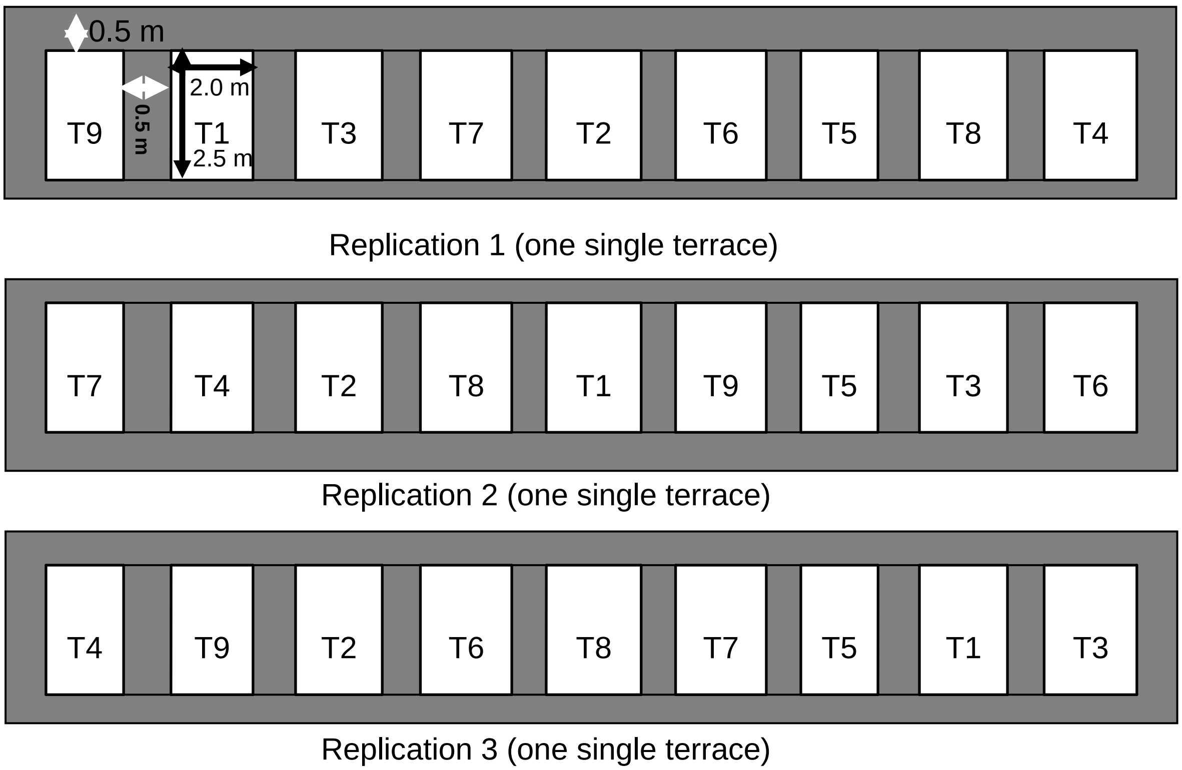

Figure 5 . Layout of the experimental field at Singfring, Ilam-8, Ilam

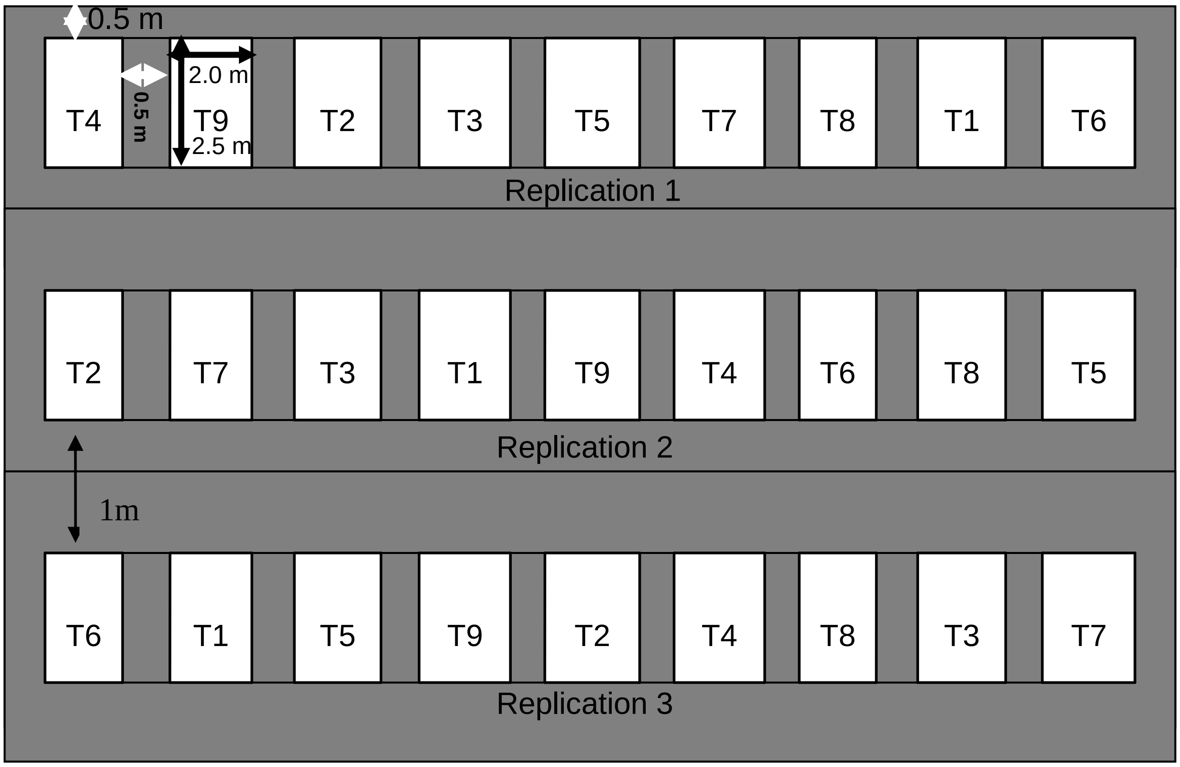

Figure 6. Layout of the experimental field at, Godak, Ilam-10, Ilam

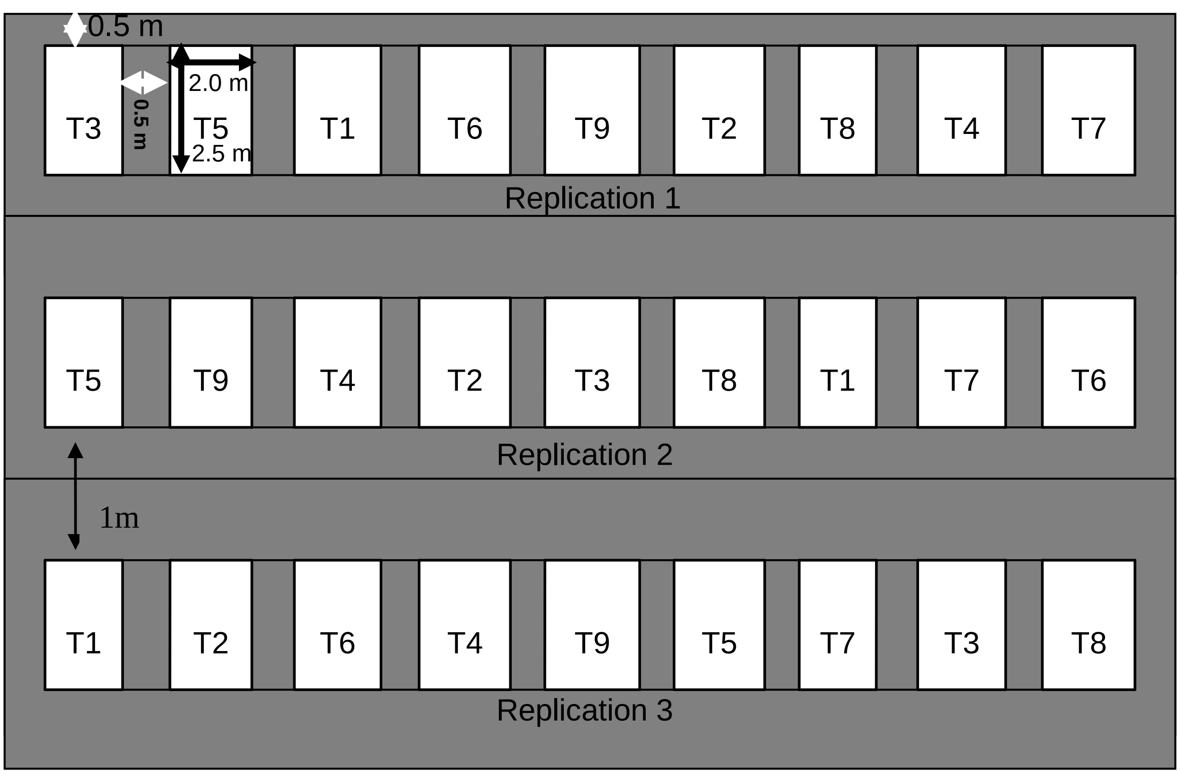

Figure 7. Layout of the experimental field at Puwamajhuwa, Ilam-3, Ilam

3.7 Preparation of Nasabike manure

Nasabike manure was prepared a month prior of start of each experiment. Locally collected Rice bran : Oil cake : Compost : Topsoil in the ratio of 1:1:1:1 by weight were mixed with the help of shovel. 1/5 part wood ash and 1/2 part fresh cattle urine were also mixed. A heap of mixture is made inside the gloomy room. The heap was covered with jute sheet. The mixture was allowed to decompose for 15 days. The heap was turned at the interval of 2 days to bring down the temperature to the range of 35-40^{o}C that promote the development of beneficial micro-organism. While turning the heap moisture was checked and maintained approximately 40% by sprinkling water. The prepared *Nasabike* manure was packed in plastic bags maintaining moisture level below 30%.

3.7.1 Laboratory analysis of *Nasabike* manure

A sample of fresh *Nasabike* manure was tested at laboratory of Soil Science Division of National Agriculture Research Council, Khumaltar, Lalitpur, Nepal. The major nutrients and other constituents of *Nasabike* manure was obtained through laboratory test (Table 6).

Table 6.Major constituents of *Nasabike* manure

OC (%)	OM (%)	N (%)	P_2O_5 (%)	K_2O (%)	Total bacteria	Total fungus	Azotobactor	Actinomycetes
11.60	20.04	4.10	2.54	3.00	$36X10^{-6}$	$2X10^{-4}$	$17X10^{-2}$	*A. valentin* *A. chlorococcus*

(Lab report of Division of Soil Science, NARC, Khumaltar, Lalitpur, Nepal)

3.8 Preparation of Nasabike agri-medicine

Nasabike agri-medicine was prepared a month before start of the experiment. The various plant having pesticidal properties used for the preparation are shown in Table 7.

Table 7. Ingredients of *Nasabike* agri-medicine

Botanical name	Nepali name	Part used	Amount (fresh) kg
Melia azedarach L.	*Bakaino*	leaf	1
Artemisia indica Willd.	*Titepati*	leaf	1
Solanum tabacum	*Surti*	leaf	1
Justicia adhatoda L.	*Asuro*	leaf	1
Tagetus erecta L.	*Sayapatri*	leaf	1
Vitex negundo L. var. *negundo*	*Simali*	leaf	1
Chrysenthemum sp.	*Godavari*	leaf	1
Urtica dioca L.	*Sisnu*	growing shoot	1
Acorus calamus L.	*Bojho*	rhizome	1
Zanthoxylum armatum DC.	*Timur*	fruit	1
Capsicum sp.	*Khursani*	ripe fruit	0.5
Allium sativum	*Lahasun*	bulb	0.5
Agave sp.	*Hattibar*	leaf	1
Cattle urine	*Goumut*		5.00 l.
Water	*Pani*		5.00 l.
Wood ash	*Kharani*		1.00 kg

Kerosene	*Mattitel*	0.25 l.

The collected plant parts were allowed to wilt for 24 hours, chopped finely by chopping knife, and mixed together. The mixture was placed in the black plastic drum, wood ash was spread on the top of the mixture. The cattle urine and water were mixed and poured from the top until all the mixture was settled down under the liquid. 250 ml kerosene was added and allowed to spread on the surface of liquid. The drum was covered with lid and placed in the gloomy room for a month. Ten liter water was added to the mixture, stirred with stick, and filtered in a bucket. The filtered solution was bottled in a dark brown bottle, and stored in dark and cold place.

3.9 Crop and variety

For the experiment T-621, a hybrid cabbage variety, produced and packed by American Taki Seed Company, was used. It is early maturing variety, and average days to maturity is 60 DAT. Head is compact, round shaped with light green leaves, weighing 1-1.2 kgs. This variety can be grown throughout the year under Ilam condition. To produce seedling in the nursery, a packet of 10 gm seed was purchased from Agriculture Seed Store, Ilam bazar, and used to raise seedling in nursery.

3.10 Nursery raising

Nursery bed was prepared nearby each experimental site of each location in each year. Raised bed of 1 m x 10 m area was allocated for the nursery. Well decomposed FYM @ 20 kg/m^2 was incorporated in the nursery bed as a basal application. After 5 days of bed preparation, seeds were sown in shallow furrow of 1.5 cm deep. The line to line distance was maintained at 10 cm, while the seeds in the line were dropped approximately in 1 cm gap. The furrows were covered by soil then the bed was pressed slightly with hand. The bed was irrigated with the help of rose can. Bed was covered by transparent plastic tunnel of 75 cm height. Nursery was irrigated at the interval of 4 days. The seedlings were allowed to grow till 25 days when 90% of them attained height of 12 cm and developed 4 true leaves. The problems of diseases, insect pests, and weeds were not observed during the entire seedling growing period. No fertilizers, and pesticides were applied in the nursery.

3.11 Land preparation and application of fertilizer

In each location and year, the experimental field was prepared manually by hoeing two times. Basal dose of fertilizers were applied at final hoeing. Each individual plot was measured 2.5 m length, and 2 m width, with an area of 5 m^2. FYM @ 20 mt ha^{-1} as basal dose, split dose of well prepared *Nasabike* manure @ 5 mt ha^{-1} and chemical fertilizer @ NPK 120:60:30 kg ha^{-1} was applied in the plot where allocated as per the layout of experimental plots. Nitrogen, phosphorus and potassium were applied through urea (46% N), single super phosphate (16% P) and muriate of potash (60% K), respectively. Half dose of nitrogen, full dose of phosphorus, and potassium were incorporated into soil at the time of seedling transplanting. Remaining amount of nitrogen was split into two equal parts and each part was top-dressed at 20, and 40 days after transplanting.

3.12 Application of pesticide

In each location and year, chemical pesticides were applied in the plot with pesticide treatment. Malathion (5%) @ 20 kg was incorporated in the plot as basal application. Similarly, chemical treatment plot were drenched with Cyperin-10 (cypermethrin) @ 1.5 ml l^{-1} before transplanting. No pesticides were applied in the plot with treatment other than pesticides.

3.13 Transplanting of seedling

In each location and year, nursery bed was irrigated before 2 hours of the uprooting the seedlings. Uniform sized 25 day old seedlings having 4 true leaves were transplanted in the experimental plots. The row to row spacing was 50 cm and plant to plant spacing was 40 cm. Each plot contained 25 plants, and plots were separated by space of 50 cm. A light irrigation was given with rose can after transplanting of the seedlings.

3.14 Irrigation

During the initial period after transplanting of seedling, irrigation was done with rose can. Irrigation was scheduled once at two day's interval till 12 days for firm establishment of the newly transplanted seedlings. After two weeks, irrigation was scheduled for entire growth period of crop at regular interval of a week. Medium forced plastic sprinklers were installed in between two plots at a height of 1.5 m covering two plots at a time. Irrigation was continued until the cabbage heads were fully developed, and attained full maturity.

3.15 Plant protection measures

Weeding was done manually in all plots at 20 and 40 days after transplanting. The plots with chemical treatment were drenched with Cyperin-10 (Cypermethrin) @ 1.5 ml l^{-1} of water to protect seedling from cutworm. The crops in the chemical treatment plots were sprayed 2 times with Malathion 20% @ 2ml l^{-1} of water at 20 and 40 days after transplanting to manage cabbage butterfly, and diamondback moth. Similarly, Rogor (50%) @ 2ml l^{-1} of water was sprayed 3 times at the interval of 15 days to manage aphids. The plots with *Nasabike* agri-medicine as a treatment were sprayed with *Nasabike* agri-medicine @ 50 ml l^{-1} of water in 10 days interval to protect crop from all types of insect pests.

3.16 Weeding and earthing up

In each location and year, first weeding, and earthing up was done at 20 DAT in all plots. Similarly, second weeding and earthing up was done at 40 DAT. The plots with the treatment of chemical fertilizer were top dressed with ¼ N at the time of weeding and earthing up at 20, and 40 DATs.

3.17 Harvesting

In each location and year, the crop was ready to harvest at 60 days of transplanting. Harvesting was carried out manually with sickles. Harvested plants of each plot were separated into roots, above biomass, marketable head, and they were weighed separately. The leaf number, largest leaf length and breadth were also recorded at harvesting. The disease scoring was also done at the time of harvesting.

3.18 Observations recorded

Observations were taken from inner nine plants of each plot while the remaining 16 plants were considered as border plants. The following parameters were taken during the field experiment.

3.18.1 Yield and yield components

Biomass production: After the final harvest of the cabbage, inner nine plants from each experimental plot were uprooted and total weight of root and shoot was recorded and converted into mt ha^{-1}.

Root weight: After calculating the total biomass, portion below the soil surface were cut off and weighed. The average root weight was calculated from the inner nine plants of each experimental plot and expressed in gm plant^{-1}.

Total yield: Weighing of individual cabbage head along with the inner leaves covering head was done with electronic balance and recorded in gram, which was converted into mt ha^{-1}.

Marketable head yield: Weighing of individual head after removing the inner leaves covering head was done with the help of electronic balance and recorded in gram. It was converted into mt ha^{-1}.

Days to maturity: The number of days taken to 90% maturity of cabbage was recorded from each experimental plot.

Harvest index: Harvest index of each treatment was calculated by dividing the marketable head yield by biological yield and the outcome was multiplied by 100.

3.18.2 Production quality

Storage duration and weight loss: The five cabbage heads of each treatment of three replications were taken for the storage quality analysis. The cabbage heads were placed on the floor inside the room without adjusting temperature and humidity. Each head were weighed every day to find the weight loss per day. The damaged and dried leaves were removed to make fresh and marketable look. Duration of storage until the cabbage heads looking like fresh was recorded in number of days. The loss during storage was recorded in gm day^{-1}.

Dry matter content of cabbage head: Fresh cabbage head was chopped with the chopping knife. 500 gm of each treatment and dried in sun light until moisture level reached 0%. The dried mass was weighed with the help of electronic digital weighing machine. The dry matter was calculated in percentage.

3.18.3 Weed diversity and density

Weed diversity, density, abundance, and standing crops in each location- by using 1X1 m quadrate as suggested by Singh and Chalam (1936) and calculation as per Ambasth (1984) as follow.

Diversity- collection, identification and categorization under family, genera and species

Density- D= Total no of individuals of a species in all quadrate/total No. of quadrates used.

3.18.4 Physico-chemical properties of soil

Soil sampling was done before plantation and after harvest of crops and assessed the physical, chemical and biological properties of soil delivering the sample to the soil testing laboratory of National Agriculture Research Council, Khumaltar, Lalitpur Nepal. the assessed properties include- Bulk density, pH, NPK and OM

3.18.5 Bio-diversity and population dynamics

Total faunal diversity (earthworm, soil burrowing insects etc.) was recorded in the interval of 4 months.

3.18.6 Meteorological information

In each location maximum temperature, minimum temperature, relative humidity and rainfall were recorded in the research field by establishing meteorological station in each location. The meteorological data from 2015 to 2018 were compiled and analyzed to find the climate trend.

3.19 Statistical analysis

The data were first tabulated in Microsoft Excel and analyzed by using MSTAT-C. Means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984). Some data were analyzed by using Excel statistical data analysis tools. To make the analysis easy and to draw the result and conclusion the data of two years was first compiled and average is calculated for all three locations. In some cases to find the effect of ecological zone on several parameters, each location was taken as replication. Optimum yield in terms of quality and quantity is the final goal of farming, so this study the yield and yield attributing characters was given high priority while doing analysis and interpreting the result.

CHAPTER FOUR

RESULT AND DISCUSSIONS

The recorded data of the research were analyzed by statistical software, MSTAT-C, and the findings have been presented under this chapter with figures and tables wherever necessary. An attempt has been made to evaluate the obtained results to give explanation with available evidences as far as possible for the observed variation in mentioned parameters. The cause and effect relationship was established between appropriate variables if applicable.

4.1 Effect on yield and quality attributing characteristics

4.1.1 Biological yield

Biological yield (sum of head weight, shoot weight and root weight) were significantly different among the treatments (Appendix 1). The effect of different types of pesticides on the biological yield of cabbage was found significant. The highest biological yield (112.56 mt ha^{-1}) was observed in the treatment with *Nasabike* agri-medicine while the lowest (101.11 mt ha^{-1}) was observed in control treatment (Table 8). The result revealed that *Nasabike* agri-medicine contributed to the increment of yield. The reason behind this might be the positive impact of *Nasabike* agri-medicine to the plant health as it contains plant nutrient in liquid form, which is available to plant through foliar application.

The effect of different types of fertilizer was found highly significant on biological yield of cabbage. The highest yield (116.17 mt ha^{-1}) was found in treatment with chemical fertilizer. Similarly, the lowest yield (85.78 mt ha^{-1}) was observed in FYM (Table 8). Though, the biological yield from *Nasabike* manure applied plot was lower as compared with chemically fertilized plot, it was far better if compared with the yield from control plot. The reason behind the higher yield in chemically fertilized plot might be due to the readily available nutrient in the soil.

Table 81. Effect of different types of fertilizer and plant protection measures on biological yield of cabbage at the time of harvesting

	Biological yield (mt ha^{-1})			
Treatment	*Nasabike* manure	Chemical fertilizer	FYM	Mean
Nasabike agri-medicine	122.7^{a}	117.7^{ab}	97.33^{cd}	112.56^{a}
Chemical pesticide	113.3^{ab}	120.8^{a}	72.50^{e}	102.22^{b}
Traditional	105.8^{bc}	110.0^{abc}	87.50^{d}	101.11^{c}
Mean	113.94^{b}	116.17^{a}	85.78^{c}	105.29

SEM±	Individual	2.600
	Interaction	4.504
$LSD_{0.05}$	Individual	7.796
	Interaction	13.50
CV	4.75%	

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The interaction effect of the combination of different fertilizers and pesticides on biological yield of cabbage head was found significant. The highest biological yield (122.7 mt ha^{-1}) was observed in the treatment (*Nasabike* agri-medicine + *Nasabike* manure), and it was at par with treatment (Chemical fertilizer + chemical pesticide), (*Nasabike* agri-medicine + chemical fertilizer), and treatment (*Nasabike* manure + chemical pesticide). The lowest biological yield (72.50 mt ha^{-1}) was observed in treatment (FYM + chemical pesticide) (Table 8). The result revealed that the interaction effect of *Nasabike* manure and agri-medicine is quite positive for higher yield. The reason behind this might be the beneficial impact of *Nasabike* manure to soil and plant health, and similar impact of *Nasabike* agri-medicine to the plant health.

4.1.2 Root weight of cabbage plant

The individual effect of pesticides and the interaction effect of combination of pesticides with fertilizers on the average root weight was non-significant, while the individual effect of fertilizers was found significant (Appendix 1). Types of pesticide did not contribute significantly to the average root weight of cabbage at the time of harvest. However, the highest root weight (80.00gm $plant^{-1}$) was observed in the treatment with control while the lowest (78.22 gm $plant^{-1}$) was observed in the treatment with *Nasabike* agri-medicine (Table 9). The lower root weight in the plot treated with *Nasabike* agri-medicine might be due to the plant nutrient content of the same, which might help the plant to meet some nutritional requirement through foliar application of *Nasabike* agri-medicine.

The individual effect of different types of fertilizer was found highly significant on average root weight of cabbage. The highest root weight (89.11 gm plant^{-1}) was recorded in FYM treatment, followed by 79.33 gm plant^{-1} in the treatment with *Nasabike* manure, while the lowest (69.33 gm plant^{-1}) was observed in the treatment with chemical fertilizer (Table 9). The reason behind the lowest root weight in chemically fertilized plot might be the availability of plant nutrient in the soil in the instant form, which was readily absorbed by root without travelling further as compared to the plot with *Nasabike* manure and FYM.

Table 9. Effect of different types of fertilizer and plant protection measures on average root weight of cabbage at the time of harvesting

Treatment	Average root weight (gm plant^{-1})			Mean
	Nasabike manure	Chemical fertilizer	FYM	
Nasabike agri-medicine	77.00^{cd}	70.67^{de}	87.00^{ab}	78.22^{a}
Chemical pesticide	83.67^{bc}	66.67^{e}	88.33^{ab}	79.56^{a}
Traditional method	77.33^{cd}	70.67^{de}	92.00^{a}	80.00^{a}
Mean	79.33^{a}	69.33^{a}	89.11^{a}	79.26
SEM±	Individual 1.255			
	Interaction 2.174			
$LSD_{0.05}$	Individual 3.763			
	Interaction 6.517			
CV	4.75%			

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The interaction effect of the combination of different fertilizers and pesticides on average root weight of cabbage was found non-significant. However, the highest root weight (92.00 gm plant^{-1}) was observed in treatment (traditional method + FYM), and lowest (66.67 gm plant^{-1}) was recorded in treatment (Chemical fertilizer + chemical pesticide) (Table 9).

4.1.3 Average aerial weight

Both the individual and interaction effect of the application of pesticides, and fertilizers on the average aerial weight of cabbage was found significant (Appendix 1). The effect of different types of pesticide on average aerial weight of cabbage was found significant. The highest aerial weight (2.173 kg plant^{-1}) was observed in the treatment with the application of *Nasabike* agri-medicine, followed by 1.96kg plant^{-1} in the treatment with chemical pesticide. The lowest average aerial weight (1.942 kg plant^{-1}) was observed in the treatment with traditional plant protection (Table 10).

Table 10. Effect of different types of fertilizer and plant protection measures on average aerial weight of cabbage at the time of harvesting

Treatment	Aerial weight (kg plant^{-1})			Mean
	Nasabike manure	Chemical fertilizer	FYM	
Nasabike agri-medicine	2.377^{a}	2.283^{ab}	1.860^{cd}	2.173^{a}
Chemical pesticide	2.183^{ab}	2.350^{a}	1.360^{e}	1.964^{b}
Traditional method	2.040^{bc}	2.130^{abc}	1.657^{d}	1.942^{c}
Mean	2.200^{b}	2.254a	1.626^{c}	2.027

SEM±	Individual	0.05164
	Interaction	0.08944
$LSD_{0.05}$	Individual	0.1548
	Interaction	0.2681
CV		7.58%

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The application of different types of fertilizer influenced greatly to the aerial weight of cabbage. The highest aerial weight (2.254 kg plant^{-1}) was observed in treatment with chemical fertilizer, which was followed by the treatment with *Nasabike* fertilizer (2.200 kg plant^{-1}), while the lowest (1.626 kg plant^{-1}) was observed in FYM .

The interaction effect of the combination of different fertilizers and pesticides on average aerial weight of cabbage was found significant. At the time of harvest, the highest aerial weight, i.e. 2.377 kg plant^{-1} was observed in treatment (*Nasabike* manure + *Nasabike* agri-medicine). The lowest aerial weight (1.360 kg plant^{-1}) was observed in treatment (chemical pesticide + traditional method) (Table 10).

4.1.4 The head yield

The effect of different plant protection measures on yield of cabbage in terms of total and marketable head yield was found significant (Appendix 2). The treatment with *Nasabike* agri-medicine gave the highest yield in both the total head yield (84.167 mt ha^{-1}) and marketable head yield (67.878 mt ha^{-1}), while the lowest head yield was observed in traditional method (Table 11). The reason behind the higher yield in *Nasabike* agri-medicine treated plot might be the nutrient content of *Nasabike* agri-medicine, which was utilized efficiently by the plant through leaves.

The effect of different types of fertilizer was found highly significant on both the total and marketable head yield of cabbage (Appendix 2). The highest total, and marketable head yield was 89.944 mt ha^{-1}, and 72.778 mt ha^{-1}, respectively in treatment with chemical fertilizer. Similarly, the lowest yield in terms of the total, and marketable head was observed in FYM (Table 11). The result showed that the chemical fertilizer is responsible for the higher head yield, but it is less efficient than *Nasabike* manure in terms of the difference between the total and marketable head yield. In *Nasabike* manure applied plot the difference between the total and marketable head was 15.85 mt, whereas in case of chemically fertilizer plot it was 17.16 mt, which indicates that, *Nasabike* manure is more efficient in terms of marketable head yield.

Table 11. Effect of different types of fertilizer and pesticide on head yield of cabbage at the time of harvesting at Ilam-7, Ilam, Nepal, 2008.

Treatment	Head yield (mt ha^{-1})	
	Total	Marketable
Plant protection measures		
Nasabike agri-medicine	84.167[a]	67.878[a]
Chemical pesticide	75.411[a]	60.611[a]
Traditional method	74.056[a]	58.211[a]

Fertilizers		
Nasabike manure	83.556[a]	67.711[a]
Chemical fertilizer	89.944[a]	72.778[a]
FYM	60.133[a]	46.211[a]
Mean	77.878	62.233
SEM±	2.399	2.370
$LSD_{0.05}$	7.192	7.106
CV	9.24%	11.43%

Means within the column followed by the same letter are not significantly different at 5% level of significance by DMRT

Table 12. The interaction Effect of different types of fertilizers and plant protection measures on head yield of cabbage at the time of harvesting.

Treatment	Head yield (mt ha^{-1})	
	Total	Marketable
Nasabike manure + agri medicine	91.83[a]	77.50[a]
Chemical fertilizer + agri medicine	91.50[a]	72.33[ab]
FYM + agri medicine	69.17[c]	53.80[cd]
Nasabike manure + chemical pesticide	82.67[ab]	66.33[abc]
Chemical fertilizer + chemical pesticide	95.67[a]	78.67[a]
FYM + chemical pesticide	47.90[d]	36.83[e]
Nasabike manure + traditional mentod	76.17[bc]	59.30[bcd]

Chemical fertilizer + traditional method	82.67^{ab}	67.33^{ab}
FYM + traditional method	63.33^{c}	48.00^{de}
Mean	77.878	62.233
SEM±	4.155	4.105
$LSD_{0.05}$	12.46	12.31
CV	9.24%	11.43%

Means within the column followed by the same letter are not significantly different at 5% level of significance by DMRT.

The interaction effect of the combination of different fertilizers and plant protection measures on head yield of cabbage was found significant in both the total head, and marketable head (Appendix 2). The highest yield in terms of the total, and marketable head was observed in treatment (chemical fertilizer + chemical pesticide) as 95.67 mt ha^{-1}, and 78.67 mt ha^{-1}, respectively. The lowest yield both in the total and marketable head was observed in the FYM and traditional method (Table 12). Though, the yield from chemical plot was higher, the gap between the total and marketable yield was higher, i.e. 17.00 mt, where as in case of the yield from the plot with *Nasabike* manure in combination with *Nasabike* agri-medicine the gap was 14.33 mt. which was lower by 2.67 mt as compared to chemically produced.

This result revealed that the interaction effect of *Nasabike* manure and agri-medicine is more efficient in terms of producing marketable head. The reason behind this might be the beneficial impact of both the *Nasabike* manure and agri-medicine to the soil and plant health. Higher head yield of cabbage from organic manure applied plot than the chemical plot was also reported by Budathoki *et al* (2007).

4.1.5 The harvest index of cabbage

The effect of different types of pesticide on harvest index of cabbage was found non-significant (Appendix 2). However, the highest harvest index (59.850) was observed in the treatment with *Nasabike* agri-medicine. The treatment with the chemical pesticide gave slightly lower result, i. e. 58.05, while the lowest (57.146) was observed in the traditional method of pest control (Table 13).

The effect of different types of fertilizer on harvest index of cabbage was significantly higher (Appendix 2). The treatment with chemical fertilizer showed the highest harvest index (62.334) followed by 59.06 observed in the treatment with the *Nasabike* manure, while the lowest (53.620) was observed in FYM (Table 13). The result demonstrated that the harvest index between chemical plot and *Nasabike* manure applied plot did not differ greatly as compared to the harvest index of FYM plot. It indicated that the *Nasabike* manure is also efficient in terms of harvest index.

Table 13. Effect of different types of fertilizer and plant protection measures on harvest index of cabbage at the time of harvesting.

Treatment	Harvest index			
	Nasabike manure	Chemical fertilizer	FYM	Mean
Nasabike agri-medicine	63.19[a]	61.25[ab]	55.11[bc]	59.85[a]
Chemical pesticide	58.13[ab]	64.91[a]	51.01[c]	58.02[a]
traditional method	55.86[bc]	60.84[ab]	54.74[bc]	57.14[a]

Mean		59.06[a]	62.33[a]	53.62[a]	58.34
SEM±	Individual	1.217			
	Interaction	2.108			
$LSD_{0.05}$	Individual	3.649			
	Interaction	6.320			
CV		6.26%			

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The interaction effect of the combination of different fertilizers and plant protection measures on harvest index of cabbage was found non-significant (Appendix 2). However, the highest harvest index (64.91) was observed in treatment (chemical fertilizer + chemical pesticide), and it was at par with treatment (*Nasabike* manure + *Nasabike* agri-medicine), (chemical fertilizer + *Nasabike* agri-medicine), (*Nasabike* manure + chemical pesticide), and (chemical fertilizer + traditional method), while the lowest (51.01) was observed in treatment (chemical pesticide + FYM) (Table 13). Though, the higher harvest index was found in chemical plot, the difference with the *Nasabike* manure and agri-medicine applied plot is very nominal, i.e. 1.72. The result indicated that the interaction of *Nasabike* manure and agri-medicine contributes to harvest index of cabbage nearly similar with chemical fertilizer and pesticide.

4.1.6 The average days to maturity

The effect of different plant protection measures on the days to maturity of cabbage head was found significant (Appendix 3). The highest days to maturity (61.56

days) was observed in the traditional method, while the lowest duration (59.67 days) was observed in treatment with *Nasabike* agri-medicine (Table 14).

Table14. Effect of different types of fertilizer and plant protection measures on the average days to maturity of cabbage head

Treatment		Days to maturity DAT			
		Nasabike manure	Chemical fertilizer	FYM	Mean
Nasabike agri-medicine		55.67^{d}	61.67^{ab}	61.67^{ab}	59.67^{b}
Chemical pesticide		58.33^{c}	62.00^{ab}	63.33^{a}	61.22^{ab}
Traditional method		59.33^{bc}	61.67^{ab}	63.67^{a}	61.56^{a}
Mean		57.78^{b}	61.78^{ab}	62.89^{a}	60.815
SEM±	Individual	0.4806			
	Interaction	60.815			
$LSD_{0.05}$	Individual	1.441			
	Interaction	0.8325			
CV		2.37%			

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The effect of different types of fertilizer was found highly significant on the days to maturity of cabbage head (Appendix 3). The highest days to maturity (62.89 days) was observed in FYM, followed by 61.78 days in the treatment with chemical fertilizer, while the lowest (57.78 days) was observed in treatment with *Nasabike* manure (Table 14). The result showed that the response of *Nasabike* manure to the average days to maturity is better as compared to the chemical fertilizer because it contributed shortening the average days to maturity. Budathoki *et al* (2007) reported 65 days to maturity of chemically grown T-621 cabbage variety under Khumaltar condition.

The interaction effect of the combination of different fertilizers and plant protection measures on the days to maturity of cabbage head was found non-significant (Appendix 10). However, the highest duration (63.67days) for maturity was observed in treatment (FYM + traditional method). The lowest duration (55.67days) was observed in the treatment (*Nasabike* manure + *Nasabike* agri medicine) (Table 14). The interaction of *Nasabike* manure and agri-medicine showed the higher efficiency in shortening the days to maturity as compared to chemical and control plot. It also indicated that the higher yield in short duration can be achieved through the combination of *Nasabike* manure and agri-medicine.

4.1.7 The dry matter content

The effect of different plant protection measures on dry matter of cabbage head was found highly significant (Appendix. 3). The average dry matter content of cabbage head in the treatment with *Nasabike* agri-medicine was the highest (8.35%), followed by the same figure (7.91%) in both the treatment viz. traditional method and chemical pesticide (Table 15). The highest dry matter indicated the higher efficiency of *Nasabike* agri-medicine in improving the plant health by providing the plant nutrient during foliar application.

The effect of different types of fertilizer on dry matter content of cabbage head was found highly significant (Appendix 3). The highest dry matter (8.40%) was observed in the treatment with *Nasabike* manure, while the lowest (7.56%) was observed in FYM (Table 15). The contribution of *Nasabike* manure to the increment of dry matter was found higher as compared to chemical. The reason behind this might be the high nutrient content of *Nasabike* manure and the positive impact of the same to the soil and plant health.

Table 15. Effect of different types of fertilizer and plant protection measures on the dry matter content of cabbage head

Treatment		Dry matter content (%)			
		Nasabike manure	Chemical fertilizer	FYM	Mean
Nasabike agri-medicine		8.80 ^{a}	8.53^{ab}	7.73^{e}	8.35^{a}
Chemical pesticide		8.27^{bc}	8.26^{bc}	7.20^{f}	7.91^{b}
Traditional method		8.13^{cd}	7.86^{de}	7.73^{e}	7.91^{c}
Mean		8.40^{a}	8.22^{b}	7.56^{c}	8.06
SEM±	Individual	0.05774			
	Interaction	0.1000			
$LSD_{0.05}$	Individual	0.1731			
	Interaction	0.2998			
CV		2.16%			

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The interaction effect of the combination of different fertilizers and pesticides on dry matter of cabbage head was found highly significant (Appendix 3). The highest dry matter (8.80%) was observed in the treatment (*Nasabike* manure + *Nasabike* agri-medicine) and it was at par with treatment (chemical fertilizer + *Nasabike* agri-medicine). The lowest (7.20%) was observed in treatment (FYM + chemical fertilizer) (Table 15). The highest dry matter of cabbage produced from the plot with *Nasabike* manure and agri-medicine demonstrated that the interaction of the same is better as compared to other combination. Highest dry matter indicates the high nutritional status, so the *Nasabike* manure and agri-medicine can improve the nutritional status of cabbage thereby increasing the quality.

4.1.8 The storage duration of cabbage head

The effect of different types of pesticide on the storage duration of cabbage head was found highly significant (Appendix 3). The maximum duration (26.89 days) was observed in the treatment with *Nasabike* agri-medicine. The shortest duration (23.67 days) was observed in the treatment with chemical pesticide (Table 16). This result revealed that, the chemical pesticide is not good as it reduces the storage life of cabbage head. The reason behind this might be the chemical residue, that spoil the storage life, and the high level of water content in chemically produced head. On the other hand, the impact of *Nasabike* agri-medicine to the storage life was positive as it was longer.

The effect of different types of fertilizers on the storage duration of cabbage head was found highly significant (Appendix 3). The maximum duration (27.22 days) was observed in the FYM plot, while the shortest duration (23.78 days) was observed in the treatment with chemical fertilizer (Table 16). The result revealed that the storage life of chemically produced cabbage is normally shorter as compared to organically produced.

Table 16. Effect of different types of fertilizer and plant protection measures on the storage duration of cabbage head

Treatment		Storage duration (day)			Mean
		Nasabike manure	Chemical fertilizer	FYM	
Nasabike agri-medicine		27.67^{a}	24.67^{b}	28.33^{a}	26.89^{ab}
Chemical pesticide		23.67^{b}	22.67^{b}	24.67^{b}	23.67^{b}
Traditional method		28.33^{a}	24.00^{b}	28.67^{a}	27.00^{a}
Mean		26.56^{ab}	23.78^{b}	27.22^{a}	25.85
SEM±	Individual	0.4170			
	Interaction	0.7223			
$LSD_{0.05}$	Individual	1.250			
	Interaction	2.165			
CV		4.84%			

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The interaction effect of the combination of different fertilizers and pesticides on storage duration of cabbage head was found non-significant (Appendix 3). However, the maximum duration (28.67 days) was observed in the treatment (FYM + traditional method). The shortest storage duration was observed in the treatment (chemical fertilizer + chemical pesticide), i, e. 22.67 days. (Table. 16). The result revealed that the organically produced cabbage head perform better in the storage as it can remain fresh for longer duration as compared to the chemically produced.

4.1.9 Weight loss during storage

The effect of different types of pesticide on the weight loss of cabbage head during storage was found significant (Appendix 3). During storage period the maximum average weight loss (12.61 gm day^{-1}) was observed in the traditional method of pest control, while the minimum average weight loss (10.90 gm day^{-1}) was observed in the treatment with *Nasabike* agri-medicine (Table 17).

Table 17. Effect of different types of fertilizer and plant protection measures on the average weight loss of cabbage head during storage.

Treatment	Average weight loss (gm day^{-1})			Mean
	Nasabike manure	Chemical fertilizer	FYM	
Nasabike agri-medicine	09.90^{d}	12.73^{abc}	10.08^{d}	10.90^{c}
Chemical pesticide	11.07^{cd}	13.34^{ab}	10.85^{cd}	11.75^{b}
Traditional method	12.26^{bc}	14.18^{a}	11.41^{cd}	12.61^{a}
Mean	11.08^{b}	13.41^{a}	10.77^{c}	11.75
SEM± Individual	0.3307			

	Interaction	0.5727
$LSD_{0.05}$	Individual	0.9913
	Interaction	1.717
CV		8.43%

Means within the column and row followed by the same letter are not significantly different at 5% level of significance by DMRT

The effect of different types of fertilizers on the weight loss of cabbage head during storage was found highly significant (Appendix 3). The maximum weight loss (13.41 gm day^{-1}) was observed in the treatment with chemical fertilizer, while the minimum weight loss (11.08gm day^{-1}) was observed in the treatment with *Nasabike* manure (Table 17).

The interaction effect of the combination of different fertilizers and pesticides on the weight loss of cabbage head during storage was found non-significant (Appendix 3). However, The maximum weight loss (14.18gm day^{-1}) was observed in the treatment (chemical fertilizer + traditional method), and it was at par with treatment (chemical fertilizer + chemical pesticide). The minimum weight loss (9.90gm day^{-1}) was observed in treatment (*Nasabike* manure + *Nasabike* agri-medicine) (Table 17). This result revealed that quality of chemically produced cabbage is inferior as it showed shorter storage duration and higher weight loss in storage.

4.2 Effect of types of fertilizer and plant protection measures on population and diversity of weed

The effect of different sources of fertilizer to the population and diversity of weeds in different ecological zones was found significant (Appendix 4). Both the weed population and diversity was found higher in Godak where as the least population and diversity was recorded from Puwamajhuwa. The population and diversity was higher in the plots with farm yard manure followed by *Nasabike* manure and chemical fertilizer.

The effect of ecological zone was high in the population of weed as the population of weed in warm area i.e. Godak was significantly higher followed by Singfring and Puwamajhuwa area viz. mild and cold area respectively. In all three places the plots with farm yard manure have highest weed population, density and the diversities in terms of genera and species of weed, where as the plots with chemical fertilizers contained fewer weed population (Table. 18, 19, 20 and 21). The reason behind the same may be the presence of weed seed in farm yard manure, *Nasabike* manure and chemical fertilizer do not contain weed seed, so both the weed population and diversity in plots other than FYM is low.

Table 18. Effect of different types of fertilizers on the weed population in cabbage field at three places of Ilam,

SUMMARY	Farm yard manure	*Nasabike* manure	Chemical fertilizer	Total
Godak				
Replication	3	3	3	9
Sum	2088	1044	870	4002
Mean	696	348	290	444.67
Variance	47163	4116	5427	50339.5
Singfring				
Replication	3	3	3	9
Sum	829	614	562	2005

Mean	276.33	204.67	187.33	222.78
Variance	10234.33	5854.33	3690.33	6614.44
Puwamajhuwa				
Replication	3	3	3	9
Sum	297	65	46	408
Mean	99	21.67	15.33	45.33
Variance	3411	202.33	22.33	2536.50
Total				
Replication	9	9	9	
Sum	3214	1723	1478	
Mean	357.11	191.44	164.22	
Variance	85699.11	22609.03	16730.69	

The density of weed in FYM plot and *Nasabike* plot was found higher in all 3 locations. It revealed that the weed density is more in organic plots which was also supported by Hald (1999) as density of non-crop flora in conventional cereal fields was around a third of that in organic fields. In FYM plot highest density was recorded in Godak, which is warmer area and lowest density was recorded in Puwamajhuwa that represents cold area. Similarly in chemical plots the weed density in Godak was 88.93 sq m^{-1} while the weed density in Puwamajhuwa was only 9.07 sq m^{-1}. In Singfring, the weed density was found in between of two locations (Table. 19). It shows that the effect of source of fertilizers and the ecological zone to the population and density of weed is highly significant (Appendix. 4). It can be concluded that both the population and density of weed is always higher in warm area and in lesser in cold area and the same way it is always higher in organic plot as compared to chemical treated plots.

Table 19. Effect of different types of fertilizers on the density of weed in cabbage field at three places of Ilam,

SUMMARY	FYM	*Nasabike* manure	Chemical fertilizer	Total
Godak				
Replication	3	3	3	9
Sum	417.60	208.80	174.00	800.40
Mean	139.20	69.60	58.00	88.93
Variance	1886.52	164.64	217.08	2013.58
Singfring				
Replication	3	3	3	9
Sum	165.80	122.80	112.40	401.00
Mean	55.27	40.93	37.47	44.56
Variance	409.37	234.17	147.61	264.58
Puwamajhuwa				
Replication	3	3	3	9
Sum	59.40	13.00	9.20	81.60
Mean	19.80	4.33	3.07	9.07
Variance	136.44	8.09	0.89	101.46
Total				
Replication	9	9	9	
Sum	642.80	344.60	295.60	
Mean	71.42	38.29	32.84	
Variance	3427.96	904.36	669.23	

The number of genera of weeds was higher in FYM treated plot in Godak followed by Singfring. The mean value of number of genera in FYM treated plot in Godak, Singfring and Puwamajhuwa was 4.67, 3.67, and 3 respectively while the same in chemical plot in the same location is low. Similar result was reported in case of species diversity of weed. Higher composition of weed species in organic plot in warm area and lowest was reported in cold area (Table. 20 and 21).

Table 20. Effect of different types of fertilizers on the generic diversity of weeds in cabbage fields at three places of Ilam.

SUMMARY	FYM	*Nasabike* manure	Chemical fertilizer	Total
Godak				
Replication	3	3	3	9
Sum	14	12	10	36
Mean	4.67	4	3.33	4
Variance	1.33	0	1.33	1
Singfring				
Replication	3	3	3	9
Sum	11	9	10	30
Mean	3.67	3	3.33	3.33
Variance	0.33	0	2.33	0.75
Puwamajhuwa				
Replication	3	3	3	9
Sum	9	5	3	17
Mean	3	1.67	1	1.89
Variance	0	0.33	0	0.86
Total				
Replication	9	9	9	
Sum	34	26	23	
Mean	3.78	2.89	2.56	
Variance	0.94	1.11	2.28	

Similar finding is reported by Frieben and Kopke (1995) as the mean number of weed species in both margins and cereal fields was more than twice as high under organic management. The finding revealed that both the diversity of genera and species is always higher in farm yard manure treated land. Besides, the ecological zone has also effect on the diversity and number of weed genera. The current study revealed that the diversity and the number of genera is higher in warmer area as it was found higher in Godak which represent warm area and lower in Puwamajhuwa area which represent cold area while it was in between of two location in Singfring that represent mild climatic area.

Table 212. Effect of different types of fertilizers on the diversity of weed species in cabbage fields at three places of Ilam.

SUMMARY	Farm yard manure	*Nasabike* manure	Chemical fertilizer	Total
Godak				
Replication	3	3	3	9
Sum	22	16	15	53
Mean	7.33	5.33	5	5.89
Variance	0.33	0.33	1	1.61
Singfring				
Replication	3	3	3	9
Sum	19	12	13	44
Mean	6.33	4	4.33	4.89
Variance	2.33	0	2.33	2.36
Puwamajhuwa				
Replication	3	3	3	9
Sum	14	5	3	22
Mean	4.67	1.67	1	2.44
Variance	0.33	0.33	0	3.03
Total				
Replication	9	9	9	
Sum	55	33	31	
Mean	6.11	3.67	3.44	
Variance	2.11	2.75	4.28	

4.3 Effect of different fertilizers on soil and surface fauna

The effect of different fertilizers to the population and diversity of soil and surface fauna in different ecological zones was found significant (Appendix 5). Both the species and number of fauna was found higher in Godak where as the least diversity was recorded from Puwamajhuwa. The population and diversity was higher in the plots with farm yard manure followed by *Nasabike* manure and chemical fertilizer. The measures of plant protection applied on plots also influenced the number and types of faunal species as the highest number of species was observed in the plots with traditional measures of plant protection while least numbers and types of species was observed in plot with chemical pesticides (Fig. 8 and 9).

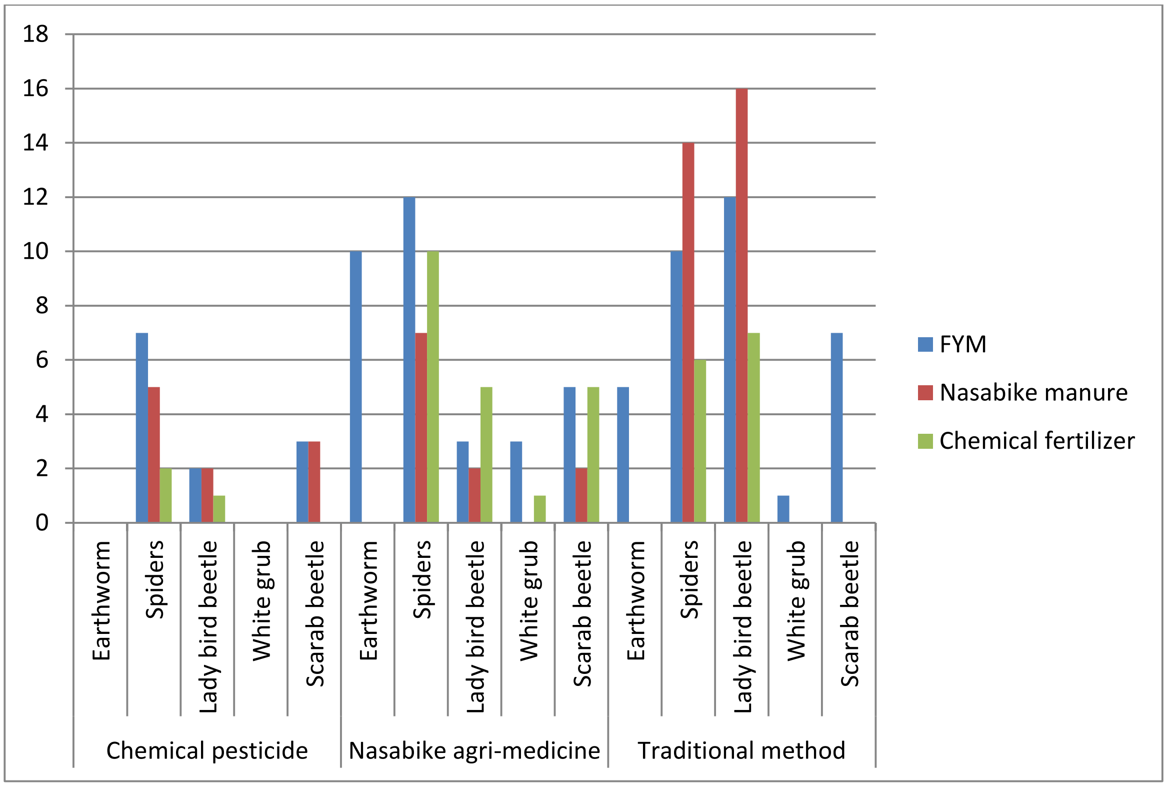

Fig 8. Types and average numbers of soil and surface fauna in different combination of fertilizers and plant protection measures

The major fauna observed in all location were earthworm and white grub under soil and ladybird beetle, scarab beetle, and spiders on soil surface. The highest numbers of scarab beetle was observed in Singfring in the plot with FYM as fertilizer combined

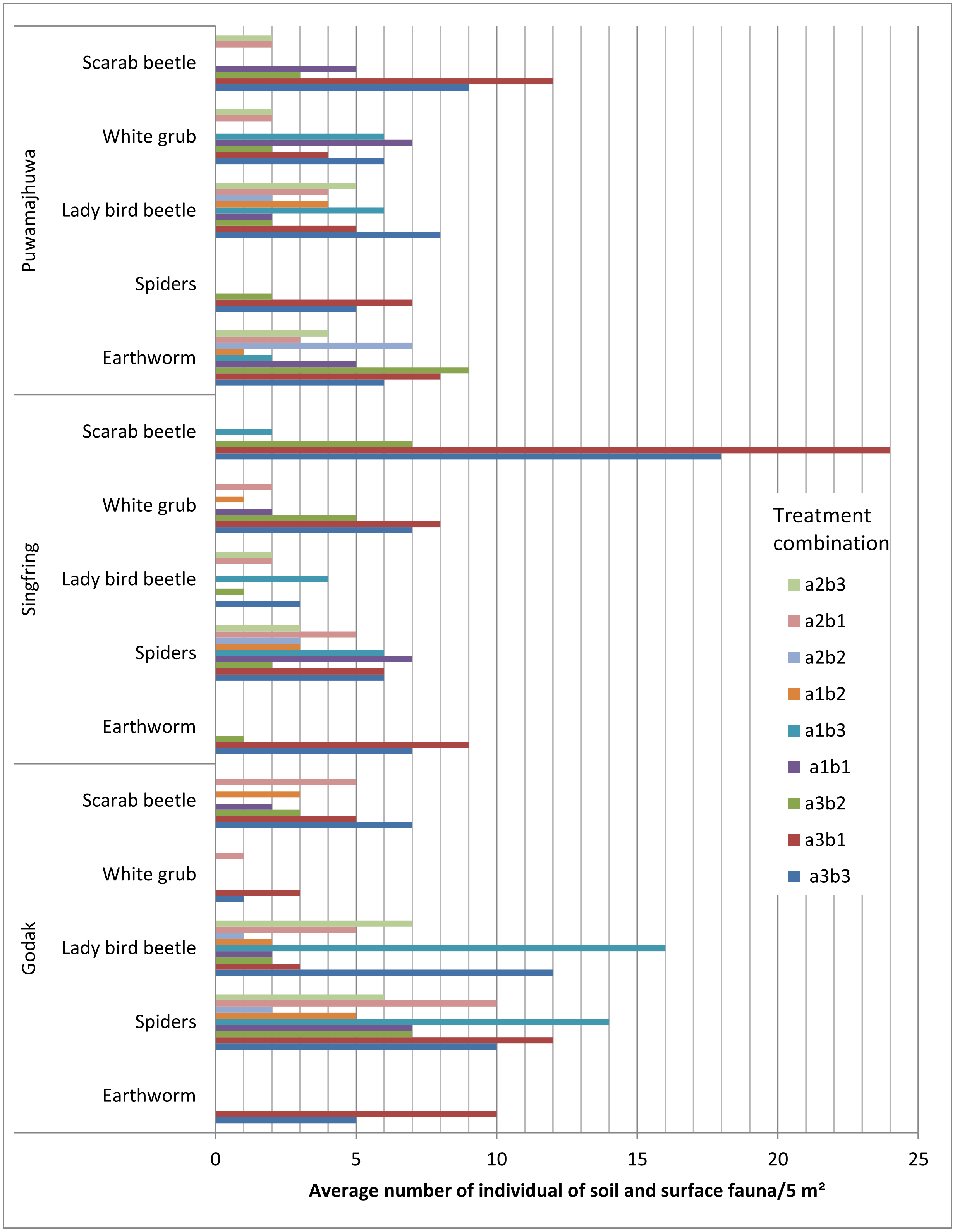

Fig 9. Type and average number of soil and surface fauna in different combination of fertilizers and plant protection measures in three location of Ilam.

with *Nasabike* agri-medicine as plant protection measures followed by the plot with FYM combined with traditional method of plant protection. Highest number of surface spider and ladybird beetle was observed in Godak in the plot treated with *Nasabike* manure as fertilizer combined with traditional method of plant protection followed by the plot with FYM combined with traditional plant protection measures. The highest number of white grub was observed in Singfring in the plot with FYM and *Nasabike* manure followed by the plot with FYM and traditional method of plant protection.

The result of the observation show that the species and numbers of fauna is always in organic plots because of suitable environment for fauna. The current study showed that the plot treated with chemical fertilizer and chemical pesticide was free of earthworn while the plot with FYM and organic pest management method have higher number of earthworm. Pfiffner and Luka (2007) also reported that the mean biomass, abundance and species richness of earthworms found higher in the organic fields. Other several work supported the finding as Brown (1999) reported higher earthworm abundance (almost twice the density) and species diversity, both in-field and within grass margins, in organic than conventional fields. Similarly, Gerhardt (1997); Brooks et al. (1995); Liebig and Doran (1999); and Berry and Karlen (1993) reported that organic sites held larger and more active earthworm populations.

In case of surface spider, lady bird beetle, scarab beetle the higher number was observed in organic plots and similar result was reported in several studies. Booij and Noorlander (1992), Moreby et al. (1994), Reddersen (1997), Pfiffner and Luka (2003) and

Pfiffner and Niggli (1996) all reported a higher abundance of spiders under organic management (up to twice as many spiders on organic (Pfiffner and Niggli, 1996)), although differences were not always statistically significant across studies and years. Organically managed fields contain a greater abundance and diversity of arthropods than conventionally managed fields (Berry et al., 1996; Brooks et al., 1995; Letourneau and Goldstein, 2001; and Reddersen, 1997) and similar result was obtained in current study. Several other studies across world also supported that the higher species richness of carabids on organically managed fields (Booij and Noorlander, 1992; Carcamo et al., 1995; Clark, 1999; Dritschilo and Wanner, 1980; Hokkanen and Holopainen, 1986; Irmler, 2003; Kromp, 1989; Kromp, 1990; O'Sullivan and Gormally, 2002; Pfiffner and Luka, 2003; Pfiffner and Niggli, 1996; and Reddersen, 1997)

4.4 Effect of different fertilizers on physico-chemical properties of soil

The effect of different fertilizers to the soil pH, total nitrogen, phosphorus, potassium, and organic matter was found significant. Overall soil physico-chemical properties was found better in organic plots as compared to chemical plots.

The effect of fertilizers on the pH of soil found significant. The pH in FYM and *Nasabike* manure treated plots increased significantly in all three locations. The increment of pH in FYM treated plot was highest in Puwamajhuwa followed by Singfring and Godak. The *Nasabike* manure treated plot shows similar result in pH increment in all three locations. In case of chemical fertilizer treated plot, the pH in chemical fertilizer treated plot was found decreased than before trial while in Singfring and Godak it was found increased (Fig. 10).

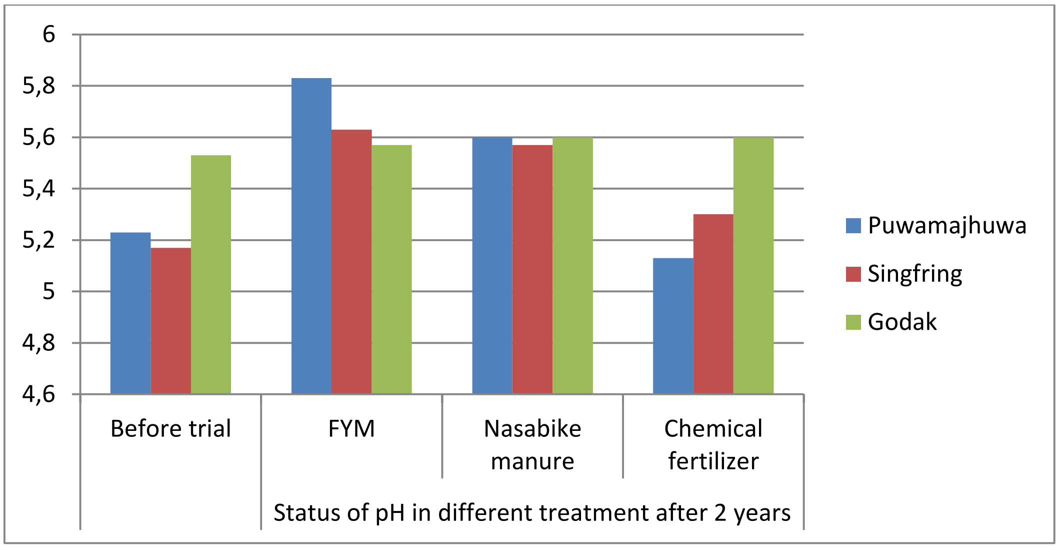

Fig. 10. Status of pH in different fertilizer applied plots in 3 ecological zones of Ilam

The effect of fertilizer sources to the soil nitrogen was also significant. The FYM treated plot in all three location showed good nitrogen which was increased significantly in Puwamajhuwa and the reason behind this may be the slow release of nutrient from organic fertilizers in temperate zone. The same FYM treatment in Godak that represent subtropical zone did not increase soil nitrogen as compared to Puwamajhuwa and Singfring because of fast release of nutrient in warm area. The increased of nitrogen in Singfring in FYM treated plot was in between of Puwamajhuwa and Godak.

In case of Phosphorus, *Nasabike* manure performed good in all three locations. The highest increment of phosphorus kg ha^{-1} was recorded in Singfring in *Nasabike* manure treated plot followed by FYM and Chemical fertilizer treated plot respectively. In Godak the highest increment of phosphorus reported from FYM treated plot followed by

Nasabike manure and chemical fertilizer. In Puwamajhuwa the increment of phosphorus was not significant and the chemical fertilizer treated plot performed better. The result of soil phosphorus analysis showed that the organic fertilizer performs better in terms of increment of available phosphorus in soil (Fig. 12).

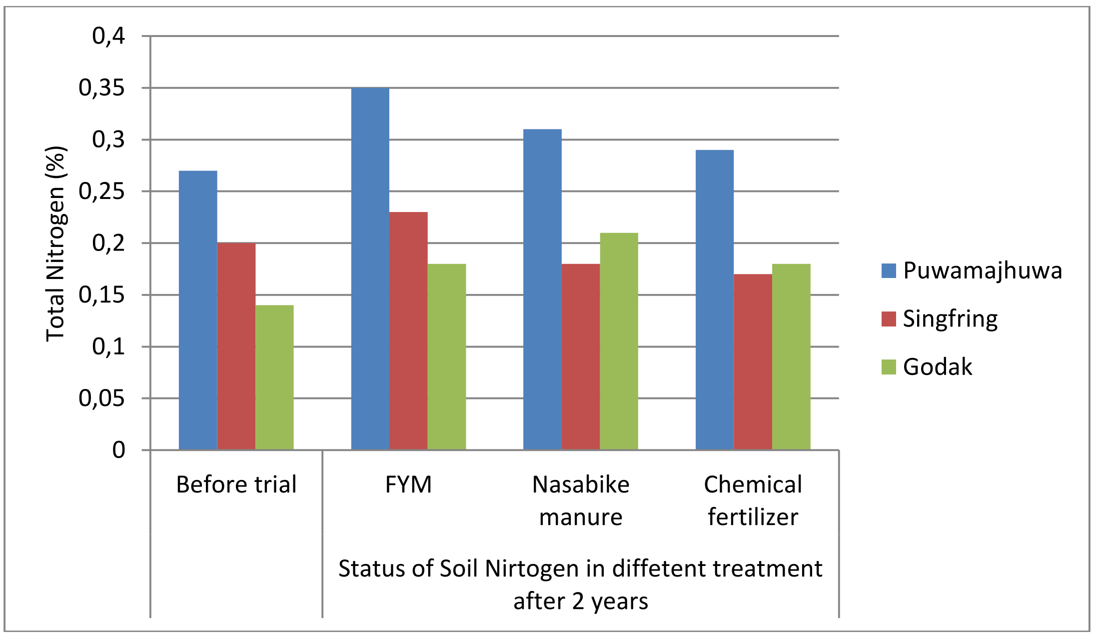

Fig. 11. Status of total nitrogen in different fertilizer plots in 3 ecological zones of Ilam

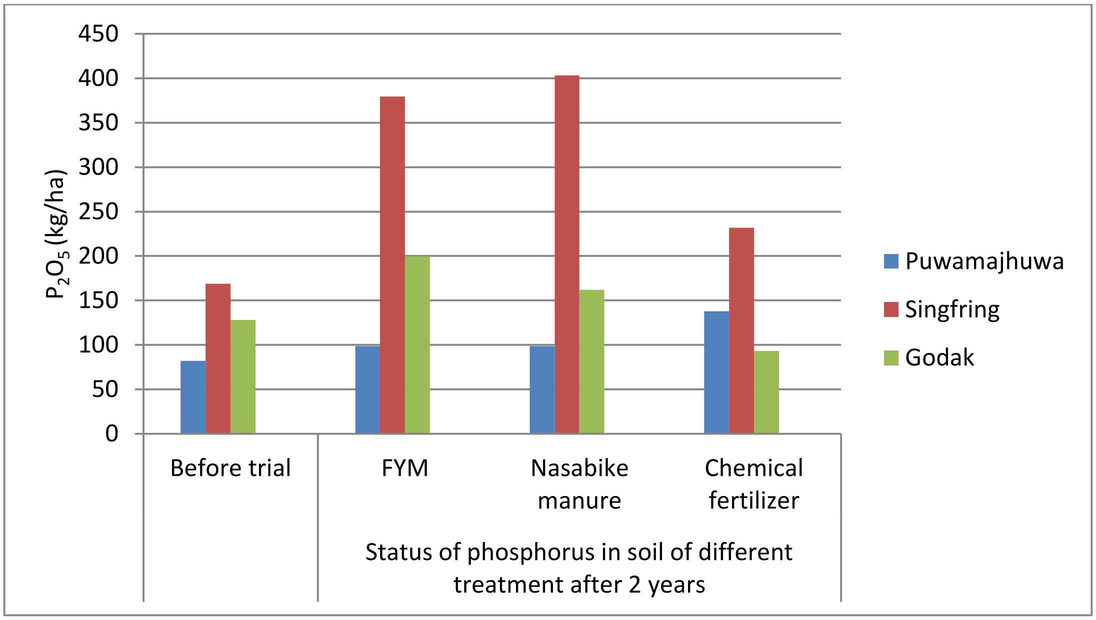

Fig. 12. Status of total nitrogen in different fertilizer plots in 3 ecological zones of Ilam.

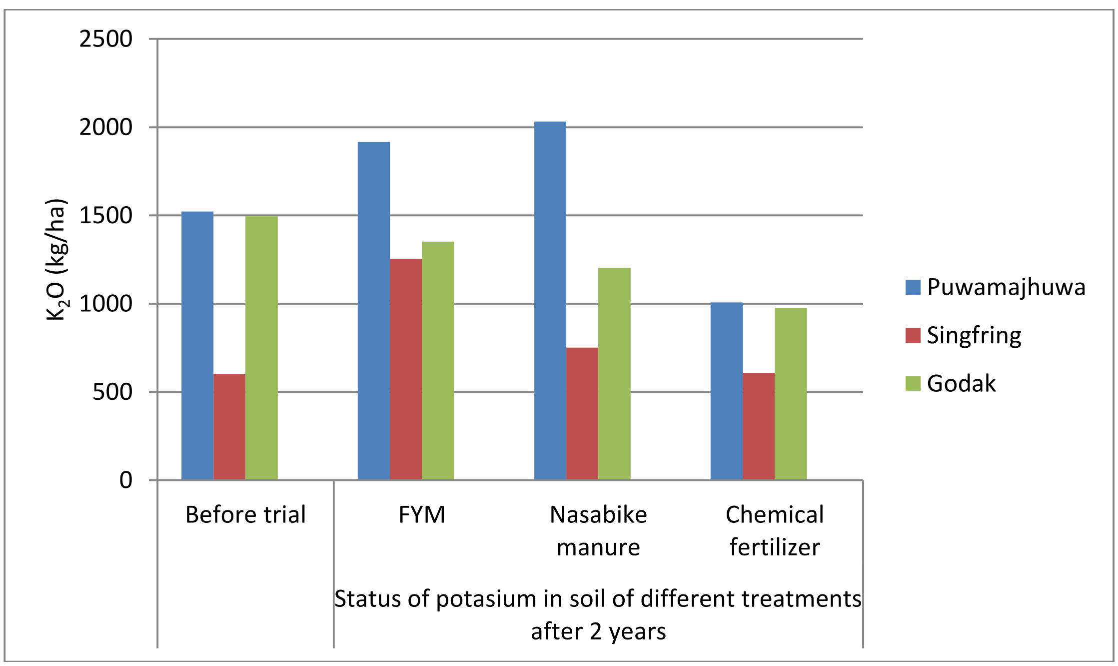

Fig. 13. Status of potassium in different fertilizer plots in 3 ecological zones of Ilam

Farm yard manure (FYM) performed better for the availability of potassium in soil in all locations however it was lesser in Godak that represents warm climate. The highest increment of potassium in soil was reported from *Nasabike* manure treated plot in Puwamjhuwa followed by FYM treated plots. Similarly in Singfring the highest availability of potassium was reported from FYM treated plot followed by *Nasabike* manure treated plot. In Godak, the availability of potassium was decreased in all treatments (Fig. 13).

In case of soil organic matter, the FYM performed best in all three location as the organic matter content was increased significantly. Highest increment of organic matter was reported from Puwamajhuwa followed by Godak and Singfring area however the difference of the same in Godak and Singfring was nominal. In chemical fertilizer treated plot the organic matter in soil was decreased in Puwamajhuwa and Singfring while it was increased in Godak and the reason behind this may be the higher weed population in warm area which adds organic matter after incorporated in soil (Fig. 14).

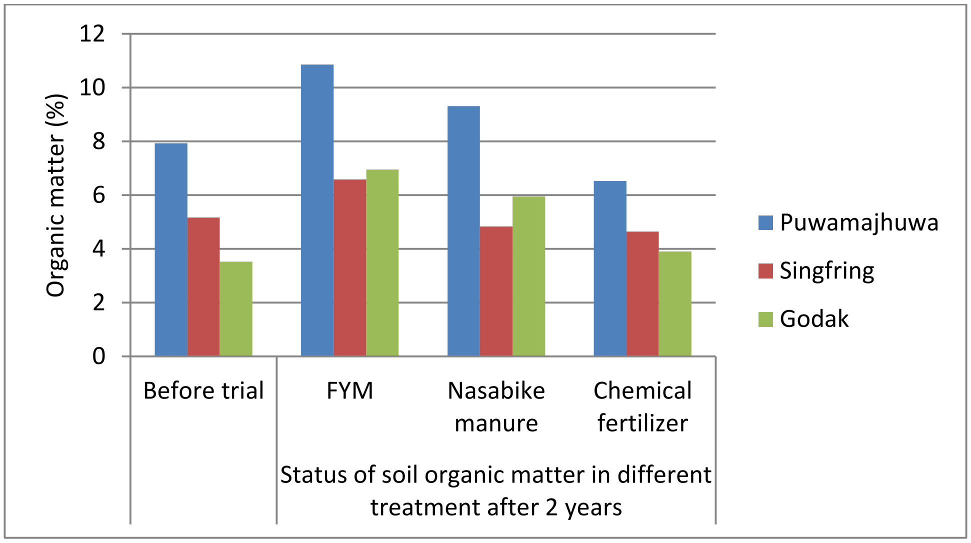

Fig. 14. Status of soil organic matter in different fertilizer plots in 3 ecological zones of Ilam

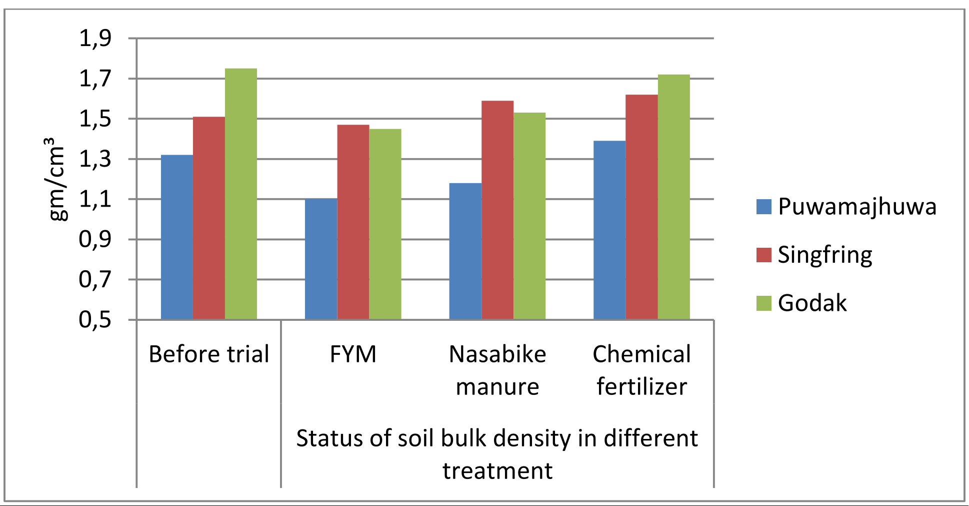

Fig. 15. Status of soil bulk density in different fertilizer plots in 3 ecological zones of Ilam

In case of Bulk density the FYM performed better than other fertilizers. The bulk density was significantly decreased in FYM treated plot in Puwamajhuwa followed by Godak and Singfring area. In chemical fertilizer treated plot the bulk density increased in

Puwamajhuwa and Singfring, however nominal decrease was reported in Godak (Fig 15).

CHAPTER FIVE

SUMMARY AND CONCLUSION

Until 1960s almost all farming in Nepal was using organic inputs produced in household level. From 1965 government encouraged the use of high yielding crop varieties, chemical fertilizers and pesticides to increase crop productivity in order to meet the food requirement of ever increasing population. In the beginning bags of chemical fertilizers were distributed freely to the farmers. Similarly, use of pesticides and other agrochemicals were also promoted to the farmers through trainings, demonstration and other communication means. Gradually use of agrochemicals increased in the country. Average consumption of agrochemicals is still low as compared to other south Asian countries, however unbalanced use of agrochemical is widespread in the areas where commercial production of crops has already started. Commercial vegetable farming is one of the major agro-based income generating activities in peri-urban and rural areas of Nepal in general and particularly in Ilam. Among different vegetables, cabbage becoming popular as it can be grown throughout year in Ilam condition.

Common cabbage, *Brassica oleracea* L. var. *capitata* (2n=18) is an important, widely grown commercial vegetable is Nepal. It is one of the vegetables having domestic as well as international demand, and produced in hills, and Terai as well. It is consumed as cooked vegetable, raw as salad, pickled, and as other form as per local preferences. In Ilam district, it ranks second place in terms of area, and production after broad leaved mustard (*Rayo*). These days, the commercial production of organic cabbage in Ilam is getting more attention, but the quality production is one of the major challenges in the absences of alternatives to agro-chemicals. *Nasabike* manure and *Nasabike* agri-medicine, the innovation of Namsaling Community Development Center (NCDC), Ilam are promising alternatives to agro-chemicals to go organic for quality production of cabbage and to ensure positive impact on human health and environment.

The study on the 'Effect of organic farming on cabbage crop ecology with reference to productivity, biodiversity and soil properties in Ilam, Nepal' was accomplished through multi location and multiyear trial research. The research sites were Puwamajhuwa, Singfring, and Godak representing the cold, mild, and warm climatic area of Ilam Municipality respectively.

In every location and every year the experiment field was prepared a month prior with a couple of hoeing. The F_1 hybrid cabbage variety 'T-621' was tested to evaluate the performance of different fertilizers and pesticides. The experiment was laid out in 2 factors factorial randomized complete block design (RCBD) with three replications. A total of 9 treatments with the combination of different fertilizer with different plant protection measures was given in each replication. The seedling of cabbage was transplanted with the spacing of 50cm x 40cm in each plot (2 m x 2.5 m).

Data on various growth parameters like number of leaf, length of leaf, width of leaf, plant height, plant spread, head diameter, head perimeter etc. were recorded at 20, 40 and 60 DATs. The yield and quality characteristics of cabbage like biological yield, head yield, average root weight plant^{-1}, harvest index, days to maturity, storage performance, and average weight loss head^{-1} day^{-1} was recorded after harvest of cabbage head. In addition, weed population and diversity, biodiversity, physic-chemical properties of soil were recorded during crop period and after harvest of crop.

The yield attributing characteristics like biological yield, head yield plant^{-1}, head diameter, head perimeter, harvest index, average root weight plant^{-1}, and quality attributing characters, like dry matter content, average storage duration, and average weight head^{-1} day^{-1} were also influenced by the individual as well as interaction effect of the different fertilizers and pesticides. Biological yield was the highest (116.17 mt ha^{-1}) in the treatment with chemical fertilizer, but the combination of *Nasabike* manure with *Nasabike* agri-medicine gave the highest biological yield, i.e. 122.7 mt ha^{-1}. The total head yield was the highest (95.67 mt ha^{-1}) in the combination of chemical fertilizer with chemical pesticide which was higher by 3.84 mt ha^{-1} as compared to treatment with *Nasabike* manure in combination with *Nasabike* agri-medicine. However, in case of marketable head yield this difference was found only of 1.17 mt ha^{-1} (chemical fertilizer + chemical fertilizer = 78.67 mt ha^{-1}, and *Nasabike* manure + *Nasabike* agri-medicine = 77.50 mt ha^{-1}). The harvest index of chemical treatment was 64.91 which was lower by only 1.72 than the treatment of *Nasabike* manure with *Nasabike* agri-medicine (63.19). The shortest days to maturity, i.e. 55.67 days was found in the treatment with *Nasabike* manure in combination with *Nasabike* agri-medicine. Similarly, the *Nasabike* manure in combination with

Nasabike agri-medicine gave the highest dry matter content, 8.80%, while chemical fertilizer in combination with chemical pesticide gave 8.26% dry matter. The storage duration of cabbage produced by *Nasabike* manure and *Nasabike* agri-medicine was 27.67 days, but in case of chemically produced cabbage the storage duration was only 22.67 days. In addition, the average weight loss/head/day was minimum, i.e. 9.90 gm day^{-1} in the cabbage produced by applying *Nasabike* manure and *Nasabike* medicine, while it was observed maximum 13.43 gm head^{-1} day^{-1} in chemically produced cabbage.

In case of weed population, density and diversity the maximum population, and diversity was found in the plot with FYM followed by Nasabike manure. All three parameters were high in Godak, representing warm area and gradually decreased as elevation increased. The diversity of soil and surface fauna was also high in FYM treated plot followed by Nasabike treated plots. The population and diversity of fauna was highest in Godak and lowest in Puwamajhuwa while in Singfring it was in between of two locations. Besides, the physico-chemical properties of soil was found better in the plot with FYM and Nasabike manure.

On the basis of the findings of the experiment, it can be concluded that the chemical farming gives good production but similar result can also be achieved by organic farming. The *Nasabike* manure if applied in combination with *Nasabike* agri-medicine can give production of cabage almost similar with chemical farming. Besides, organically produced cabbage has good quality as compared to that of chemically produced.

Sustainability is another important aspect of farming. The effect and impact of farming to the bio-diversity of farm, non crop biomass production, and soil properties play vital role in determining agriculture sustainability. The present study showed that organic fertilizers and plant protection measures perform better to enhance the bio-diversity, non crop biomass production per unit area, and the soil properties in farm. Based on the result of the research, it can be concluded that the production from organic farming is almost similar with chemical based farming, however quality is better in organic production. The overall effect and impact of organic farming to biodiversity, soil, and above all to the environment is positive which contribute to ensure agriculture sustainability in the long run.

The present study has established the fact that the performance of organic farming is better in terms of productivity, farm bio-diversity, soil properties, and pest status etc. leading the agriculture toward sustainability, however further study is necessary to find the performance of combination of different organic fertilizers, eg. Nasabike manure, FYM and other organic fertilizers.

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APPENDICES

Appendix 1: Biological yield, average root yield, and average aerial weight

ANOVA table: Biological yield (mt ha^{-1})

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	799.185	399.593	6.5654	0.0083
2	Factor A	2	716.963	358.481	5.8899	0.0121
4	Factor B	2	5165.352	2582.676	42.4340	0.0000
6	AB	4	834.315	208.579	3.4270	0.0332
-7	Error	16	973.815	60.863		
	Total	26	8489.630			

Coefficient of Variation: 7.41%

ANOVA table: Average root weight (gm $plant^{-1}$)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	51.185	25.593	1.8054	0.1963
2	Factor A	2	15.407	7.704	0.5434	
4	Factor B	2	1760.296	880.148	62.0875	0.0000
6	AB	4	141.481	35.370	2.4951	0.0843
-7	Error	16	226.815	14.176		
	Total	26	2195.185			

Coefficient of Variation: 4.75%

ANOVA table: Average aerial weight (kg $plant^{-1}$)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.305	0.153	6.4632	0.0088

2	Factor A	2	0.293	0.146	6.1923	0.0102
4	Factor B	2	2.185	1.093	46.2455	0.0000
6	AB	4	0.334	0.084	3.5377	0.0299
-7	Error	16	0.378	0.024		
	Total	26	3.496			

Coefficient of Variation: 7.58%

Appendix 2: Total head yield, marketable head yield, harvest index

ANOVA table: Average total head yield (mt ha^{-1})

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	1131.202	565.601	10.9205	0.0010
2	Factor A	2	542.196	271.098	5.2343	0.0178
4	Factor B	2	4434.362	2217.181	42.8087	0.0000
6	AB	4	818.402	204.601	3.9504	0.0204
-7	Error	16	828.684	51.793		
	Total	26	7754.847			

Coefficient of Variation: 9.24%

ANOVA table: Marketable head yield (mt ha^{-1})

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	916.096	458.048	9.0588	0.0023
2	Factor A	2	456.027	228.013	4.5094	0.0280
4	Factor B	2	3581.127	1790.563	35.4121	0.0000
6	AB	4	689.133	172.283	3.4073	0.0338
-7	Error	16	809.018	50.564		
	Total	26	6451.400			

Coefficient of Variation: 11.43%

ANOVA table: Harvest index

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	159.044	79.522	5.9654	0.0116

2	Factor A	2	34.283	17.141	1.2859	0.3035
4	Factor B	2	348.786	174.393	13.0823	0.0004
6	AB	4	111.150	27.787	2.0845	0.1305
-7	Error	16	213.288	13.330		
	Total	26	866.550			

Coefficient of Variation: 6.26%

Appendix 3: Storage duration, weight loss, days to maturity, and dry matter content

ANOVA table: Average storage duration (day)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	0.296	0.148	0.0947	
2	Factor A	2	64.519	32.259	20.6154	0.0000
4	Factor B	2	60.074	30.037	19.1953	0.0001
6	AB	4	9.481	2.370	1.5148	0.2449
-7	Error	16	25.037	1.565		
	Total	26	159.407	Coefficient of Variation: 4.84%		

ANOVA table : Average weight loss during storage (gm day^{-1})

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	3.581	1.791	1.8205	0.1939
2	Factor A	2	13.210	6.605	6.7155	0.0076
4	Factor B	2	37.553	18.776	19.0899	0.0001
6	AB	4	1.001	0.250	0.2545	
-7	Error	16	15.737	0.984		
	Total	26	71.083	Coefficient of Variation: 8.43%		

ANOVA table: Average days taken for maturity (DAT)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	2.074	1.037	0.4989	
2	Factor A	2	18.296	9.148	4.4009	0.0300
4	Factor B	2	130.074	65.037	31.2873	0.0000
6	AB	4	10.370	2.593	1.2472	0.3309
-7	Error	16	33.259	2.079		
	Total	26	194.074	Coefficient of Variation: 2.37%		

ANOVA table: Total dry matter content (%)

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	2	1.221	0.610	20.0976	0.0000
2	Factor A	2	1.185	0.593	19.5122	0.0001
4	Factor B	2	3.567	1.784	58.7317	0.0000
6	AB	4	0.806	0.201	6.6341	0.0024
-7	Error	16	0.486	0.030		
	Total	26	7.265	Coefficient of Variation: 2.16%		

Appendix 4: Weed population, density and diversity

ANOVA table: weed population

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Ecological zone	720565	2	360282.5	40.471	2.18E-07	3.555
Fertilizers	196177.9	2	98088.93	11.018	0.001	3.555
Interaction	119504.4	4	29876.09	3.356	0.032	2.928
Within	160241.3	18	8902.296			
Total	1196489	26				

ANOVA table: Weed density

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Ecological zone	28822.60	2	14411.30	40.471	2.18E-07	3.555
Fertilizer	7847.11	2	3923.56	11.018	0.001	3.555
Interaction	4780.17	4	1195.04	3.356	0.032	2.928
Within	6409.65	18	356.09			
Total	47859.54	26				

ANOVA table: Weed genera

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Ecological zone	20.963	2	10.481	16.647	8.07E-05	3.555
Fertilizer	7.185	2	3.593	5.706	0.012	3.555
Interaction	2.370	4	0.593	0.941	0.463	2.928
Within	11.333	18	0.630			
Total	41.852	26				

ANOVA table: weed species

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Ecological zone	56.519	2	28.259	36.333	4.79E-07	3.555
Fertilizer	39.407	2	19.704	25.333	5.84E-06	3.555
Interaction	2.593	4	0.648	0.833	0.521513	2.928
Within	14	18	0.778			
Total	112.519	26				

Appendix 5: Population of soil and surface fauna

ANOVA table:

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Ecological zone	101.733	2	50.867	2.9708	0.064	3.259
Fertilizer	64.133	2	32.067	1.8728	0.168	3.259
Interaction	46.533	4	11.633	0.6794	0.611	2.634
Within	616.4	18	17.122			
Total	828.8	26				