EFFICACY OF MULCHING AND FARM YARD MANURE ON OKRA (*Abelmoschus esculentus* L.) PRODUCTIVITY DURING SPRING-SUMMER SEASON AT NAWALPARASI, NEPAL

KHEM PRASAD OLI

JANUARY 2015

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KHEM PRASAD OLI

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REQUIREMENTS FOR THE

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(CONSERVATION ECOLOGY)

JANUARY 2015

CERTIFICATE

This is to certify that the thesis entitled **"EFFICACY OF MULCHING AND FARM YARD MANURE ON OKRA (*Abelmoschus esculentus* L.) PRODUCTIVITY DURING SPRING-SUMMER SEASON AT NAWALPARASI, NEPAL"** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** with major in **Conservation Ecology** of the Postgraduate Program, Institute of Agriculture and Animal Science, Rampur, is a record of original research carried out by **Mr. KHEM PRASAD OLI, Id. No. R-2012-COE-05 M,** under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been acknowledged.

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ACRONYMS

%	Percentage
@	At the Rate of
<	Less than
AGDP	Agriculture Gross Domestic Product
ARS	Agricultural Research Station
AVRDC	The World Vegetable Center
B:C	Benefit/Cost Ratio
cm	Centimeters
Cu	Copper
DAM	Days After Mulching
DAS	Days After Sowing
df	Degree of Freedom
DMRT	Duncon's Multiple Range Test
Dr.	Doctor
et al.	And associates
etc	Etcetera
F test	Fisher's Significant Test

FAO	Food and Agriculture Organization
Fe	Ferrous
Fig.	Figure
FYM	Farm Yard Manure
g	Grams
ha	Hectare
i.e.	That is to Say or in Other Words
IAA	Indole Acetic Acid
IAAS	Institute of Agriculture and Animal Science
IBPGR	International Board for Plant Genetic Resource
IPCC	Inter Governmental Pannel for Climate Change
IRs.	Indian Rupees
K	Potash
kg	Kilo grams
kg ha^{-1}	Kilograms per Hector
km	Kilo Meters
LSD	Least Significance Difference
m	Meters

m^2	Meter Square
Mg	Magnesium
Mg ha^{-1}	Mega Gram per Hector
mm	Millimeter
Mn	Manganese
MoA	Ministry of Agriculture
MoAD	Ministry of Agriculture Development
MT	Metric Ton
N	Nitrogen
NARC	Nepal Agricultural Research Council
NHRDF	National Horticulture Research and Development Foundation
NPK	Nitrogen, Phosphorus and Potash
NS	Non significant
^{o}C	Degree Celsius
OM	Organic Matter
P	Probability
P	Phosphorus
pH	Negative Logarithm of Hydrogen Ion Activity in Solution

RCBD	Randomized Complete Block Design
Rs.	Nepalese Rupees
S.Em.	Standard Error of Mean
t/ha	Ton/ha
Tk.	Taka (Currency of Bangladesh)
V	Varieties
VDD	Department of Vegetable Development
WHO	World Health Organization
YVM	Yellow Vein Mosaic Virus
Zn	Zinc

1 INTRODUCTION

Okra *Abelmoschus esculentus* L. (Moench), is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. The vegetable holding India ranks first in the world with 3.5 million tonnes (70% of the total world production) of okra produced from over 0.35 million ha land (FAO, 2008). Recent years okra is growing commercially in Nepal. Total number of holdings of okra is 8,09,238 and total area covered by 9,555 ha. (Annual report, Department of Vegetable Development 2010/2011). Okra shares 5.1 % of total vegetable production area (Rekhi *et al.*, 1990) and VDD (1991). Okra provides an important source of vitamins, calcium, potassium and other mineral matters which are often lacking in the diet of developing countries (IBPGR, 1990). Its medicinal value has also been reported in curing ulcers and relief from hemorrhoids (Adams, 1975). 100 gm edible portion of okra contains Minerals 0.7 g, Protein 1.9 g, Carbohydrates 6.4 g, Fat 0.2 g, Calcium 66 mg, Fibre 1.2 g Iron 0.35 mg, Calories 35, Potassium 103 mg, Phosphorus 56 mg, Thiamine 0.07 mg, Sodium 6.9 mg, Nictonic acid 0.6 mg, Sulphur 30 mg, Vitamin C 13 mg, Riboflavin 0.1 mg, Magnesium 53 mg, Oxalic acid 8 mg and Copper 0.19 mg (Gopalan *et al.*, 2007).

A significant change in climate on a global scale will impact agriculture and consequently affect the world's food supply. Climate change *per se* is not necessarily harmful; the problems arise from extreme events that are difficult to predict (FAO 2001). More erratic rainfall patterns and unpredictable high temperature spells will consequently reduce crop productivity. Developing countries in the tropics will be particularly vulnerable. Latitudinal and altitudinal shifts in ecological and agro-economic zones, land degradation, extreme geophysical events, reduced water availability, and rise in sea level and salinization are postulated (FAO, 2004). Unless measures are undertaken to mitigate the effects of climate change, food security in developing countries in the tropics will be under threat.

Vegetables are the best resource for overcoming micronutrient deficiencies and provide smallholder farmers with much higher income and more jobs per hectare than staple crops (AVRDC, 2006). The worldwide production of vegetables has doubled over the past quarter century and the value of global trade in vegetables now exceeds that of cereals. In Asia, vegetable production grew at an annual average rate of 3.4% in the 1980s and early 1990s, from 144 million MT in 1980 to 218 million MT in 1993 (Ali, 2000). The total vegetable area in Nepal increased steadily from 82,000 ha in 1974 to about 140,000 ha in 1988. Vegetable area and yield both grew at an annual rate of about 3.0%, so total vegetable production in Nepal increased by 5.9% per year (MoA, 1995). According to vegetable survey report 2009/2010 there were 3,243,521 vegetable holding. Terai accommodates most of the vegetable holding (1.6 million). Total area under vegetable crops was estimated at 2,44,102 hectares. The total production of the vegetable crops turned out to be 32,03,563 metric tons where total household consumption contributed 1,100,710 metric tons (39 percent) and total sale contributed 1,719,818 (61 percent) in terms of the volume of the production. The proportion of sale was the highest in Central Terai (79.2 percent) and the lowest proportion is noted in Mountains (15.5 percent). The aggregate yield rate of vegetable crops was observed 12,142 kilogram per hectare. The highest yield rate was found in Central Terai (14,851 kg/ha) and the lowest rate was found in Far West development region (9,331 kg/ha).

Dry season vegetable like okra production is a great potential opportunity to get income of small land holding farmers. The growth of the vegetable market even during the dry season and the improved nutritional awareness of people, have attracted farmers to bring greater areas under vegetable farming in summer and spring seasons in the foot-hill and plain areas of Nepal. The market value of okra is high at dry season period. But decreased water availability, the area and production is not increasing as increasing of winter season vegetable crops. Therefore, there is great scope to utilize the conservation agricultural practices like organic mulching, and organic manure to cope the adaptive mechanism of climate change. However, water use of the crops may be greatly lowered by mulching to conserve soil moisture. This can be an important practical aid in water saving and to minimize the cost of water for the resource poor farmers. Increased soil–water storage due to mulching could also help increased availability and uptake of nutrients by plant roots. However, dry weather during this season creates a condition of water scarcity for many crops requiring frequent irrigation. Several studies reported mulch to conserve soil moisture and improve crop yield (Singh and Gangwar, 1972; Singh *et al.,* 1976) and reduce the water requirement at scarce period. Mulching the soil surface by organic matter favorably influences the soil moisture regime by controlling evaporation from the soil surface (Anikwe *et al.,* 2007), improves infiltration (Jones *et al.,* 1997), soil water retention (Bhagat & Acharya, 1987; Anikwe *et al.,* 2007). Peters (1997) stated that the use of plastic mulch reduced 50% in evaporation water losses in groundnut. Similarly, Abu- Awwad (1998) showed that covering the soil surface reduced irrigation requirement in pepper by about 14 to 29% as a result of elimination of soil evaporation. Mulching also controls the weed emergence and reduce the cost for weeding.

Organic manures as a means of maintaining and increasing soil fertility has been advocated (Rodale, 1984; Alasiri and Ogunkeye, 1999). Farm yard manure, when efficiently and effectively used; ensure sustainable crop productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields (Sharma and Mittra, 1991; Abou El Magd *et al.,* 2005). Manures are usually applied at higher rates, relative to inorganic fertilizers. When applied at high rates, they give residual effects on the growth and yield of succeeding crops (Makinde and Ayoola, 2008) Improvements of environmental conditions as well as the need to reduce cost of fertilizing crops are reasons for advocating use of organic materials (Bayu *et al.,* 2006). Organic manures improve soil fertility by activating soil microbial biomass (Ayuso *et al.,* 1996). Application of manures sustains cropping system through better nutrient recycling (El-Shakweer *et al.,* 1998). Manures provide a source of all necessary macro- and micro-nutrients in available forms, thereby improving the physical and biological properties of the soil (Abou El-Magd *et al.*, 2006).

1.1 Statements of problems

Nepal's economy is largely based on agriculture; it contributes about 40% to GDP and provides employment to two-thirds of the population. However, Nepalese agriculture is mainly rain fed, and agriculture production in both rain fed as well as irrigated areas are being badly affected due to droughts, flooding, erratic rainfall, and other extreme weather events. The stream water resources are disappearing and ground level water table is decreasing day by day. Nepal has a cultivated area of 2,642,000 ha (18% of its land area), of which two third (1,766,000 ha) is potentially irrigable. At present 42% of the cultivated area has irrigation of some sort, but only 17% of cultivated area has year round irrigation. An estimate shows that less than 8% of the country's water potential is used for irrigation (water resource of Nepal, 2011, MoE). Thus climate change and or climate variability is a constraint on vegetable production. It stresses the primary cause of crop losses worldwide, reducing average yields for most major crops by more than 50% (Boyer 1982, Bray *et al.,* 2000). The tropical vegetable production environment is a mixture of conditions that varies with season and region. Climatic changes will influence the severity of environmental stress imposed on vegetable crops. Moreover, increasing temperatures, reduced irrigation water availability, flooding, and salinity will be major limiting factors in sustaining and increasing vegetable productivity. Extreme climatic conditions will also negatively impact soil fertility and increase soil erosion and insect pest outbreaks.

Like flood, long drought period is another impact of climate change which is most important limiting factor for crop production and it is becoming an increasingly severe problem in many regions of the world (Passioura, 1996 and Passioura, 2007). Generally drought stress occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evaporation. (Khaje Hosseini *et al.,* 2003). The plants under dry condition change their metabolism to overcome the changed environmental condition. According to S. Kusvuran (2011) drought stress decreased the plant growth parameter; shoot fresh weight (FW) and dry weight (DW), leaf number, leaf area, plant height and stem diameter in all of the okra genotypes. Seed germination is one of the most important phases in the life cycle of plant and is highly responsive to existing environment. Drought decrease germination and seedling growth, and this are one important case to produce crops (Gamze *et al.,* 2005).

Temperature is rising at an average of 0.4° Celsius per decade hence affecting soil moisture because of increased evapotranspiration; rainy days are decreasing at a rate of 0.8 days per year (Regmi and Adhikari, 2007) leading to a delay in monsoon season and scarcity of water which in turn is causing a change in cropping patterns and crop maturity periods. Additionally high humidity provides a conducive environment for breeding of insects, bacteria and fungi leading to the rise of tropical diseases and also crop destroying pests become more prevalent (Regmi and Adhikari, 2007).

Despite the numerous uses of okra, its productivity is low due to drought condition and it is becoming costly due to the external use of inputs chemical fertilizers, pesticides, plant growth regulators, hormones and manual labour for weeding. The non judicious use of chemical pesticides and fertilizers is very serious to environment and human health hazards. It reduces the soil micro organism in soil and imbalance the predator prey relationship so that pest outbreak. Mulches can improve soil fertility, retain soil moisture and reduce weed problem (Schippers, 2000). It will also provide a source of nutrition, reduce erosion, run-off and contamination of soil water otherwise be lost to leaching, improve soil physical properties, and reduce cost of weed management (Schippers, 2000). Nepalese farming system is integrated and based on livestock and agro forestry. Farm yard manure is cheap a source of organic fertilizer which supply micro and macro nutrients to the plants. It also improves soil physical, biological and chemical properties. It supplies organic matter to the soil. The nutrient loss is lower because the organic matter slowly decomposes, mineralize and utilize by soil organism. Thus nutrients are available for relatively longer period. The organic manure also increases the cation exchange capacity of the soil.

1.2 Rational of the study

Due to the change in climate being widely experienced in Nepal, the temperature is rising at an average of 0.4° Celsius per decade hence affecting soil moisture because of increased evapotranspiration; rainy days are decreasing at a rate of 0.8 days per year (Regmi and Adhikari, 2007) that decrease the vegetable production and productivity specially dry season vegetables like okra. According to annual report of Vegetable Development Department, MoAD, government of Nepal 2010/2011 the area of okra coverage in Nepal is 9,555 hacter and in Nawalparasi district only 184 hacter and total production in Nepal is 105,878 Mt. and productivity is 11.08 Mmg ha^{-1}. But Nawalparasi district's productivity is only 10.51 Mmg ha^{-1}. The area and productivity is limiting due to the drought and decreasing level of water availability. Obviously, the organic mulching conserve the soil moisture and the FYM and mulching both improves the soil physical, chemical and biological properties. The interaction of mulching and FYM reduces the water requirement and increases the scarce water resources utilization efficiently and effectively.

Chemical fertilizers, pesticides, plant growth regulator are costly and increase the cost of production and decrease the net profit. The chemical fertilizers and pesticides have hazardous effect in human health, environment, soil microorganism and aquatic and terrestrial ecosystem. The chemical fertilizer mostly nitrogenous fertilizers enhance soil acidic and reduce soil microorganism activity and soil cation exchange capacity. Nepalese farming system is integrated with livestock and forestry. The farm yard manure (FYM) is organic manure produced from plant residues and animal dung. It is cheap source of plant nutrients and provides all necessary macro- and micro-nutrients in available forms, thereby improving the physical and biological properties of the soil (Abou El-Magd *et al.*, 2006).

There is no doubt that organic, sustainable agricultural practices can provide synergistic benefits that include mitigating climate change. As stated in the 2002 report of the United Nations Food and Agriculture Organization (FAO), organic agriculture enables ecosystems to better adjust to the effects of climate change and has major potential for reducing agricultural greenhouse gas emissions (Hattam *et al.*, 2002). The FAO report found that, "Organic agriculture performs better than conventional agriculture on a per hectare scale, both with respect to direct energy consumption (fuel and oil) and indirect consumption (synthetic fertilizers and pesticides)", with high efficiency of energy use. Since 1999, the Rodale Institute's long-term trials in the United States have reported that energy use in the conventional system was 200 percent higher than organic systems.

1.3 Objectives

Broad objective

- To evaluate the effect of mulching and FYM on okra production in response of drought condition in Nawalparasi district.

Specific objectives

- To evaluate the effect of mulching and FYM in okra production.
- To know the moisture retention capacity of soil under mulching and FYM levels.
- To assess the Benefit cost ratio of okra in conservation farming practices.

2 LITERTATURE REVIEW

2.1 General background

Okra is a member of the *Malvaceae* family which also includes fiber crop such as cotton. Okra popularly known as Bhindi belongs to the genus *Abelmoschus* (Sharma and Arora, 1993). This genus contains about 150 known species with *esculentus* as the cultivated species of okra (Thompson and Kelly, 1957).The present accepted binomial of okra is *Abelmoschus esculentus* (Duzyaman, 1997). It is originated in tropical Africa and was also grown in Mediterranean region and its wild forms are available in India (Hussain *et al.*, 2006). Commercial okra cultivars are erect, annual in growth habit and become woody at maturity. The main stem usually bears 2 to 5 branches per plant. The plant often reaches 60 to 180 cm in height, but an extremely tall type in central parts of Nepal reaches up to 4 m (Velayudhan and Upadhyay, 1994). Leaves are present at each node and fruits are born upright.

Plants flower 34 to 67 days after sowing. Although okra is assumed to be self pollinated, hermaphroditic flowers display entomophilous features such as colored petals, nectarines and sticky pollen grains. Cross pollination can reach up to 63% depending on the level of insect population and temperature (Duzyaman, 1997).

Vegetable is the most inexpensive and rich source of nutrients (Hossain, 1995). Okra fruits are nutritionally very rich. They contain carbohydrates (6.4%), proteins (1.9%), fats (0.2%), mineral (0.7%) and moisture (89.6%). They also contain β-carotene (53 mg), thiamine (0.07 mg), riboflavin (0.1 mg), vitamin C (13 mg), calcium (66 mg), magnesium (43 mg), oxalic acid (8 mg), phosphorus (56 mg), iron (1.5 mg), sodium (6.9 mg), potassium (103 mg), copper (0.19 mg) and sulphur (30 mg) per 100 gm edible portion (ICMR, 1980). Due to their high nutritive value, the tender fruits are generally marketed in the fresh state for use as vegetables, salad or sours. Sometimes it is marketed in canned or dehydrated forms. The black or brown-eyed seeds or ripe okra fruits are sometimes roasted and are used as substitute for coffee (Mehta, 1959). The plants are used in the paper industries and the stem for extraction of fiber (Dadhee, 1972). Leaves are consumed in some African countries (Charrier, 1984; Hamon *et al.,* 1986). The roots and stems of okra are used for clearing the cane juice from which brown sugar is prepared (Chauhan, 1972). Okra is said to be very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). In some places, the plants are soaked in water and resulting solution is used as clarifier in the manufacture of jaggery.

2.2 Climatic requirement of okra

Okra is grown throughout the tropics and warmer parts of the temperate zone (Sharma and Arora, 1993). It is widely cultivated as a summer crop in Nepal (Acharya, 2004). It is a summer season crop and requires long warm growing season. The plants make good growth in hot and humid weather during rainy season. It is sensitive to frost and thus requires frost free growing period. Okra seed planted early in the season (February-March) lead to poor germination and produce fewer plants per unit area than those planted in later season. This eventually reduces yield from plantings exercised before April at Chitwan condition (Shrestha, 1986). Optimum temperature requirement is 24 to 27^oC (Nath *et al.,* 1987). Monthly average temperature range of 21 to 30 ^oC is considered appropriate for growth, flowering and pod development (Tindal, 1983; Nonnecke, 1989). Seed does not germinate when temperature is below 20^oC (Chaudhary, 1979). There is no problem of seed germination during rainy season but there is a problem of poor germination in North Indian plains when sown in February. Temperature higher than 42^oC may cause flower drop (Chauhan, 1972).

In North Indian plains spring/summer crop is sown in February-March whereas in Eastern and Western India optimum sowing time is January-February. Out of 3 cropping seasons viz. winter, summer and rainy season, the rainy season crop gives the highest pod yield followed by summer season in India (Bisaria and Shamshery, 1979). The seed crop is usually sown in rainy season. The optimum time of sowing of seed crop is middle of June (Singh *et al.*, 1988).

2.3 Commercial okra varieties

Cultivars with outstanding agronomic traits and yield have largely been developed in the USA and India and are often among introductions to many tropical, subtropical and Mediterranean countries (Duzyaman, 2006). Most of the varieties cultivated in Nepal are introduced from India. Nepal Agriculture Research Council (NARC) has verified the performance of 'Parvani Kranti' an Indian variety in terai region, and released as 'Parvati' (Budhathoki *et al.*, 1998) while 'Arka Anamika', another Indian variety is also popularly cultivated in Nepal. Shagun is another important variety especially in the western part of Nepal.

India has developed several okra varieties such as Pusa Makhmali, Pusa Sawani, CO.1, MDU-1, Punjab Padmini, Gujarat Bhindi, Harbhajan, Selection-2, Parbhani Kranti, P-7, Arka Anamika and so on (Sharma and Arora, 1997). Due to considerable heterosis in yield and yield components and other characters like plant height, number of fruits per plant, fruit size, fruit weight, earliness and resistant to yellow vein mosaic virus (YVM), etc. Some private companies have developed hybrid variety in India (Hazra and Som, 1999). Some Indian hybrid varieties such as Anokhi, Uma, Vijaya Improved etc. and open pollinated varieties such as Parvani Kranti, Arka Anamika, K-51, Shagun, etc. are also available in Nepalese market.

Very few research works have been done in okra in Nepal and thus a few okra varieties have been exploited in the past. Pusa Sawani (Shrestha, 1986), Parvani Kranti and Arka Anamika have been tested in Rampur, Chitwan (Acharya, 2004).

2.4 Agro-techniques for spring summer okra production

2.4.1 Seed rate

Seed rate requirement for okra cultivation depends on the growing season and planting density. Specific seed rate for spring summer season has not been recommended in Nepal. However, the varied germination percentage reported in different sowing condition has emphasized the requirement of different seed rate. The recommended seed rate for okra cultivation is 12 to 14 kg/ha (Yawalkar, 1985). In India, some researches have been done considering different growing season. Saimbhi (1997) recommended 40-45 kg for February, 20-25 kg for March and 12-15 for June-July sowing. In Bangladesh, the highest yield (10.26 mg ha^{-1}) was obtained by using seed in the range of 18-22 kg/ha (Jahagir Kabir *et al.,* 2002). Higher amount of seed is required during spring summer season due to lower temperature which affects the germination of the okra seed. Higher seed rate is required for early crop also due to high density planting. If the seeds have low germination rate then higher seed rate reduces the risk of low plant population per unit of land.

2.4.2 Planting density

The vegetative and reproductive growth of okra is highly influenced by the growing environment. So the planting density should be varied according to sowing time. However, season specific planting density has not been recommended in Nepal. Acharya (2004) obtained the maximum production with the spacing of 45 cm x 30 cm under Rampur, Chitwan condition in April sowing. Suitable planting density is required because it influences the overall growth and productivity of okra. Hermann *et al.* (1990) first reported that not only final fruit yield, but also the distribution pattern of the yield through out the harvest period, is affected by the production system. At lower population densities (e.g. 4 plants/m^2) yield loadings shifted towards later stages of the harvest period, the second half of the yield being formed during the last 2 weeks within a production period of 3 months. At higher plant densities (e.g. 16 plants/m^2), however, most of the yield was attained prior to the mid-harvest period, accompanied by number of changes in the whole plant architecture. As population densities increased over all vegetative structure of the plants including leaf area and stem diameter decreased and plants became elongate. Number of lateral branches also decreased and contribution of lateral branches to fruit yield also decreased (down to zero). Furthermore, fruit diameter decreased, number of aborted buds and flower increased, flower initiation was delayed (for approx.10 days) and the number of generative nodes translated into fruits decreased. Similarly number of fruits per plant decreased, whilst fruit number and area increased (Duzyaman, 2006). In India, Godwa and Godwa (1981) found 45 cm x 30 cm spacing as best for winter season crop. Recent studies carried out at Jalandhar showed that a spacing of 30 cm x 15 cm was the best in case of both summer and rainy season. The wider spacing 67.5 cm x 20 cm resulted in earlier flowering (50.95 days) than 45 x 30 cm (51.96 days) in case of Varsa Upahar in Haryana condition of India (Yadav and Dhankhar, 1999). Dense plantings (14 plants/m^2) were suitable for seed production (Palanisamy and Karivaratharju 1984).

2.4.3 Nutritional requirement

Nutritional requirement of okra depends on various factors such as soil condition, growing season, varieties, etc. However, a total of 75 to 120 kg N /h a, 20 to 60 kg P_2O_5 /ha, plus 60 to 130 kg K_2O /ha is sufficient for fruit or seed production (Lee *et al.*, 1990). The highest pod yield was obtained with 75 kg N/ha (Wahab, 1978; Singh, 1978). Most important source of N for okra has been found to be urea (Singh and Singh, 1965).

Nitrogen leaching due to excessive rains (Mclaurin *et al.,* 1984) or non availability due to low soil moisture (Majanbu *et al.,* 1986) are the reasons for the ineffectiveness of nitrogen fertilizers to improve yield (Adejonwo *et al.,* 1989). Excess N fertilization can reduce yield by enhancing vegetative growth at the expense of fruit development (Lee *et al.,* 1989). Plant height and number of branches/plant increased with increasing rates of nitrogen. Number of green fruit, fruit yield, gross and net return as well as benefit cost-ratio were increased up to 100kg N/ha and thereafter declined at 150 kg N/ha in Bangladesh (Mozumder *et al.,* 2003). Rahman *et al.* (1992) obtained maximum fruit yield with 120 kg N/ha without organic manure. The optimum level of nitrogen for maximum yield of okra is 74.1 kg/ha and economic dose of nitrogen is 73.6 kg/ha with 5 mg ha-1 FYM in Bangladesh condition (Mozumder *et al.,* 2003). Nitrogen application generally increased fruit and shoot dry weights markedly whereas phosphorus increased them only moderately. Leaf and primary branch production and plant height were also enhanced by nitrogen fertilization up to 100 kg N/ha but were not influenced by phosphorus application. The application of nitrogen enhanced the concentration of N, P and K in fruits and N and Mg in leaves while P and K concentrations in leaves were depressed. Nutrient concentrations in plant tissues were also partly a function of plant age and variety (Majanbu *et al.,* 1986). Fertilizer was applied at the rate of 150 kg urea, 100 kg Triple Super Phophate (TSP) and 150 Murate of Potash (MOP)/ha in spring summer season in Bangaladesh (Rashid, 1993). Okra gives higher yield with the use of proper dose of fertilizer and trace element amendments (Koay and Chua, 1978). In general, trace element like molybdenum increases the stem length, node extension, number and weight of leaves at an early stage of growth. Molybdenum induces early flowering and early maturity of the fruits (Mozumder *et al.,* 2003). They also reported that the optimum level of P_2O_5 for yield of okra are 75.2 kg/ha and economic dose was 74.2 kg/ha. They obtained the highest okra yield from lower dose

(50 kg K/ha). The highest number of pods (31.4 pods/plant) and pod yield (22.4 mg ha-1) were obtained with 0.5 kg molybdenum (Mo)/ha. Most of the yield and yield attributes were reduced with higher dose (1.0 kg/ha) of molybdenum (Mozumder *et al.,* 2003). A research conducted with cv. BARI Dherosh-1 in Bangladesh obtained the highest yield (39.4 mg ha-1) when manure and fertilizers were applied @ 5 ton FYM/ha, 150 kg/ha urea, 100 kg/ha MOP and 5 kg/ha Zinc sulphate with 60kg/ha K/ha (Mohanta *et al.,* 2002). Singh (1978) obtained highest pod yield with 60 kg P_2O_5/ha at Varanasi, India. Most important source of P is super phosphate and whole of P should be applied at the time of final soil preparation.

2.4.4 Irrigation and weeding

There should be enough moisture in the soil at the time of seed sowing. Okra displays a "root osmotic" adjustment to water-deficit stress and tolerates water stress well (Wullschlenger and Oosterhuits, 1991). Nevertheless, water is the most limiting factor in okra production in areas with dry growing periods (Hamon and Hamon, 1991).The effects of moisture stress depend on the phenological stage of the plant. The flowering/pod-filling stages are critical and water stress can reduce the yield more than 70% (Mbagwu and Adesipe, 1987). Total water (irrigation + rain) of 460 mm during a 4-month growing period is required for good yields (Gupta, 1990). First irrigation may be given after the seed has germinated. Subsequent irrigations may be given at an interval of 4 to 5 days during summer season (Thakur and Arora, 1986). Studies carried out on the irrigation requirement of summer season crop showed that crop irrigated at 60 cumulative pan evaporation (CPE) gave the highest pod yield (Sharma, 1970; Pandey and Singh, 1970). In case of rainy season crop there was no requirement of extra irrigation (Gupta and Rao, 1979). Drip irrigation provided higher yield than furrow irrigation (Sivanappan *et al.,* 1974) but it was not used commercially due to higher initial costs.

Weeds may result in more than 79.39% reduction in the yield of okra (Tiwari *et al.*, 1985). Competition of weeds was serious especially when okra was at the stage of establishment and accompanied by yield losses ranging from 54 to 91% (Iremiren, 1988). Frequent weeding is necessary in order to keep the crop free from weeds. First weeding may be done 15 to 20 days after seed sowing. A total of 3 to 4 weeding are needed. Herbicides like fluchloralin @ 1.2 kg/ha and alachlor @ 2.5 kg/ha showed good performance (Singh *et al.,* 1985).

2.4.5 Insect/pest problems in okra

Okra can tolerate considerable apical pest damage and at least 25% leaf damage, especially at early growth stage, before significant yield loss (Olasantan, 1988). Jassid (*Amrasca biguttula biguttula* Ishida), spotted bollworm (*Earias vittela* Fab.), cotton leaf roller (*Syllepta derogata* Feb.), cotton semilooper (*Anomis flava* Fab.) and the red cotton bug (*Dysdercus coenigii* Fab.) are very serious for a successful cultivation of okra (Neupane, 1989). Among them cotton jassid is the most serious and it may destroy even the seed quality (Thapa *et al.,* 1994) causing complete destruction of plant due to hopper burn (Eftal, 1997).

2.4.6 Disease problems in okra

The most serious disease affecting the productivity of okra is yellow vein mosaic virus (Sultana *et al.,* 1997) which has been reported to cause losses between 50-90% (Sharma and Arora, 1993). In the recent past *Cercospora* leaf spot disease showed its presence (Sharma and Arrora, 1993). Chauhan *et al.* (1979) reported the infestation of root rot disease of okra by *Rhizoctonia bataticola*.

Okra crop has been infected by many fungal disease (Rahman, 1997), a majority of which cause fruit disease at maturity leading to seed infection (Hema, 1989). Some fungi are saprophytic and some are pathogenic which reduce seed germination, cause rot of the seeds and seedlings diseases and increase seedling mortality (Khanzada *et al.*, 1988). *Colletotrichum* the causal organism of anthracnose of okra is seed transmitted and cause 9-13% yield loss in okra (Sarker, 1996). Saxena *et al.* (1987) reported that some seed dressing chemical compounds gave increased percentage of germination and root shoot length of okra by inhibiting the association of seed borne fungi. Seven seed born fungi have been identified from seed samples viz. *Alternaria, Ceratocystis, Chaetominum, Cladosporium, Curvularia, Fusarium* and *Nigrospora*. The incidence of *Alternaria* (25.33%), *Fusarium* (42.66%), *Chaetomium* (29.66%) and *Curvularia* (22.5%) were comparatively higher than other fungi (Islam, 2000). Gupta *et al.* (1989) reported that *Fusarium, Curvularia* and *Alternaria* are internally seed-borne and caused varying degrees of seed and seedling mortalities. Khanzada *et al.* (1988) also reported that okra seed might carry large number of seed borne fungi which reduce seed germination, causes seed rot or seedling mortality. Many of them produce systemic and local infection of host plant and cause severe yield loss (Sarkar, 1996). Among the fungicides, Bavistin was found to be the most effective in reducing incidence of majority of the fungi followed by Vitavax and Thiram (Islam, 2000).

Root-knot nematode (*Meloidogyne sps*) is one of the major pest attacking okra, particularly in areas having lighter soil (Jain and Bhatti, 1983). It affects plants exhibiting stunting, yellowing and wilting, and subsequently dying due to food starvation (Gondane and Bhatia, 1994). Bhatti and Jain (1977) reported 90.9 percent loss in okra yield due to *M. encognita* at population level of 2800-3460 larvae/kg of soil. Parvani Kranti is moderately tolerant (11-30 galls/plant) variety to nematodes (Gondane and Bhatia, 1994).

2.4.7 Fruit set and harvest

The pods are ready for harvest in about 45 and 60 days after seed sowing depending upon variety and season. Harvesting is difficult and time consuming work.

Frequent pickings are necessary so that pods do not grow too large for marketing (Saimbhi, 1993). Since fruit elongation starts soon after pollination and is very rapid (2 cm/day), picking must be done regularly (4 to 6 days after fruit set) to ensure good consumer quality (Singh *et al.*, 1990). This interval does not necessarily translate into harvesting every 4 to 6 days since in one harvest round the youngest fruits may not be picked and will over mature in the second round. Therefore, harvest is mostly done two, three or even four times per week (Duzyaman, 1997). The maximum increment in length, girth and fresh weight of okra fruit was measured between 5^{th} and 10^{th} days of anthesis while maximum reduction occurred between 30^{th} to 35^{th} days of anthesis. The fruits started dehiscing with the formation of cracks along the ridges by 35^{th} day after anthesis, when the seeds attained the harvestable maturity (Velumani and Ramaswami, 1980). The loss in weight recorded during the last five days of maturation may be mainly due to dehydration during which period the seed has reached the physiological maturity and ready for harvest (Velumani, 1976). Thus over mature fruit needs to be removed to increase plant growth. A simple test for fibrousness is to break the fruit tips by pressing with the fingers. Exudates from trichomes in several plant parts including pod and leaves might cause skin inflammations (Matsushita *et al.*, 1989), and harvesters often use gloves. Akoroda (1986) estimated that dry seed yield per unit area is 90% less than fresh fruit weight. In open pollinated cultivars, farmers can first harvest fresh fruits and then harvest for seed crop (Bhuibhar *et al.*, 1989). A yield of 7 to 12 mg ha^{-1} of immature fruits is considered excellent yield, but yields of 22 mg ha-1 have been reported (Nagel, 1995). Furthermore, Mohanta *et al.* (2002) reported very high yield (39.4 mg ha^{-1}) with cv. BARI Dherosh-1 in Bangladesh.

2.4.8 Climate change impact on vegetable

Due to the change in climate being widely experienced in Nepal, the temperature is rising at an average of 0.4° Celsius per decade hence affecting soil moisture because of increased evapotranspiration; rainy days are decreasing at a rate of 0.8 days per year (Regmi and Adhikari, 2007) that decrease the vegetable production and productivity specially dry season vegetables like okra. A significant change in climate on a global scale will impact agriculture and consequently affect the world's food supply. Climate change *per se* is not necessarily harmful; the problems arise from extreme events that are difficult to predict (FAO, 2001). More erratic rainfall patterns and unpredictable high temperature spells will consequently reduce crop productivity. Developing countries in the tropics will be particularly vulnerable. Latitudinal and altitudinal shifts in ecological and agro-economic zones, land degradation, extreme geophysical events, reduced water availability, and rise in sea level and salinization are postulated (FAO, 2004). Unless measures are undertaken to mitigate the effects of climate change, food security in developing countries in the tropics will be under threat.

2.5 Significance of mulching

The word mulch has probably derived from the German word "molsch" means soft to decay, which apparently referred to the gardener's use of straw and leaves as a spread over the ground as mulch (Jack *et al.,* 1955). Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus, it facilitates for more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops. Further, reported that mulching boosts the yield by 50-60 per cent over no mulching under rainfed situations (Dilip *et al.,* 1990).

2.5.1 Effect of mulching on okra production

Okra production was significantly higher under straw mulch followed by dust mulch over control (Batra *et al.,* 1985). Similar beneficial effects of mulching through improvement of soil environment resulting in better plant growth and tuber yield of potato were observed (Sood and Sharma 1996). Application of straw mulch @ 6 t/ ha increased yield of tomato and okra by 100 and 200 per cent, respectively over control (Gupta and Gupta 1987). The yield of potato was the highest under paddy straw mulch (27.9%) and also starch content was highest in paddy straw mulch (18.18%) than unmulched plot (Dixit and Majumdar 1995). Organic mulches induced earliness in flowering, less days to fruit set and days to harvest, also increased number of flowers and per cent fruit set in tomato crop over control (Ravindrakumar and Shrivastav 1998).

2.5.2 Effect of mulching on soil moisture conservation

The conservation of soil moisture through mulching is one of the important purposes. The micro-climatic conditions are favorably affected by optimum degree of soil moisture. When soil surface is covered with mulch helps to prevent weed growth, reduce evaporation and increase infiltration of rain water during growing season. Plastic mulch helps prevent soil water loss during dry years and sheds excessive water away from the crop root zone during periods of excessive rain fall. This can reduce irrigation frequency and amount of water, it may help reduce the incidence of moisture related physiological disorders such as blossom end rot on tomato, fruit cracking in lime and pomegranate. Research has shown that mulch provides many benefits to crop production through soil and water conservation, enhanced soil biological activity and improved chemical and physical properties of the soil (Cooper, 1973). Menezes *et al.* (1974), Chung (1987) and Aliudin (1986) reported that mulches conserved more soil moistures, enhances vegetative growth and yield contributing characters of garlic. Adeoye (1984) recorded high moisture content up to a depth of 60 cm in grass-mulched soil together with good infiltration and reduced evaporation. Chen (1985) also reported high water content in the top 5 cm of soil (an increase of 4.7 per cent in clayey, 3.1 per cent in loamy and 0.8–1.8 per cent in sandy soil) with polythene mulch from sowing to the emergence of groundnut seedlings. According Bhelia (1988) increased plant dry weight for mulched plants is due to the capabilities of mulch to maintain soil moisture as well as increased efficiency in water uptake by plants.

Straw mulch conserved higher soil moisture to an extent of 55 per cent more compared to control (Rajput and Singh 1970). Average available soil moisture stored up to 1.5 m depth of soil increased significantly by mulching of wheat residue @ 6730 kg/ha compared to bare soil (Black, 1973). Koni (1983) found that sorghum stubbles, cotton stubbles and maize stubbles as mulch in chilli conserved more moisture compared to control. Abu-Awwad (1998) and Abu-Awwad (1999) showed that covering of soil surface reduced the amount of irrigation water required by the pepper and the onion crop by about 14 to 29 and 70 per cent respectively. Trials conducted in the higher potential areas of Zimbabwe between 1988 and 1995 indicated that mulching significantly reduced surface runoff and infiltration (Erenstein, 2002).

Mulching increases the total intake of water due to formation of loose soil surface. The rain drops on mulched soil do not seal the particles as they do on unmulched soil. This sealing effect of rain drops results in more loss of water through erosion. The water infiltrated in soil can be utilized by crops there-by crop yields are increased. Mulches obstruct the solar radiation reaching to soil. Infiltration and soil evaporation are among the key processes that determine soil water availability to crops in semi arid agriculture. The presence of crop residue mulch at the soil-atmosphere interface has a direct influence on infiltration of rainwater into the soil and evaporation from the soil. Mulch cover reduces surface runoff and holds rainwater at the soil surface thereby giving it more time to infiltrate into the soil.

2.5.3 Effect of mulching on weed control

By providing a physical barrier, mulching reduces the germination and nourishment of many weeds. If somehow weeds are growing they become pale and ultimately die. Mulching materials such as wheat straw, dry grasses and saw dust are good in this respect. Pimpini (1974) found that the plastic mulching benefitted the crop, black and photo selective plastic being preferable to the transparent type in eggplant for weed control. The mulching favours the reduction of evaporation leading to higher soil moisture content, a reduction in weed growth and the decomposition of added mulches might have also contributed to increase the supply of nutrients and moisture for overall increase in crop yields (Gupta, 1985; Gupta and Gupata 1987; Derwerken and Wilcox 1988). Covering or mulching the soil surface can prevent weed seed germination or physically suppress seedling emergence. Loose materials like straw, bark and composted municipal green waste can provide effective weed control (Merwin *et al.,* 1995). Saw dust is a wonderful soil improver and weed suppressor as it conserves soil moisture, decreases run-off, increases infiltration and percolation, decreases evaporation, etc. and weed growth can be substantial under clear mulch (Waterer, 2000). White and green covering had little effect on weeds, whereas brown, black, blue or white on black (double color) films prevented weeds emerging (Bond and Grundey, 2001). Daisley *et al.* (1988) and Ossom *et al.* (2001) also observed significant differences in weed control between mulched and unmulched plots of eggplant, cowpea and sweet potato. Mulching operation also keeps the weed under control (Anonymous Commercial flowers Vol-II, 2nd revised addition, Naya Prokashan Calcutta (2003).

2.5.4 Effect of mulching on pest control

Transparent polyethylene mulch reduced whitefly populations, aphids caught in yellow traps and virus diseases incidence, in comparison to bare soil. The reflective plastic mulches can reduce the incidence of aphid-borne viruses and exclude some species of pest (Schalk *et al.,* 1979). Transparent mulch reduced the incidence of virus disease, and delayed by 2 weeks the onset of virus symptoms compared with the bare soil (Nameth *et al.,* 1988). Transparent polyethylene mulch has a repellent effect on pest and vector insects, such as aphids (Brown *et al.,* 2001; Jone R.A.C. 1999, whiteflies (Kelly *et al.,* 1989), and thrips (Greenough *et al.,* 1990). Transparent mulch has a reflective effect and reduces the incidence of virus diseases by confusing aphids, which vector the virus (Brown *et al.,* 1993; Orozco *et al.,* 1994).

2.5.5 Effect of Mulching on soil improvement

Organic mulches return organic matter and plant nutrients to the soil and improve the physical, chemical and biological properties of the soil after decomposition, which in turn increases crop yield. Soil under the mulch remains loose and friable. Aeration and soil microbial activity are enhanced. In heavy black soil also, application of mulches like coir pith @ 20 mg ha^{-1}, press mud @ 10 mg ha^{-1} decreased the bulk density over control (Mayalagu, 1983). The organic mulches not only conserve the soil moisture, they also increase the soil nutrients through organic matter addition (Dilip and Sachin, 1990). Organic mulches have the advantage of being biodegradable, but decomposition may result in a temporary reduction in soil mineral nitrogen (Wallace and Bellinder, 1992). Gajri *et al.* (1994) reported that both soil strength and bulk density decreased by increasing mulch levels. Lal *et al.* (1996) reported decrease in bulk density under straw mulch (1.42 g/cm) compared to bare soil (1.50 g/cm). Mulching increased soil moisture, organic matter contents leading to suitable environment for root penetration. Ghuman *et al.* (2001) concluded that mulching decreases bulk density of the surface soil. The soil organic matter increased due decomposition of applied mulch. Applications of crop residue mulches increase soil organic carbon contents (Havlin *et al.,* 1990, Paustin *et al.,* 1997, Duiker and

Lal 1999, Saroa and Lal 2003). Lal *et al.* (1980) and Khurshid *et al.* (2006) concluded that organic matter was significantly higher when more mulch was applied. Acharya and Sharma (1994) and Muhammad *et al.* (2009) observed that mulched treatments show significantly greater total uptake of nitrogen, phosphorus and potassium than corresponding unmulched ones. Higher organic carbon content of soil recorded with sunhemp mulch (0.71%) followed by silkworm bed waste (0.68%) and paddy straw (0.66%) mulched plots. Least organic carbon content was recorded in no mulched plot (0.48%).

Mulching stimulates soil micro-organisms such as algae, mosses, fungi, bacteria, actinomycetes and other organisms like earth worms etc., owing to loose, well aerated soil conditions, uniform moisture and temperatures thus resulting in a more rapid breakdown of organic matter in the soil and release of plant nutrients for crop growth. Under the mulch layer earth worms proliferate and help to improve the soil aggregate stability and infiltration etc. Mulching conserves moisture, suppresses weed growth, protects the upper fertile soil from erosion, minimize variation in soil temperature and affords winter protection. In addition mulches are also reported to enhance soil microbial activity (Gopal *et al.*, 1960).

2.6 Effect of farm yard manure on okra production

The nutrient content of FYM varies with the constituents/ composition of FYM. The nutrient content of FYM in a study by Chatterjee *et al.* (1979) was found to be 0.64 per cent of N, 0.07 per cent P and 0.29 per cent K. Subbaiah *et al.* (1982) reported that combined application of 25 t FYM per ha and inorganic fertilizer (80:35:35 kg NPK/ha) was beneficial in increasing the yield of chilli as compared to fertilizer alone. Effect of varying levels of N with and without FYM was studied at Agricultural College, Tirupati by Narasappa *et al.* (1985). Their study revealed that, yield of green chillies was maximum at

150 kg N + 10 t FYM per ha Whereas, Sharma and Mitra (1989) reported that the FYM contained 26.1 per cent of C, 1.71 per cent of N, 0.24 per cent of P and 2.04 per cent of K on dry weight basis, the C: N ratio was 15:1 and the nutrients added from 2.5 t of FYM were 42.7, 5.9 and 51.1 kg N, P and K per ha. Damke *et al.* (1988) observed enhanced plant height of chilli with application of FYM @ 9 t per ha along with 50 kg each of N, P_2O_5 and K_2O. Similarly, Surlekov and Rankov (1989) reported greater plant height, number of branches and number of leaves per plant in chilli with the application of farmyard manure @ 20 t per ha along with 100:80:100 kg N, P_2O_5 and K_2O per ha. Nair and Peter (1990) recorded the highest fruit number, fruit weight per plant and yield of chilli per ha with combined application of organics and inorganics and concluded that only organic or inorganic fertilizer sources will not increase yield of chilli. Natarajan (1990) noticed higher plant height and number of branches per plant in chili when FYM was applied @ 25 t per ha as a basal dose along with 75:33:35 kg NPK per ha. An experiment conducted at Agriculture Improvement Station, Taiwan on chilli has showed that plant height was significantly higher with organic manures than the chemical fertilizers (Hsieh-Ching Fung *et al.*, 1994).

According to Mallanagouda *et al.* (1995) the application of recommended dose of NPK (100:80:80 kg per ha) + FYM (10 t per ha) improved the growth parameters, yield (2099 kg/ha) and yield components of chilli. The FYM used in the trials of Sriramachadrasekharan *et al.* (1996) had 1.2 per cent N, 0.21 per cent P, 1.96 per cent K, and 26.90 per cent C with C: N ratio of 22.4:1.0. Subramanian *et al.* (2000) opined that the inclusion of organic manures *viz.*, FYM and sunhemp in the fertilizer schedule not only increased the yield but also improved the soil moisture storage by 31.4, 31.2 and 31.4 per cent at 0-15, 15-30 and 30-60 cm soil depth, respectively.

In a long term trial (5 years) conducted by Shashidhara (2000), the plant height, number of branches, leaf area and leaf area index, yield and yield parameters increased significantly at all growth stages due to combined application of organics (FYM/Biogas Spent Slurry/redgram stalk), inorganics (100% RDF > 50% RDF). The growth, yield parameters and yield with organics are comparable to that of inorganics from 4th year onwards in a long term trial.

The farmyard manure seems to act directly by increasing the crop yield either by accelerating the respiratory process through cell permeability or by hormone growth action. It supplies nitrogen, phosphorus and sulphur in available forms to the plants through biological decomposition. Indirectly, it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Chandramohan, 2002). According to Malawadi (2003), the plant height, number of branches, leaf area, LAI and total dry matter production in various plant parts and yield of chilli recorded significantly higher values with combined application of NPK + FYM as compared to NPK alone. The application of organics *viz.*, FYM, chilli stalks and FYM + chilli stalks with inorganic fertilizers (RDF) significantly influenced growth, yield, nutrient uptake and quality of chilli and the magnitude of combined effect of organic and inorganics was higher than inorganics alone (Kattimani, 2004). Similarly, Ching Fang and Kvonon (1994) reported that application of organic manures + chemical fertilizers significantly increased the fruit size, number of fruits per plant and yield of sweet pepper than application of chemical fertilizers alone. Maheswarappa *et al.* (1997) observed that, organic carbon content was increased to a greater extent at 0.25 m depth with FYM and vermicompost application than the other organic sources.

Chavan *et al.* (1997) found that combined application of nitrogen through FYM and urea was more beneficial compared to fertilizer alone in order to increase the yield and quality of chilli. Dhiman *et al.* (1998) reported that application of FYM @ 10 t ha^{-1} + 100 per cent recommended N increased the organic carbon content. Incorporation of organic manures in the form of FYM and crop residues increased the organic matter content of the soil (Thakur *et al.*, 1999). Radha Madhav *et al.* (1999) observed that incorporation of FYM in field crops improved the phosphorus status of the soil through slow decomposition of FYM. According to findings from the field experiment conducted at University of Agricultural Sciences, Dharwad by Sutagundi (2000), combined application of RDF + FYM resulted in significant improvement in yield and yield attributes of chilli. The beneficial effect of FYM on various physico-chemical properties of soil and to sustain higher yield levels was reported by Sudhakar (2000). Suresh (2000) reported that, combined application of RDF (100:50:50 kg NPK per ha) + FYM recorded significantly higher dry chilli fruits as compared to RDF alone (11.28 q/ha). Katkar *et al.* (2002) reported that, the treatments which received FYM, greengram bio-mulching, green foliage lopping of glyricidia and sunhemp green manuring resulted in increased organic carbon content in the soil from 1.72 to 3.92 per cent. Malawadi (2003) found that application of NPK (100:50:50) + FYM (10 t per ha) recorded significantly higher dry chilli fruit yield (844.39 kg per ha) over NPK alone (695.46 kg per ha) and growth and yield components of chilli were also significantly higher with application of NPK + FYM. Application of organics *viz.*, FYM @ 10 t per ha along with 100 per cent RDF resulted in higher fruit yield (919 kg/ha) and enhanced the uptake of nutrients, like N, P, K, Ca, S and Fe by 14.1, 44.9, 37.4, 15.5, 20.3 and 26.7 per cent, respectively over RDF alone in Byadagi dabbi as compared to RDF alone (781 kg/ha) (Kattimani, 2004). Various types of liquid manures are prepared from plant and animal origin *viz.*, dung, urine, butter milk, plant extracts and jaggry etc. This includes amritpani, jeevamrut, panchagavya, beejamrut, sasyamrut, vermiwash, etc. Use of liquid manures prepared from cowdung, cow urine, leguminous leaves or vermiwash are effective in promotion of growth and fruiting. Although, these manures may not provide enough nutrients in the area of application, but they help in the quick build up of soil fertility through enhanced activity of soil micro-flora and fauna (Yadav and Mowade, 2004).

2.7 Significance of liquid manure (Jhol mal)

Pests (including insects, diseases, weeds, rodents, and mites) are the major biotic constraints to increasing agricultural production. According to one estimate, the loss due to pests (insect pests and diseases) ranges from 30-35% (G.C. and Ranabhat, 2001). Application of pesticides to control pests has disturbed the natural balance, caused monetary losses through the need for more pesticide purchases. This in turn has led to further outbreaks of secondary pests and increasing concern about environmental hazards. Pesticides are responsible for some 20,000 accidental deaths each year, and 200,000 suicide deaths, according to the World Health Organisation (WHO). They also account for about three million cases of acute poisoning each year (John, 2002). Nepal is rich in botanical diversity and there are many indigenous plants of pesticidal value (Regmi and Karna, 1988). Their use against insect pests and diseases is an age-old practice, where more than 50 species of plants have been used in Nepal (Gyawali, 1993). An indigenous weed such as *Chenopodium botrys* L. used against the potato tuber moth has been found as effective as modern insecticide (Fenvelerate 0.02%) and even superior to *Pyrethrum* sp. (0.2%) (Pradhan, 1988). Farmers use *Euphorbia pulcherrima* W. to control weevils in cereals (Sahu, 1997). It is also reported that the majority (>70%) of farmers use wood ash for disease and pest control in the western hills of Nepal (Lohar and Budhathoki, 1992). Other plant materials like neem (*Azadirachta indica* A. Zuss.), marigold (*Tagetes minuta* L.), and titepati (*Artemisia vulgaris* L.) are popular for their pesticidal value against different types of pests. Application of twigs and leaves of "khirro" (*Sapium insigne*) and titepati (*Artemisia vulgaris* L.) were found effective in lowering the effects of red ant while planting potato inside the furrow (GC *et al*., 1997). Similarly, the extract prepared from parts of the sisnu (*Urtica dioca* L.) plants and fruits of timur (*Zanthoxylum armatum* DC.) is used to control many kinds of chewing, biting and cutting insects, like the larvae of cabbage butterfly, hairy caterpillars, cut worms, red ants and termites (Budhathoki *et al.*, 1993). Garlic clove extract and kerosene are also used for caterpillars, cutworms and aphids in many vegetable crops. Botanical pesticides are attractive alternatives to chemicals for a variety of reasons, most significantly because most of the solely chemical-based technologies are likely to have limited worth, as insects build up resistance after a few years. By contrast, the use of natural resources is more sustainable and cost effective, as there is less chance of resistance build-up by the pests. The strategy seems more stable and sustainable from the technical, ecological, economical and environmental viewpoint.

Extracts from the Indian neem tree, *Azadirachta indica* A. Juss., or its most active principle, the limonoid azadirachtin (AZA), have been extensively investigated in recent years, with demonstrated activity reported against 200 species of insects from several orders (Saxena 1989; Isman *et al.,* 1990). The diverse biological activities of neem or AZA include feeding and oviposition deterrence, repellency, growth disruption, reduced fitness, and sterility (Saxena 1989; Isman *et al.,* 1990; Koul *et al.,* 1990, Schmutterer 1990).

2.8 Economics of okra production

The rate of adoption and sustainability of okra production practice depends upon the productivity and efficiency of resources used in okra cultivation (Hafeez *et al.*, 2004). Furthermore, the rate of expansion of crops will depend on the profitability of crop production (Kabir *et al.*, 2002). However, low productivity, uncertainty of profits and high production costs are some limiting factors in accelerated growth of okra production (Acharya *et al.*, 2002). Production costs and the net return depend on inputs levels and price of those inputs which highly fluctuate in the market. That is the reason why cultivation cost varies place to place and year to year. These parameters need to be analyzed time to time. In Nepal, very nominal work has been done regarding economics of fresh vegetable production.

Acharya *et al.* (2002) conducted a field study along Dumre-Besisahar road corridor of Lumjung district, Nepal to assess the economic return from major vegetable crops. According to their study Rs. 73,158.00 was required to cultivate one hectare of okra. They observed gross margin of Rs. 34,036.00/ha from okra cultivation. They also observed very high labour cost (Rs. 51,395.00) in okra production as compared to non-labour cost (Rs. 21,758.00). They observed average B/C ratio of 1.5 while it ranged from 1.1 to 3.0. The average price of okra at that time was Rs.12.85/kg. They also observed difference in production cost and net return at different production areas.

In India, Singh and Saharan (1994) observed difference in net return from okra production among various sowing dates and varieties. They found the highest net return from the crop sown on 20th February (IRs. 46,195) and the lowest (IRs.25, 269) from the crop sown on 22nd March. They obtained the highest return from HB-55 and the lowest from Pusa Sawani. Another experiment conducted on Arka Anamika in rainy season in India with different nutrient combination gave B/C ratio ranging from 1.45 to 3.05 while cost of cultivation ranged from IRs. 11, 400.00 to IRs. 13,800.00 and net return from IRs. 5, 900.00 (control) to IRs. 28, 920.00 (Sharma and Bhalla, 1995). Per unit cost of input they applied was urea IRs.10/kg, DAP IRs.15/kg, Potash IRs.5/kg and compost cost IRs.20/quintal.

In Bangladesh, Kabir *et al.* (2002) reported that okra growers were using human labour from 177 to 322 man-days, animal labour 16-44 pair days, seed 4-22 kg, FYM 5-24 t and urea 149-411 kg per hectare. They observed that yield of okra increased with increased levels of inputs. Likewise, Hossain *et al.* (2000) calculated the requirement of human labour as 230 man days and animal labour 26 pair days per hectare. Total cost of cultivation, the gross return and B/C ration was Bangladesh Taka (Tk.) 23,487.00/ha, Tk. 69,560.00/ha and 2.68 respectively. The human labour wage rate used in the calculation was Tk. 50 per day (Tk is the currency of Bangladesh and almost equivalent to Nepalese Rupees). A study conducted in Bangladesh to know the economics of year round production of okra revealed that the maximum gross return (Tk. 1, 25, 255.00/ha) was obtained from May sowing with the closest spacing (60 cm x 30 cm) followed by (Tk. 1, 21,770.00/ha) in March sowing (Hossain *et al.*, 2001). Hafeez *et al.* (2004) estimated the cost of Tk. 49, 380 for cultivation of okra in Gazipur, Bangladesh. Among all the cost items, human labour and fertilizer covered 34.09% and 12.18% cost of cultivation respectively. They also found that net return from okra was Tk. 47, 721.00/ha. Mozumder *et al.* (2003) obtained the maximum yield, net return and B/C ratio of 26.2 mg ha^{-1}, Tk.1.27 lakh/ha and 4.31 respectively.

3 MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted at farmers field of Pithauli VDC Ward No. 9, Nawalparasi district, during March 2013 to July 2013. The site is situated at 85 Km east from district headquarter Parasi, Nepal. The geographical location of the site is situated about 27^{o}417' North latitude and 84^{o}217' East longitude at an altitude of about 154 m above mean sea level.

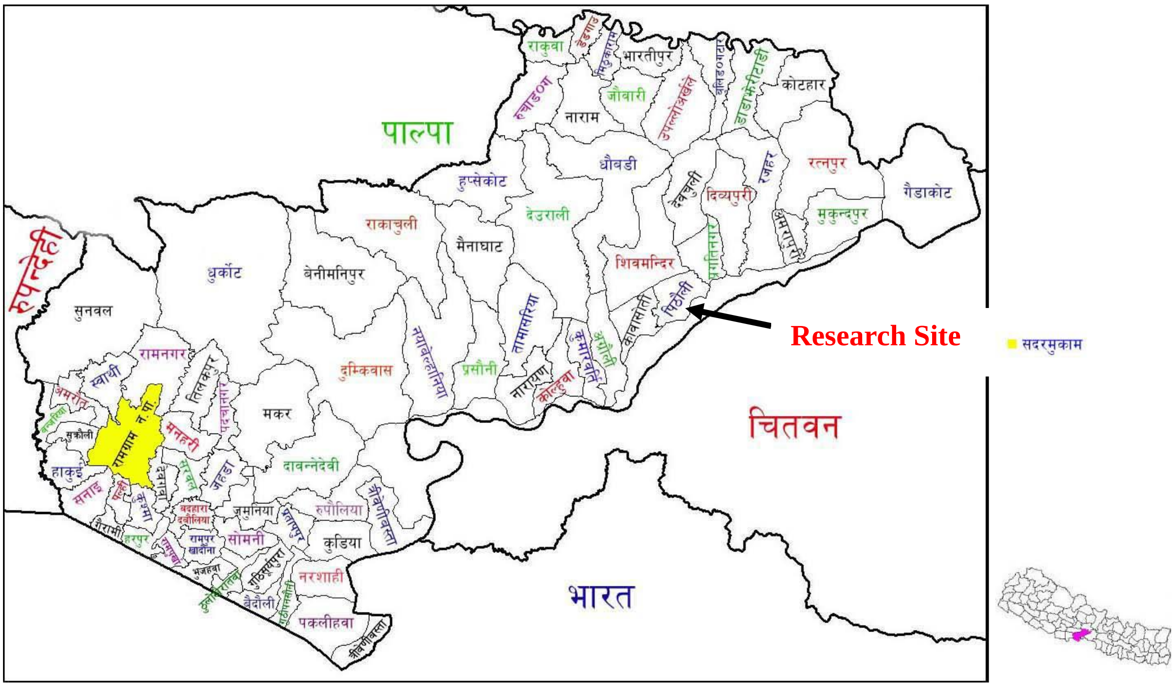
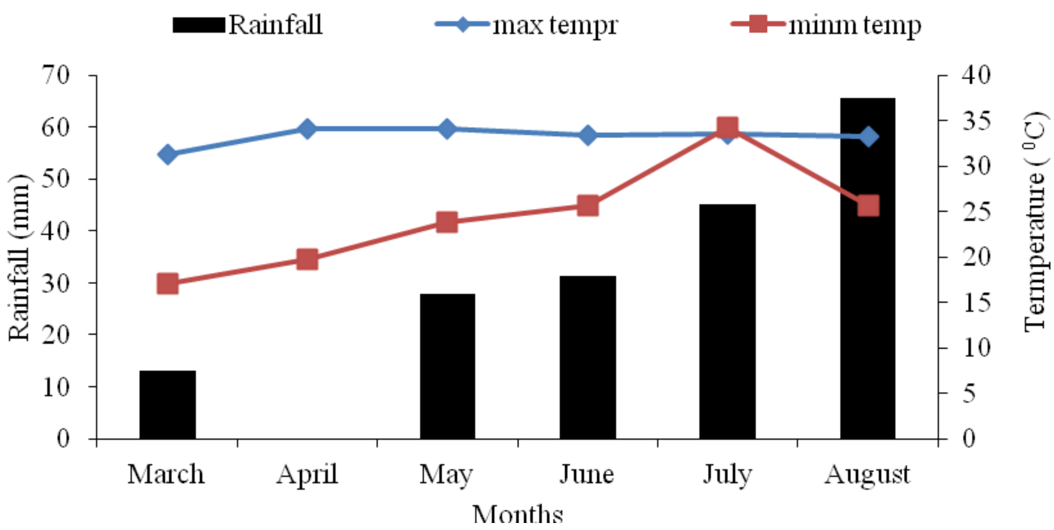


Figure 1. Map of Nawalparasi District arrow showing the research site (Pithauli VDC)

3.2 Climate

Pithauli, Nawalparasi lies in the subtropical humid climatic zone. It is characterized by three distinct seasons: monsoon (June to October), winter (November to February) and spring (March to May). The meteorological data recorded for the cropping season (March-August, 2013) at Meteorological station, Dumkauli, Nawalparasi, located about 13 Km far from the research site has been presented in Figure 2 and appended in Appendix 1.

The total rainfall received during cropping season from April to August was 1875 mm in 106 days. The monthly maximum (34.21 ^{o}C) and minimum (19.67 ^{o}C) temperatures were in May and April respectively. Likewise, the monthly maximum (34.04 ^{o}C) and minimum (19.67 ^{o}C) was recorded in month April during seed sowing.



(Source: Meteorological station, Dumkauli, Nawalparasi, Nepal)

Figure 2. Monthly meteorological data during cropping season (March 2013 to August 2013), Dumkauli, Nawalparasi, Nepal, 2013

3.3 Soil characteristics

Composite soil samples of 0-20 cm depth were taken from the field before start of experiment. The samples were air dried, ground, sieved and used for analysis. Organic matter (O.M) was determined by Walkley-Black (potassium dichromate digestion) method (Nelson and Sommers, 1982) and total soil nitrogen was determined by the Kjeldahl method (Bremner and Mulvancy, 1982). Available P was determined by spectrophotometer (Olsen *et al.,* 1954) and available potassium by ammonium acetate method (Black, 1965). Soil pH was determined by 1:2 soil and water suspensions by Beckman Glass Electrode pH meter (Wright, 1939) and soil texture by hydrometer method.

Table 1. Physio-chemical properties of the soil at Pithauli, Nawalparasi, Nepal, 2013

Soil parameters	Value	Indicator
pH	5.65	Moderately acidic
Organic matter (%)	0.3	Low
Total N_2 (%)	0.05	Low
P_2O_5(kg ha^{-1})	176	High
K_2O(kg ha^{-1})	556	High
Textural class		Silt Loam

(Source: Soil science lab (Nepal Agriculture Research Center, Khumaltar, Nepal, 2013)

Soil was moderately acidic (pH 5.65). The organic matter and total N% was low but phosphorus and potash were high. The soil texture was silt loam.

3.4 Cropping history

The experimental field was under mustard cultivation before the present experiment.

3.5 Experimental details

The experiment was conducted at Pithauli-9, Rajmandir, Nawalparasi during spring-summer season (March 25 to July 30, 2013). The experiment was laid out in two factor factorial RCBD design with 3 replications**.**

3.5.1 Experimental materials

3.5.1.1 Okra variety

The variety Arka Anamika was selected for experiment purpose. It was YVM resistant variety developed at Indian Institute of Horticulture Research, Banglore (Ram, 1997). The plants were tall (175 cm), erect and well branched, fruits were medium long (20 cm) with 5-6 ridges, spineless, tender and lush green in colour, fruit stalk was long and easy to snap. It yielded 20-25 mg ha^{-1} under improved management condition and can be cultivated in kharif and summer season (NHRDF, 2000). This variety was widely used by the farmers of Nepal. The seed was purchased from local market, Narayangarh. The company was Krishidhan vegetable seeds Pvt. Ltd.

3.5.1.2 Farm yard manure

The well decomposed FYM of 0, 10, 20, 30, 40 Mg ha^{-1} was used after field preparation, before a week of sowing. The FYM was applied in the particular plot after the layout of the plot. FYM was applied on 9 April, 2013.

3.5.1.3 Mulching

Rice straw @ 6 Mg ha^{-1} was used as mulching material. Mulching was done on 10^{th} May, 2013 after the emergence of okra seedling.

3.5.2 Experimental unit

The spacing of the okra was 50 x 30 cm^2. Each plot was 2.5 m length and 2.4 m width. Spacing between two replications were 1m and between two treatments 0.5m.The individual plot area was 6.0 m^2, and net area plot area was 259.55 m^2.

There were 5 rows in a plot and number of plant per row was 8 and ultimately total plants per plot were 40. Out of 5 rows, 2 rows were taken as a border and remaining 3 rows were used for observation and net yield. Spacing between replication block and plots were 1m and within block 0.5 m respectively. The outer border was 1m around the main plot.

3.5.3 Treatment and replication

This field experiment was conducted in a 2 factorial randomized complete block design (RCBD) with three replications.

Factor A: Level of mulching (2 levels)

M_0 = No mulching (control)

M_1= Mulching with rice straw (6 Mg ha^{-1}.)

Factor B: Level of FYM (5 levels)

F_0 = 0 Mg ha^{-1}

F_1 = 10 Mg ha^{-1}

F_2 = 20 Mg ha^{-1}

F_3= 30 Mg ha^{-1}

F_4= 40 Mg ha^{-1}

3.5.4 Treatment combination

Table 2. Treatment combination of experiment, Pithauli-9, Nawalparasi, Nepal, 2013

Treatments	Notation	Mulching +FYM
T1	M_0F_0	No mulching and no FYM
T2	M_0F_1	No mulching and FYM 10 Mg ha^{-1}
T3	M_0F_2	No mulching and FYM 20 Mg ha^{-1}
T4	M_0F_3	No mulching and FYM 30 Mg ha^{-1}
T5	M_0F_4	No mulching and FYM 40 Mg ha^{-1}
T6	M_1F_0	Mulching and no FYM
T7	M_1F_1	Mulching and FYM 10 Mg ha^{-1}
T8	M_1F_2	Mulching and FYM 20 Mg ha^{-1}
T9	M_1F_3	Mulching and FYM 30 Mg ha^{-1}
T10	M_1F_4	Mulching and FYM 40 Mg ha^{-1}

Layout of design

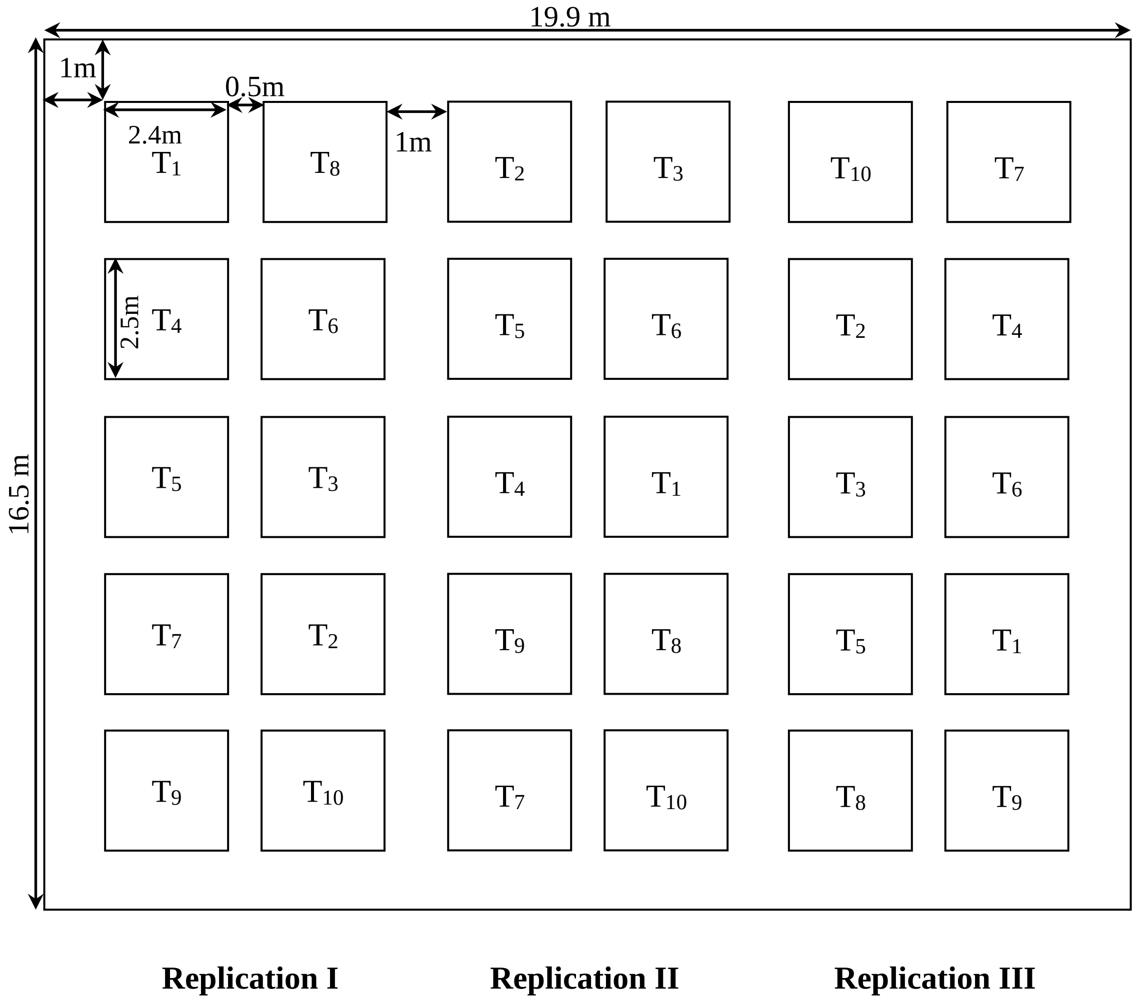


Figure 3. Layout of the experiment at Pithauli, Nawalparasi 2013

3.6 Field preparation

Field was prepared with manual hoeing on 7th April 2013.

3.7 Sowing

Okra seed were soaked in water for 24 hrs. and kept for 2/3 hrs at shade. Three seeds were sown per hill and left one seedling by thinning after the emergence. Seeding was done at 50 cm row to row and 30 cm plant to plant distance at each plot. The okra seeds were sown on 15th April, 2013.

3.8 Observations and measurement taken

3.8.1 Soil moisture percentage by mass

Soil moisture was taken before the application of mulching at 10 May, 2013 and measurements were taken at 10 days intervals. Total five measurements were taken before mulching, 10 days after mulching (DAM), 20 DAM, 30 DAM and at final harvest period. The moisture measurement was done gravimetric methods. The soil sample of 100 g were taken at field and dried on oven for 72 hours and calculated through following formula.

Water (%) by mass = (wet mass - dry mass / dry mass) x 100

3.8.2 Vegetative characters

Five plants from each treatment plot were selected at random and tagged for recording the observations on the following growth and yield parameters. The observations were first recorded at 30 days after sowing and subsequently every 15 days interval up to harvest.

3.8.2.1 Parameters recorded

3.8.2.1.1 Plant height

Plant height was measured from the base of the plant to the tip of the apical or flower bud tip.

3.8.2.1.2 Number of leaves

Total numbers of fully developed fresh leaves attached to the plant at the time of data collection were taken for the measurements.

3.9 Yield and yield parameters

3.9.1 Number of pickings per plant

Fruits were regularly harvested from five randomly selected and tagged plants within net plot area. The total number of pickings from the first to final picking comprised the number of pickings.

3.9.2 Number of fruits per plant

Fruits were regularly harvested from five randomly selected and tagged plants. The total number of fruits harvested during the crop period was divided by 5 to obtain number of fruits per plant**.**

3.9.3 Average fruit length (cm) and diameter (cm)

Fruit length and diameter were measured at harvest and averaged for determining average fruit length and diameter.

3.9.4 Average fruit weight (g)

The average fruit weight was decided by diving total fruit weight produced by five randomly selected plants by the number of fruits produced by the same five randomly selected plants.

3.9.5 Yield per plant (g)

The total yield produced under net plot area was divided by the number of plants within net plot area to calculate the yield per plant.

3.9.7 Productivity (Mg ha^{-1})

The net plot yield (yield obtained from five plants leaving single boarder plant from all sides) was converted to the hectare and the unit was also converted to mega gram to determine the productivity of the production.

3.10 Quality parameters

The quality of pod and other physical disorders were observed during the data collection.

3.11 Focus group discussion

After the completion of the field research at farmer's field, one focus group discussion was conducted to collect the information on climate change and its impact on agriculture as well as the climate change adaptation technologies.

3.12 Statistical analysis

Statistical package Microsoft Excel and MSTATC were used for the analysis of different parameters collected during the experiment. Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) test were used for mean separation. The graphs were prepared using Microsoft Excel.

3.13 Cost calculation

Costs of cultivation of crops under each treatment were worked out based on prevailing market price of different inputs. Total costs of cultivation were worked out by summing up variable cost of cultivation.

3.13.1 Gross return

Economics yield (total marketable fruit harvested) was multiplied by prevailing market price of okra fruits to calculate gross return.

3.13.2 Net return

Net return from each treatment was calculated by reducing the cost of cultivation from the gross return.

3.13.3 Benefit cost ratio

B:C ratio was calculated by dividing gross return with the cost of cultivation.

3.14 Cultural practices

3.14.1 Weeding

Two weedings were done manually. One weeding before mulching on 8th May, 2013 and another on 28th May 2013 after 45 days after sowing.

3.14.2 Irrigation

Two irrigations were given one before sowing on 10th April, 2013 and second irrigation was on 10th May 2013 before the mulching.

3.14.3 Plant protection

The insect and disease were observed in the field and to control the pest and diseases, a necessary ecological pest management practice was adopted and strictly avoided chemical pesticides. The liquid bio pesticide named as jhol mal was prepared and sprayed at 15 days interval after 30 DAS. The jhol mal was prepared from locally available plant materials *neem, Asuro, titepati, bakaino, sisnoo* and cow dung and urine. The plant materials were chopped and prepared about 2 inch and equal weight of plant material, cattle dung and cattle urine were mixed into a plastic bucket and used after 15 days with mixing equal amount of water.

4 RESULTS AND DISCUSSION

The result and discussion part consists of three sections; i) the first one is relationship among mulching and FYM for different biological parameters, ii) the second one is economic benefit from okra production and iii) the last one is related with the perception of farmers on climate change. Results are presented with the help of tables and figures wherever applicable. The results are analyzed and interpreted with supporting evidences as far as possible.

4.1 Effect of mulching and FYM on growth parameters

4.1.1 Plant height (cm)

Plant height was significantly (P<0.01) affected by mulching at 45, 60, 75 DAS at harvest. FYM effects was also significant (P<0.01) at 60 and 75 DAS at harvest but that was non-significant at 30 and 45 DAS (Table 3 and Appendix 3). However, interaction between mulching and FYM was non-significant for the plant height.

Significantly higher plant height was recorded from mulching than non mulching at all growth and development stages i.e. 30 DAS, 45 DAS, 60 DAS, 75 DAS and at harvest. Similarly, higher plant height was observed under application of 40 mg ha^{-1} FYM at 60 DAS, 75 DAS at harvest. At 30 DAS, the higher plant height (20.77 cm) was measured from 20 mg ha^{-1} FYM however, at 45 DAS, the higher plant height (43.98 cm) was measured from 30 mg ha^{-1} FYM.

Table 3. Effect of mulching and FYM levels on plant height of okra during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Plant height (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Mulching					
No Mulching	18.97^{a}	40.19^{b}	68.28^{b}	88.33^{b}	106.90^{b}
Mulching	20.62^{a}	48.95^{a}	78.01^{a}	108.30^{a}	133.95^{a}
LSD	NS	3.419**	3.282**	5.270**	4.469**
SEm±	0.69	1.15	1.10	1.77	1.50
FYM levels					
0 Mg ha^{-1}	17.83^{a}	39.65^{b}	63.70^{c}	79.92^{c}	97.42^{e}
10 Mg ha^{-1}	20.75^{a}	46.82^{a}	68.71^{bc}	86.40^{c}	109.00^{d}
20 Mg ha^{-1}	20.77^{a}	44.98^{ab}	70.95^{b}	97.20^{b}	118.50^{c}
30 Mg ha^{-1}	19.17^{a}	47.43^{a}	79.77^{a}	111.00^{a}	133.20^{b}
40 Mg ha^{-1}	20.46^{a}	43.98^{ab}	82.60^{a}	116.90^{a}	143.90^{a}
LSD	NS	NS	5.189**	8.333**	7.066**
SEm±	1.10	1.81	1.74	2.80	2.38
CV%	13.64 %	10.00 %	5.85 %	6.99 %	4.84 %
Grand mean	19.79	44.57	73.14	98.29	120.40

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations DAS= Days after sowing FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, **=significantly different at (P=0.01) and CV= Coefficient of variation. NS= Non significant

The highest plant height (20.62 cm) was observed at 30 DAS from mulching and conversely, the lowest plant height (18.97 cm) observed from without mulching. The highest plant height (20.77 cm) from application of 20 mg ha^{-1} FYM and the lowest plant height (17.83 cm) was recorded from no application of FYM at 30 DAS. At 45 DAS, the highest plant height (48.95 cm) was observed from mulching and the lowest plant height (40.19 cm) from no mulching. Similarly, the highest plant height (47.43 cm) was recorded at 30 Mg ha^{-1} FYM application and the lowest plant height (39.65 cm) at no application of

FYM. The highest plant height (78.01 cm, 108.30 cm, and 133.95 cm) were recorded from mulching at 60 DAS, 75 DAS and harvest stages respectively. The lowest plant height (68.28 cm, 88.33 cm and 106.90 cm) were observed from without mulching plots at 60 DAS, 75 DAS and harvest stages respectively. Similarly, the highest plant height (82.60 cm, 116.90 cm, and 143.90 cm) were observed from the application of 40 Mg ha^{-1} FYM and on the other hand, the lowest plant height (63.70 cm, 79.92 cm, and 97.42 cm) were observed from without application of FYM at 60 DAS, 75 DAS and at harvest stages respectively. The plant height found non-significant at 30 DAS in mulching and FYM was due to the initial stages of the plants.

Mulching increased soil moisture, organic matter contents leading to suitable environment for root penetration. Ghuman *et al.* (2001) concluded that mulching decreases bulk density of the surface soil. The soil organic matter increased due decomposition of applied mulch. Applications of crop residue mulches increased soil organic carbon contents (Havlin *et al.*, 1990, Paustin *et al.*, 1997, Duiker and Lal 1999, Saroa and Lal 2003). Lal *et al.* (1980) and Khurshid *et al.* (2006) concluded that organic matter was significantly higher when more mulch was applied. Acharya and Sharma (1994) and Muhammad *et al.* (2009) observed that mulched treatments showed significantly greater total uptake of nitrogen, phosphorus and potassium than corresponding unmulched plots.

The increased application of FYM contain appreciable quantities of magnesium, might have helped in chlorophyll synthesis which in turn increased the rate of photosynthesis. The results are in agreement with the findings of Nehra *et al.* (2001) and Sanwal *et al.* (2007). Higher yield response due to organics is ascribed to improvement in physical and biological properties of soil resulted in better supply of nutrients leading to better crop growth and yield.

4.1.2 Number of leaves per plant

The number of leaves per plant of okra measured by mulching was significantly (P<0.01) affected at 45 DAS, 60 DAS, 75 DAS, and at final harvest stages. FYM significantly (P<0.01) affected number of leaves per plant of okra at 60, 75 DAS and at final harvest stages but the effect of mulching was not significant at 30 DAS similar to the number of leaves per plant by the application of FYM at 30 DAS and 45 DAS (Table 4 and Appendix 4). However, interaction between mulching and FYM was non-significant for the number of leaves per plant.

Table 4. The Number of leaves of okra per plant affected by mulching and FYM levels during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Number of leaves per plant				
	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Mulching					
No Mulching	7.90^{a}	16.56^{b}	29.75^{b}	31.25^{b}	26.23^{b}
Mulching	7.93^{a}	19.39^{a}	35.37^{a}	37.67^{a}	31.72^{a}
LSD	NS	1.711**	1.888**	1.662**	2.030**
SEm±	0.15	0.57	0.64	0.56	0.68
FYM levels					
0 Mg ha^{-1}	7.65^{a}	16.27^{b}	28.62^{c}	30.08^{c}	25.60^{c}
10 Mg ha^{-1}	8.07^{a}	18.30^{ab}	32.10^{b}	34.22^{b}	27.92^{bc}
20 Mg ha^{-1}	7.90^{a}	17.53^{ab}	31.90^{b}	34.03^{b}	28.82^{abc}
30 Mg ha^{-1}	7.85^{a}	18.52^{ab}	33.87^{ab}	36.02^{ab}	30.55^{ab}
40 Mg ha^{-1}	8.10^{a}	19.25^{a}	36.30^{a}	37.95^{a}	31.98^{a}
LSD	NS	NS	2.986**	2.629**	3.209**
SEm±	0.24	0.91	1.00	0.88	1.08
CV%	7.44 %	12.41 %	7.56 $^{\%}$	6.29 %	9.13 %
Grand mean	7.91	17.97	32.56	34.46	28.97

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations DAS= Days after sowing FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, **=significantly different at (P=0.01) and CV= Coefficient of variation. NS= Non significant

Significantly higher numbers of leaves were observed from mulching than non mulching at all stages (30, 45, 60, and 75 DAS) and at final harvest. Similarly, higher number of leaves was recorded from application of 40 Mg ha^{-1} FYM at all stages (30, 45, 60, and 75 DAS) and at final harvest.

The highest number of leaves (7.93, 19.39, 35.37, 37.67, and 31.27) were observed at 30, 45, 60, 75 DAS and at final harvest stages from mulching respectively. Conversely, lowest number of leaves (7.90, 16.56, 29.75, 31.25, and 26.23) observed from without mulching respectively at all measurement stages. Similarly highest number of laves (8.10, 19.25, 36.30, 37.95, and 31.98) were recorded from the application of 40 Mg ha^{-1} FYM at 30, 45, 60, 75 DAS and at final harvest stages respectively. On the contrary, the lowest number of leaves (7.65, 16.27, 28.62, 30.08, and 25.60) were recorded from zero application of FYM at all measurement stages (30, 45, 60, 75 DAS and at final harvest).

At 30 DAS, at all FYM levels, there were no significantly differences on number of leaves per plant. At 45 DAS, the level of FYM at 10, 20, and 30 Mg ha^{-1} have similar effect on number of leaves per plant but in successive days, there was recorded higher number of leaves at higher doses of FYM.

4.2 Effect of mulching and FYM on yield and yield parameters

4.2.1 Number of pickings per plant

Mulching significantly (P<0.01) affected the number of pickings available during the cropping period. Likewise, FYM also significantly (P<0.01) affected the number of pickings per plant in okra. However, the interaction between mulching and FYM were found non-significant (Table 5 and Appendix 5b).

The highest number of pickings (14.07) was recorded in mulching and lowest (8.61) was recorded without mulching. The highest pickings (15.18) were observed from the application of 40 Mg ha^{-1} FYM and lowest (7.58) was observed from zero application of FYM. The numbers of picking were not significantly different from the application of FYM at the rate of 10 Mg ha^{-1} and 20 Mg ha^{-1}. The numbers of pickings were increased with the increase rate of FYM application.

Table 5. Effects of mulching and FYM levels on number of picking of okra during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Number of picking
Mulching	
No Mulching	8.61^{b}
Mulching	14.07^{a}
LSD	1.143^{**}
SEm±	0.38
FYM levels	
0 Mg ha^{-1}	7.58^{d}
10 Mg ha^{-1}	9.90^{c}
20 Mg ha^{-1}	10.70^{c}
30 Mg ha^{-1}	13.33^{b}
40 Mg ha^{-1}	15.18^{a}
LSD	1.806^{**}
SEm±	0.61
CV%	13.13 %
Grand mean	11.34

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, **=significantly different at (P=0.01) and CV = Coefficient of variation

Number of pickings was associated with number of fruits per plant and also directly associated with productivity of the crop. Fruit removal at early stages (edible fruit harvest) enhanced the activity of leaves and apical growth which it in turn enhanced fruit production (Duzyaman, 1997). The importance of frequent and complete harvest for satisfactory yield was emphasized by many authors. Duzyaman (2006) observed higher number of fruits with lower fruit weight in okra. The number of pickings increased with decreased fruit harvest weight i.e. harvesting of small sized fruits enhanced the development of other new fruits.

4.2.2 Number of fruits per plant

Mulching significantly (P<0.01) affected the number of fruits per plant. Likewise, FYM also significantly (P<0.01) affected the number of fruits per plant of okra. However, the interaction between mulching and FYM were found non-significant (Table 6 and Appendix 5a).

The highest number fruits per plant (18.63) were recorded in mulching and the lowest (13.06) was recorded from without mulching. The highest number of fruits per plant (19.63) was observed from the application of 40 Mg ha^{-1} FYM and the lowest (12.82) was observed from zero application of FYM. The numbers of fruits per plant were not significantly different at 20 and 30 Mg ha^{-1} FYM application. The number of fruits per plant was increased with the increased rate of FYM.

The reason for increased fruit weight and fruit yield under higher level of FYM could be due to increased supply of mineral nutrients by the addition of FYM leading to increased uptake of NPK (Sendurkumaran *et al.,* 1998). FYM helped to improve soil quality and water holding capacity. The significance of organic manuring in sustainable agriculture is well established (Subbarao *et al.,* 2001). Recovery of P from organic manure is slightly better than from fertilizers as CO_2 released by decomposition improves availability from soil (Gopalakrishnan, 2007). The better efficiency of organic manures might be due to the fact that organic manures especially FYM would have provided the more micronutrients such as Zn, Cu, Fe, Mn and Mg to the crop. Zinc is involved in the biochemical synthesis of most important phytohormone, Indole Acetic Acid through the pathway of conversion of IAA. Iron is involved in chlorophyll synthesis pathway. Copper and Manganese are the important coenzymes for certain respiratory reaction. Magnesium is involved in chlorophyll synthesis which in turn increases the rate of photosynthesis. Application of organic manure thus would have helped in the plant metabolic activity through the supply of such important micronutrients in the early vegetative growth (Anburani and Manivannan, 2002).

Table 6. Effect of mulching and FYM levels on number of fruits per plant of okra during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Number of fruits per plant
Mulching	
No Mulching	13.06^{b}
Mulching	18.63^{a}
LSD	1.658**
SEm±	0.56
FYM levels	
0 Mg ha^{-1}	12.82^{c}
10 Mg ha^{-1}	14.90^{bc}
20 Mg ha^{-1}	15.57^{b}
30 Mg ha^{-1}	16.30^{b}
40 Mg ha^{-1}	19.63^{a}
LSD	2.621**
SEm±	0.88
CV%	13.64 $^{\%}$
Grand mean	15.84

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations DAS= Days after sowing FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, *=significantly different at (P=0.05), **=significantly different at (P=0.01) and CV= Coefficient of variation. NS= Non significant

4.2.3 Length of the fruit

The highest length of fruit (14.72 cm) was recorded in mulching treatment and the lowest (13.23 cm) was recorded without mulching. The highest length of fruit (14.87 cm) was observed from the application of 20 Mg ha^{-1} FYM and lowest (12.93 cm) was observed from zero application of FYM. The effect of mulching on fruit length was significant. Similarly, FYM also significantly (*P*<0.01) affected the length of the fruits. However, the interaction between mulching and FYM were found non-significant (Table 7 and Appendix 5a).

Table 7. Effect of mulching and FYM levels on fruit length of okra during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Fruit length (cm)
Mulching	
No Mulching	13.23[b]
Mulching	14.72[a]
LSD	0.913**
SEm±	0.31
FYM levels	
0 Mg ha^{-1}	12.93[b]
10 Mg ha^{-1}	14.73[a]
20 Mg ha^{-1}	14.87[a]
30 Mg ha^{-1}	12.95[b]
40 Mg ha^{-1}	14.39[ab]
LSD	1.444*
SEm±	0.49
CV%	8.52 %
Grand mean	13.97

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, **=significantly different at (P=0.01) and CV= Coefficient of variation

Comparatively shorter fruit length was recorded in the present study as compared to Acharya (2004). Fruit length depends on harvesting time from anthesis to fruit maturity. Fruit harvesting in short interval could be the reason for shorter fruit length. Hermann *et al.* (1990) reported an elongation in whole plant structure (main stem, laterals, internodes) and fruit as well under dense conditions.

4.2.4 Diameter of the fruit

Both mulching and increased FYM effect was significant on fruit diameter (Table 8 and Appendix 5a).

Table 8. Diameter of okra as affected by mulching and different level of FYM during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Fruit diameter (cm)
Mulching	
No Mulching	1.34^{b}
Mulching	1.49^{a}
LSD	0.059^{**}
SEm±	0.02
FYM levels	
0 Mg ha^{-1}	1.33^{c}
10 Mg ha^{-1}	1.42^{abc}
20 Mg ha^{-1}	1.38^{bc}
30 Mg ha^{-1}	1.50^{a}
40 Mg ha^{-1}	1.45^{ab}
LSD	0.093^{*}
SEm±	0.03
CV%	$5.38^{\%}$
Grand mean	1.42

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations FYM= Farm yard manure mg ha^{-1} = ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, *=significantly different at (P=0.05), **=significantly different at (P=0.01) and CV= Coefficient of variation

The highest diameter of fruit (1.49 cm) was observed in mulching and the lowest (1.34 cm) was observed in without mulching. The highest diameter of fruit (1.50 cm) was recorded from the application of 30 mg ha^{-1} FYM and the lowest (1.33 cm) was recorded from zero FYM applied plots. However, the interaction effect of mulching and FYM was non- significant in fruit diameter of okra.

4.2.5 Average fruit weight

The mulching and FYM both found non significantly affected (*P<0.05* and *P*<0.01) the average weight of the harvested fruit (Table 9 and Appendix 5a). Similarly, the interaction between mulching and FYM were non-significant.

Table 9. Effect of mulching and FYM levels on average fruit weight of okra during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Average fruit weight (g)
Mulching	
No Mulching	11.96[a]
Mulching	12.35[a]
LSD	NS
SEm±	0.20
FYM levels	
0 Mg ha^{-1}	11.92[b]
10 Mg ha^{-1}	11.62[b]
20 Mg ha^{-1}	12.18[ab]
30 Mg ha^{-1}	12.07[ab]
40 Mg ha^{-1}	12.98[a]
LSD	NS
SEm±	0.32
CV%	6.55 %
Grand mean	12.15

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations FYM= Farm yard manure mg ha^{-1} = ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, and CV= Coefficient of variation. NS= Non significant

The higher fruit weight (12.35g) recorded under mulching and then without mulching (11.96g) but the difference was not significant. The highest fruit weight (12.98 g) observed in application of 40 Mg ha^{-1} FYM and the lowest fruit weight (11.62 g) in application of 10 Mg ha^{-1} FYM. There was no significantly difference between 0 Mg ha^{-1} and 10 Mg ha^{-1} application of FYM and also no significantly difference between 20 and 30

Mg ha^{-1} application of FYM. However the difference was significant in 40 Mg ha^{-1} FYM with no FYM treatments.

4.2.6 Yield per plant

Mulching significantly affected (*P*<0.001) the yield per plant. Likewise, FYM also differed significantly (*P*<0.001) for yield per plant (Table 10 and Appendix 5b). However, the interaction between mulching and FYM were non-significant.

Table 10. Effect of mulching and FYM levels on yield per plant of okra during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Yield per plant (g)
Mulching	
No Mulching	156.58^{b}
Mulching	231.31^{a}
LSD	21.56**
SEm±	7.25
FYM levels	
0 Mg ha^{-1}	154.96^{c}
10 Mg ha^{-1}	171.27^{bc}
20 Mg ha^{-1}	190.00^{bc}
30 Mg ha^{-1}	197.28^{b}
40 Mg ha^{-1}	256.23^{a}
LSD	34.08**
SEm±	11.47
CV%	14.49 $^{\%}$
Grand mean	193.95

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations DAS= Days after sowing FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, **=significantly different at (P=0.01) and CV= Coefficient of variation

The higher yield per plant (231.31 g) was obtained from mulching and lowest yield per plant (156.58 g) obtained from without mulching. Similarly, the highest yield (256.23 g) recorded in the application of 40 Mg ha^{-1} FYM and lowest yield per plant (154.96 g) obtained from zero application of FYM. The yield per plant was not significantly different between 10 and 20 Mg ha^{-1} FYM treatments.

4.2.7 Productivity (Mg ha^{-1})

Mulching significantly affected (P<0.01) the productivity of okra. Similarly, FYM was also significantly different (P<0.001) for the productivity of okra (Table 11 and Appendix 5b). However, the interaction between mulching and FYM on productivity of okra was non-significant.

Table 11. Effect of mulching and FYM levels on productivity of okra during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Yield (Mg ha^{-1})
Mulching	
No Mulching	10.44^{b}
Mulching	15.42^{a}
LSD	1.437**
SEm±	0.48
FYM levels	
0 Mg ha^{-1}	10.33^{c}
10 Mg ha^{-1}	11.42^{bc}
20 Mg ha^{-1}	12.67^{bc}
30 Mg ha^{-1}	13.15^{b}
40 Mg ha^{-1}	17.08^{a}
LSD	2.272**
SEm±	0.76
CV%	14.49 $^{\%}$
Grand mean	12.93

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations DAS= Days after sowing FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, *=significantly different at (P=0.05), **=significantly different at (P=0.01) and CV= Coefficient of variation. NS= Non significant

The highest yield (15.42 Mg ha^{-1}) was obtained from the mulching and lowest yield (10.44 Mg ha^{-1}) was obtained from without mulching. Similarly, the highest productivity (17.08 Mg ha^{-1}) was obtained from the application of 40 Mg ha^{-1} FYM and lowest yield

(10.33 Mg ha^{-1}) got from zero application of FYM. There was no significant difference in the productivity of okra in application of 10 and 20 Mg ha^{-1} FYM.

The highest productivity could be explained as a close relation on number of pickings (15.18) and number of fruits per plant (19.63) at 40 Mg ha^{-1} application of FYM. The productivity of the okra is directly related to the number of picking, number of fruits per plant and weight of the fruits. Fruit production is a physiology process and related to the plant nutrient also. Vos and Sumarni (1997) indicated faster plant growth, early fruiting, reduced P concentration and increased N concentration in leaves and fruits and also increased fruit weight and yield of hot pepper with straw mulching compared to control. Further, they reported that rice straw mulch increased K- content and decreased P-concentration in leaves of bell pepper over no-mulch. Hundal *et al.* (2000) reported that concentration of nitrogen and phosphorus and nutrient uptake was significantly higher in mulched plots over unmulched plots in tomato.

Organic manure have the capability of supplying a range of nutrients and improving the physical and biological properties of the soil (Chaterjee *et al.*, 2005) which lead to increased up take of NPK and reduce the nutrient losses, improving the fertilizer use efficiency thus increasing the soil nutrient availability (Gruhn *et al.*, 2000). The interaction of mulching and FYM on productivity of okra was not significant.

4.3 Effect of mulching and FYM on soil moisture

Mulching significantly ($P<0.01$) affect the soil moisture percentage at 10, and 30 Days after mulching (DAM) and similarly FYM also significantly ($P<0.01$) affect the soil moisture percentage in okra field (Table 12 and Appendix 6). Conversely, not significant at 20 DAM, and at final harvest stages due to the heavy rain fall at that recorded period which was presented in Figure 2. There was no significantly difference in soil moisture percentage at different level of application of FYM at the period of before mulching but the higher soil moisture percentage (14.08%) recorded from the application of 40 Mg ha^{-1} FYM and lower soil moisture percentage (12.59%) was recorded in without application of FYM).

The higher soil moisture percentage (28.74%) recorded from mulching at 10 Days after mulching and lower soil moisture (15.71%) recorded at that day. Similarly higher soil moisture percentage (31.14%) was recorded at 40 Mg ha^{-1} application of the FYM. Lower soil moisture percentage (14.81%) recorded in without application of FYM at 10 days after mulching. There was no significantly difference on soil moisture percentage at 30 Mg ha^{-1} and 40 Mg ha^{-1} application of FYM.

Table 12. Effect of mulching and FYM levels on soil moisture percentage in okra field during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Soil moisture (%)				
	Before mulching	10 DAM	20 DAM	30 DAM	At harvest
Mulching					
No Mulching	13.40^{a}	15.71^{b}	54.06^{a}	22.38^{b}	66.11^{a}
Mulching	13.74^{a}	28.74^{a}	51.19^{a}	31.14^{a}	60.53^{a}
LSD	NS	1.741**	NS	1.297**	NS
SEm±	0.54	0.58	6.52	0.44	2.21
FYM levels					
0 Mg ha^{-1}	12.59^{a}	14.81^{d}	47.20^{a}	20.18^{d}	61.09^{a}
10 Mg ha^{-1}	13.21^{a}	18.40^{c}	50.54^{a}	21.73^{d}	66.11^{a}
20 Mg ha^{-1}	14.53^{a}	21.57^{b}	54.33^{a}	26.01^{c}	62.50^{a}
30 Mg ha^{-1}	13.45^{a}	26.96^{a}	62.73^{a}	30.51^{b}	62.88^{a}
40 Mg ha^{-1}	14.08^{a}	29.38^{a}	48.33^{a}	35.35^{a}	64.04^{a}
LSD	NS	2.752**	NS	2.051**	NS
SEm±	0.86	0.93	10.32	0.69	3.49
CV%	15.54 %	10.21 %	48.02 %	6.32 %	13.51 %
Grand mean	13.57	22.23	52.62	26.76	63.33

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations DAM= Days after mulching FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, **=significantly different at (P=0.01) and CV= Coefficient of variation. NS= Non significant

The interaction effect of mulching and FYM was also significantly (*P<0.05*) affected at 10 days after mulching and (*P<0.01*) at 30 DAM (Table 13 and Appendix 6). The higher soil moisture percentage (37.38%) found with mulching and application of 40 Mg ha^{-1} FYM and lower soil moisture (10.46%) found without mulching and FYM.

Many researchers revealed the similar significant effect of rice straw mulching than without mulching in soil moisture percentage in different crops. Rathore *et al.* (1998) reported that more water conserved in the soil profile during the early growth period with straw mulch than without it. Gandhi and Bains (2006) observed that mulches modified the microclimate by modifying soil temperature, soil moisture and evaporation and the modified microclimate affected the yield contributing characters of tomato. Ghuman *et al.* (2001) concluded that mulching decreased bulk density of the surface soil and that increased the soil porosity and ultimately increased the soil moisture of the crop field. Mulching the soil surface reduce velocity of runoff, evaporation and increase the amount of water stored in the soil profile. Higher moisture in mulching treatments is due to infiltration.

The FYM improved soil fertility and similar results revealed by Ayuso *et al.* (1996). Abou El Magd *et al.* (2006) also observed macro and micro nutrients in available forms improving the physical and biological properties of soil under FYM treatments.

Table 13. Interaction effect of mulching and FYM on soil moisture percentage in okra field during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Treatments	Moisture %	
	10 DAM	30 DAM
No mulching × FYM 0 Mg ha^{-1}	10.46^{d}	17.76^{g}
No mulching × FYM 10 Mg ha^{-1}	13.96^{d}	19.45^{fg}
No mulching ×FYM 20 Mg ha^{-1}	13.59^{d}	21.02^{ef}
No mulching ×FYM 30 Mg ha^{-1}	19.16^{c}	24.56^{d}
No mulching ×FYM 40 Mg ha^{-1}	21.38^{c}	29.08^{c}
Mulching × FYM 0 Mg ha^{-1}	19.17^{c}	22.59^{de}
Mulching × FYM 10 Mg ha^{-1}	22.85^{c}	24.01^{de}
Mulching × FYM 20 Mg ha^{-1}	29.55^{b}	31.01^{c}
Mulching × FYM 30 Mg ha^{-1}	34.77^{a}	36.46^{b}
Mulching × FYM 40 Mg ha^{-1}	37.38^{a}	41.62^{a}
LSD	3.892^{*}	2.90^{**}
SEm±	1.31	0.98
CV%	10.21 %	6.32 %
Grand mean	22.23	26.76

Treatments means followed by common letter(s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations DAM= Days after mulching FYM= Farm yard manure mg ha^{-1}= ton per hectare, LSD= Least significant difference, SEm= Standard error of mean, *=significantly different at(P=0.05), **=significantly different at (P=0.01) and CV= Coefficient of variation

4.4 Diseases of okra

4.4.1 Damping off

Damping off was observed during emergence stage. The crop was slightly affected by damping off and gap filling was done where ever the losses of seedlings. No damping off was seen at other stages of plants.

4.4.2 Yellow vein mosaic virus (YVM)

Visual symptom of YVM virus was noticed in some plants at the harvesting stages so that the loss was not noticeable. To control disease and insect pest, the ecological pest management techniques was applied and prepared jhol mal and applied at 15 days interval after the emergence of seedlings. May be the oviposition deterrence, repellency, growth disruption, reduced fitness, and sterility properties of the liquid manure, (Saxena 1989, Isman *et al.,* 1990; Koul *et al.,* 1990, Schmutterer 1990), the YVM decreased from leaves of okra and no economic losses were occurred.

4.5 Insect pests of okra

Insect pests were observed during cropping period in okra. Jassid (*Amrasca biguttula biguttula)* and leaf eating caterpillar (*Anomis flava*), *Aphids, blue beetles* and *tobacco caterpillar* observed at early vegetative stage of the crop and attacked in some plots. After the succeeding of the crop no more insects were observed. To minimize the insect pest, ecological pest management approach was applied. Prepared jhol mal (liquid manure) and applied 15 days interval after the emergence of seedlings. Weeding and cleaning of field was done in regular basis. Some insect pests like leaf eating caterpillar were crushed by hands. Due to the repellent properties of the jhol mal, stem and fruit borer and other sucking types of insects were not noticed in significant numbers to loss the crop.

4.6 Economics of okra production

4.6.1 Market price of okra during harvesting period

The weekly average market price was collected from near market center Narayangarh by researcher in month of B.S. Ashad, 2070 (June, July 2013) for analysis of net return and B/C ratio. First week of the month of Ashad, the price was Rs.25/kg, 2nd week also Rs.25/kg and the price was decline at 3rd and 4th week at Rs. 15/kg. The mean market price Rs.20/kg (Appendix 7) was calculated for cost and return analysis.

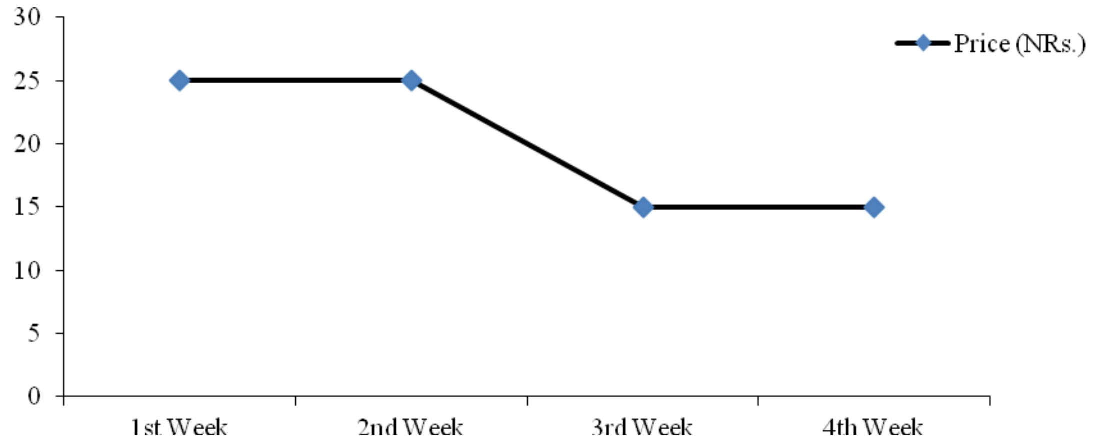


Figure 4. Weekly market price of okra of month Ashad, 2070 (June and July, 2013) of Narayangadh whole sell market

4.6.2 Labour cost

Labour is the most important and costly input used in the production of okra. Labour was used for the field preparation, seed sowing, weeding, mulching, jhol mal preparation and for harvesting. The total NRs. 70,371.00 was expended for labour cost (Table 14 and Appendix 8).

4.6.3 Other inputs cost

Other inputs seed, FYM and mulch materials (rice straw) were used. The seed used 15 kg ha^{-1} which was recommended by different researchers. Open pollinated Arka Anamika variety was used and cost for seed was NRs. 4500.00 per hectare. FYM was applied at the rate of 0, 20, 30 and 40 Mg ha^{-1} and rice straw mulch was used at the rate of 6 Mg ha^{-1}. The cost for different 0, 10, 20, 30 and 40 Mg ha^{-1} FYM levels were NRs. 0, 10,000.00, 20,000.00, 30,000.00, and 40,000.00 respectively (Appendix 8). The rice straw mulch cost was NRs. 66,667.00 per hectare.

4.6.4 Total income, net return and benefit cost (B/C) ratio

Total fresh vegetable yield (productivity), net return and B/C ratio of okra under mulching and different FYM levels were presented in Table 14 and Appendix 9. The higher income (Rs.411,140.00) was gained from mulching and application of 40 Mg ha^{-1} FYM and lower income (Rs.138,800.00) was gained from without application of mulching and FYM. Accordingly, the higher cost of production (Rs.251, 111.00) was expended in mulching and application of 40 Mg ha^{-1} FYM and lower cost of production (Rs.144, 444.00) was in without mulching and FYM. The higher net returns (Rs.16029.000) obtained from mulching and application of 40 Mg ha^{-1} FYM, similarly higher B/C ratio (1.64) was recorded from same treatment combination. The negative net returns (Rs. -5,644.00) obtained from without mulching and FYM with B/C ratio (0.96) recorded from that treatment combination.

Table 14. Total returns, total cost of production, net returns and B/C ratio of okra with mulch and different FYM levels during spring-summer season at Pithauli, Nawaparasi, Nepal, 2013

Treatments	Total returns (Rs.)	Total cost of production (Rs.)	Net Returns (Rs.)	Benefit/Cost ration
No mulching × FYM 0 Mg ha^{-1}	138,800	144,444	-5,644	0.96
No mulching × FYM 10 Mg ha^{-1}	209,540	154,444	55,096	1.36
No mulching ×FYM 20 Mg ha^{-1}	191,860	164,444	27,416	1.17
No mulching ×FYM 30 Mg ha^{-1}	231,660	174,444	57,216	1.33
No mulching ×FYM 40 Mg ha^{-1}	272,140	184,444	87,696	1.48
Mulching × FYM 0 Mg ha^{-1}	274,460	211,111	63,349	1.30
Mulching × FYM 10 Mg ha^{-1}	247,200	221,111	26,089	1.12
Mulching × FYM 20 Mg ha^{-1}	314,800	231,111	83,689	1.36
Mulching × FYM 30 Mg ha^{-1}	294,460	241,111	53,349	1.22
Mulching × FYM 40 Mg ha^{-1}	411,140	251,111	160,029	1.64

4.7 Focus group discussion with farmers at Pithauli-9, Nawalparasi

4.7.1 General background

Pithauli, VDC of Nawalparasi district is famous for vegetable production. In order to know about farming practices, perception of climate change, adopting agriculture techniques to cope the impact of climate change and profit and loss of the okra production in their own practices a focus group discussion was carried out with 20 key farmers having ecological agriculture and IPM practice from Rajmandir Mahila Krishak Samuha.

Most of the farmers were adopting substantial farming practices with livestock. Rice, wheat and maize are the main crops and some of the farmers were cultivated vegetables after main season rice harvest. Both the practices chemical and organic were practiced in crop production. For the crop nutrient most of the farmers were using chemical fertilizers and FYM and also for the plant protection both chemical and bio pesticides were used. But some of the farmers were adopting organic farming and they were preparing bio fertilizers for selling purpose also. During the discussion, they said that the government of Nepal, and also the NGO named as CARITAS Nepal was supporting them to adopt climate change smart techniques in vegetable and cereal crop production. Most of the farmers were taken vegetable production training from CARITAS Nepal so that they were aware about organic vegetable production techniques also.

During discussion, the researcher asked about the perception of climate change and feelings about weather. All the farmers agreed on changing climatic and being warmer. They also felt delayed an erratic rainfall. What are the coping mechanisms of the climate change? The coping mechanism was not popular to all farmers. Few innovative farmers believed in organic farming to cope against climate change effect. Majority of farmers believed on bio-pesticides. Some of the farmers argued lesser efficienciveness of bio pesticides compared to chemical pesticides in crop protection.

Some of the innovative farmers were cultivating okra at spring summer season and most of the farmers were cultivating maize and or left bare land due to the unavailability of irrigation facilities. Most of the farmers have no practices to calculate the cost and profit but they were confident that the vegetables were highly profitable than other cereal crops.

The farmers were utilizing local human labour for cultivating the crops and said that the labour cost is expensive and unavailable during the peak season due to foreign employment.

The farmers were also put following problems during the discussion.

- High price of inputs like seeds, chemical fertilizer and insecticides.
- Low price of products.
- Infestation of insect pests: High insect infestation and no any support and training from government sides.
- Marketing: There were no any marketing channels.
- Okra harvesting is very difficult due to the presence of hairs on fruit surface.
- Lack of training for vegetable production among farmers and also lack of knowledge.
- No organic certification and no genuine price of the organic products.

5 SUMMARY AND CONCLUSIONS

5.1 Summary

- An experiment was conducted at Pithauli-9, Nawalparasi, Nepal (154 meter average mean sea level, sub-tropical humid condition) during March to August 2013 to study the effect of mulching and FYM on okra production and soil moisture retention.
- The experiment was conducted in two factorial randomized complete block design. One mulching (mulching and no mulching) and other is FYM (0.10.20.30 40 Mg ha^{-1}) were replicated three times.
- Seeds soaked overnight in fresh water and kept 3 hrs in shade and three seed were sown on 15 April, 2013 directly in hills with 50 cm between rows and 30 cm within rows, and thinned to one plant per hill after 15 DAS. Each plot consisted of 5 rows and each rows of 8 plants.
- Well decomposed FYM (0, 10, 20, 30 and 40 Mg ha^{-1}) were applied to the particular plot as planned as treatment combination before a week of seed sowing at the time of land preparation on 9 April, 2013.
- Rice straw Mulch material was applied to the particular plot @ rate of 6 Mg ha^{-1} as planned as treatment combination at 25 DAS on 10 May, 2013. Before the mulching, the soil samples were taken from all plots to measure the soil moisture percentage of 30 cm depth soil.
- Jhol mal (liquid manure) was prepared and sprayed at 30 DAS and every 15 days of interval. The disease and insect pest infestations were observed frequently and treated with *jhol mal* to control the disease and insect pest of okra.

- Growth (plant height and leaf number) and yield (no. of picking, no. of fruit per plant, fruit length, fruit diameter, fruit weight, yield per plant and productivity) were recorded at 30, 45, 60, 75 DAS, and at final harvest stages.
- Statistical analysis was done by using Statistical packages namely Microsoft Excel, MSTATC, Duncon's Multiple Range Test (DMRT) and Least Significant Difference (LSD) test were used for mean separation.
- A focus group discussion was carried out in Pithauli-9, Nawalparasi to find out the perception on climate change and its' coping strategy of farmers.
- The highest (133.95 cm) and lowest (106.90 cm) plant height was observed from mulching and without mulching respectively. Similarly, the highest (143.90 cm) and lowest (97.42 cm) recorded from the application of 40 Mg ha^{-1} FYM and without FYM respectively.
- Number of leaves increased continuously up to 75 DAS and declined at final harvest stage. At 75 DAS, the highest number of leaves per plant (37.67) was recorded from mulching and the lowest number of leaves (31.72) was recorded from without mulching. Similarly, the highest number of leaves (37.95) recorded from the application of 40 Mg ha^{-1} FYM and lowest number of leaves (30.08) observed from without application of FYM at 75 DAS.
- The highest number of pickings (14.07) was recorded from mulching and lowest number of picking (8.61) from without mulching. Similarly, the highest number of picking (15.18) from the application of 40 Mg ha^{-1} FYM and lowest (7.58) from without FYM. The number of picking is higher with the higher application of FYM.
- The highest number of fruits per plant (18.63) obtained in mulching and lowest number of fruits per plant (13.06) found in bare land. Similarly, the highest number

of fruits per plan (19.63) recorded in the application of 40 Mg ha^{-1} FYM and lowest (12.82) from without application of FYM. The interaction of mulching and FYM were not significantly differences in number of fruits per plant.

- The longest fruit length (14.72 cm) recorded from mulching and shortest fruit length (13.23 cm) in without mulching. Similarly, the longest fruit length (14.39 cm) recorded from the application of 40 Mg ha^{-1} FYM and shortest fruit length (12.93 cm) from without application of FYM.
- The diameter of the fruit was recorded higher (1.49 cm) from mulching and lower (1.34 cm) recorded in without mulching. Likewise, the diameter of the fruits recorded higher (1.45 cm) from the application of 40 Mg ha^{-1} FYM and lower (1.33 cm) from without application of FYM.
- The average fruit weight was not significantly differences in mulching and FYM but the higher weight (12.35 g and 12.98 g) were recorded in mulching and application of 40 Mg ha^{-1} FYM respectively.
- The higher yield per plant (231.31 g) was obtained from mulching and lower (156.58 g) obtained from without mulching. Likewise, the higher yield per plant (256.23 g) obtained from the application of 40 Mg ha^{-1} FYM and lower yield per plant (154.96 g) from without application of FYM. The interaction effect of mulching and FYM was not significantly differences but the higher yield per plant was found in application of 40 Mg ha^{-1} FYM than mulching.
- The higher productivity (15.42 Mg ha^{-1}) was obtained from mulching and lower productivity (10.44 Mg ha^{-1}) obtained from without mulching. Likewise, the higher yield per hectare (17.08 Mg ha^{-1}) recorded from the application of 40 Mg ha^{-1} FYM and lower yield per hectare (10.33 Mg ha^{-1}) from without application of FYM. The interaction effect of FYM and mulching was not significantly differences in yield

per hectare but the higher yield (20.56 Mg ha^{-1}) was obtained from mulching and application of 40 Mg ha^{-1} FYM.

- The effect of mulching and FYM on soil moisture percentage was significant in 10 DAM and 30 DAM due to the low rainfall of that period. The higher soil moisture (28.74%) was recorded from mulching and lower soil moisture (15.71%) from without mulching. Similarly the higher soil moisture (29.38%) recorded from the application of 40 Mg ha^{-1} FYM at 10 DAM. The higher soil moisture (31.14 %) was recorded from mulching and lower (22.38 %) recorded from without mulching at 30 DAM. Likewise, the higher soil moisture (35.35 %) recorded from the application of 40 Mg ha^{-1} FYM and lower (20.18 %) from without application of FYM. The interaction effect of mulching and FYM was also significantly affected on soil moisture. The highest soil moisture (37.38 %) measured from mulching and 40 Mg ha^{-1} FYM and lowest (10.46 %) from without application of mulching and FYM at 10 DAM. Similarly, highest soil moisture (41.62 %) measured from mulching and application of 40 Mg ha^{-1} FYM and lowest (17.76 %) measured from without application of mulching and FYM at 30 DAM.
- Some diseases like Damping off was observed at emergence stage and Yellow Vein Mosaic virus observed at the harvesting stages in some plants.
- The insect pest, aphid, tobacco caterpillar and blue diamond beetle were observed during initial stages and they were managed by the application of jhol mal. The insect pests were disappeared, the reason behind it may be the repellent, and pesticidal effect of jhol mal.
- The highest net return (Rs. 160,029.00 /ha) was obtained from the interaction of mulching and 40 Mg ha^{-1} FYM application and lowest net returns (Rs. -5,644.00 /ha) from without application of mulching and FYM. The highest B/C ratio (1.64) was obtained from mulching and 40 Mg ha^{-1} FYM and lower B/C ration (0.96) was

obtained from without application of mulching and FYM. The net return is negative in without mulching and FYM.

- During focus group discussion, the perception of farmers on climate change found positive that they realized the changing climatic parameter from recent years. Some of the innovative farmers were aware on climate change and adopting climate change mitigation activities in their farming practices like organic farming. Some of the farmers were cultivating okra during spring summer season and applying both organic and inorganic farming practices. All the farmers said there was benefit from okra and other vegetable production than cereal crops and some organic producers farmers commented governments for organic certification, price of produce and training on organic farming. During the discussion, found that, the non government organization named CARITAS Nepal was working at their community on climate change mitigation.

5.2 Conclusions

Based on the results obtained in this study, following conclusions are made:

- Both Mulching and higher levels of FYM 40 Mg ha^{-1}significantly affected the productivity of okra. The maximum yield was obtained under application of 40 Mg ha^{-1} FYM during spring summer season at Pithauli, Nawalparasi condition.
- The interaction effects of mulching and different levels of FYM significant on soil moisture retention during spring summer season in sub-tropical humid condition
- The mulching and interaction with FYM ultimately reduce the frequency of irrigation for okra as well as any crop production during spring summer season in changing climatic condition.
- For commercial okra cultivation, the higher net returns can obtained from the combine application of mulching and 40 Mg ha^{-1} FYM.

6 LITERATURE CITED

Abou El-Magd, M.M., A.M., El-Bassiony and Z.F. Fawzy. 2006. Effect of organic manure with or without chemical fertilizers on growth, yield and quality of some varieties of Broccoli plants. Journal of Applied Science Research 2(10): 791-798.

Abu-Awwad, A M. 1998. Effect of mulch and irrigation water amounts on soil evaporation and transpiration. Journal of Agronomy and Crop Science 181: 55-59.

Abusaleha and K.G. Shanmugavelu. 1988. Studies on the effect of organic vs. inorganic source of nitrogen on growth, yield and quality of okra (*Abelmoschus esculentus* L.). Indian Journal of Horticulture 45 (3-4): 312-318.

Acharaya, U.K. 2004. Effect of plant growth regulators on growth and yield of spring summer season okra under inner Terai condition of Chitwan, Nepal. Thesis, M. Sc. Tribhuwan University, Institute of Agriculture and Animal Science, Rampur. 74p.

Acharya, C.L. and P.D. Sharma. 1994. Tillage and mulch effects on soil physical environment, root growth, nutrient uptake and yield of maize and wheat on an Alfisol in north-west India. Soil Tillage Research 4: 291–302.

Acharya, D.P., R.C. Bastakoti, K.L. Poudel and S.M. Sakaya. 2002. Profitability analysis of vegetable production along Dumre-Beshisahar road corridors. Technical paper No.4, Forum for Rural Welfare and Agriculture Development, Chitwan, Nepal. 29p.

Adams, C.F. 1975. Nutritive value of American foods in common units, U.S. Department of Agriculture, Agriculture Handbook, 425. 29p.

Adejonwo, K.O., M.K. Ahmed, S.T.O. Lagoke and S.K. Karikari. 1989. Effects of variety, nitrogen and period of weed interference on growth and yield of okra. Nigerian Journal of Weed Science 2: 21-27.

Adeoye, K.B. 1984. Influence of grass mulch on soil temperature, soil moisture and yield of maize and gero millet in a savanna zone soil. Samaru Journal of Agricultural Research 2: 87–97.

Alasiri, K.O. and O.O. Ogunkeye. 1999. Effect of different levels of poultry manure on seed yield of Okra. Proceedings 25th Annual conference of Soil Science Society of Nigeria, 21st to 5th November, 1999. Benin, Nigeria.

Ali, M. 2000. Dynamics of vegetables in Asia: A synthesis. *In:* Ali M (ed) Dynamics of vegetable production, distribution and consumption in Asia. AVRDC, Shanhua, Taiwan. pp. 1-29.

Aliudin, T. 1986. Effect of Soil tillage and application of mulch on Bhardwaj (ed). International. Journal of Research in Chemistry and Environment 2 (2): 8-20.

Anburani, A. and K. Manivannan. 2002. Effect of integrated nutrient management on growth in brinjal (*Solanum melongena* L.) cv. Annamalai. South Indian Horticulture 50(4-6): 377-386.

Anikwe, M.A.N., C.N. Mbah P.I., Ezeaku and V.N. Onyia. 2007. Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (*Colocasia esculenta*) on an ultisol in southeastern Nigeria. Soil and Tillage Research 93: 264–272.

Anonymous Commercial Flowers. 2003. Vol-II, 2nd revised addition, Naya Prokashan Calcutta. 351p.

Anonymous. 2006. Chilli exports touch all time high. Available at: http://www. thehindubusinessline.com (Retrieved on 18th June, 2013).

AVRDC. 2006. Vegetables Matter. AVRDC, The World Vegetable Center. Shanhua, Taiwan.

Ayuso, M.A., J.A. Pascal, C. Garcia and Hernandez. 1996. Evaluation of urban waste for Agricultural use. Soil Science plant Nutrition 42:105-111.

Batra, B.R., Y.S. Malik and M.L. Pandit. 1985. Evaluation of different mulching materials in okra production under dry farming conditions, Agriculture Science Division India 5: 8-9.

Bayu, W., N.F.G. Rethman, P.S. Hammers and G. Alemu. 2006. Effects of farmyard manure and inorganic fertilizers on sorghum growth, yield and Nitrogen use in a semi arid area of Ethiopia. Journal of plant Nutrition, 29:391-407. Available at: http://www.informatworld.com/smpp/content (Retrieved on 16th May, 2013).

Bhagat, R.M. and C.L. Acharya. 1987. Effect of soil management on rainfed wheat in northern India. I Hydro-thermal regime and root growth. Soil and Tillage Research 9: 65–77.

Bhattarai, D.R. and K. Budathoki. 2005. Effect of organic manures on pre and postharvest physiology and consumer' acceptability of cauliflower. Nepal Journal of Science and Technology 6: 11-14.

Bhelia, H.S. 1998. Tomato response to trickle irrigation and black polythlene mulch. Journal of the American Society of Horticultural Science 113: 543-546.

Bhuibhar, B.R., K.G. Mahakal, P.B. Kale and S.G. Wankhade. 1989. Effect of time of sowing and number of pickings of green fruits on growth and seed yield of okra (*Abelmoschus esculentus*). Vegetable Science 13: 39-43.

Bisaria, A.K. and A.P. Shamshery. 1979. Effect of different season on growth and yield attributes in okra (*Abelmoschus esculentus* L.). Haryana Journal of Horticulture Science 8: 156-157.

Black, A.L. 1973. Crop residue soil water and soil fertility related to spring wheat production and quality after fallow. Soil Science Society of American Proc. 37: 754-758.

Bond, W. and A.C. Grundy. 2001. Non-chemical weed management in organic farming systems. Weed Research 41: 383-405.

Boyer, J.S. 1982. Plant productivity and environment Science 218: 443-448.

Bray, E.A. 2002. Abscisic acid regulation of gene expression during water-deficit stress in the era of the *Arabidopsis* genome. Plant Cell Environment 25: 153-161.

Bray, E.A., J. Bailey-Serres and E. Weretilnyk. 2000. Responses to abiotic stresses. *In:* Gruissem W, Buchannan B, Jones R (eds) Biochemistry and molecular biology of plants. ASPP, Rockville, MD. pp. 1158-1249.

Brown, G.G., A. Pasini, N.P. Benito, A.M. De Aquino and M.E.F. Correia. 2001. Diversity and functional role of soil macrofauna communities in Brazilian no-tillage agro-ecosystems: a preliminary analysis. International Symposium on Managing Biodiversity in Agricultural Ecosyatems. Montreal, 8-10 November.

Brown, J.E., J.M. Dangler, F.M. Woods, K.M. Tilt, M.D. Henshaw, W.A. Griffey and M.S. West. 1993. Delay in mosaic virus onset and aphid vector reduction in summer squash grown on reflective mulches. Horticultural Science 28: 895-986.

Brown, J.E., W.D. Goff, J.M. Dangler, W. Hogue and M.S. West. 1992. Plastic mulch color inconsistently affects yield and earliness of tomato. Horticultural Science 27: 11-35.

Budhathoki, K., D.B. Gurung and D.P. Lohar. 1993. Vegetable crops: Indigenous knowledge and technology in the western hills of Nepal. Seminar Paper No. 1992/93. Lumle Regional Agriculture Research Centre, Nepal.

Budhathoki, K., M.S. Ghale, S. Ahamad and P.R. Bhurtyal. 1998. Approach and priority for horticultural crop research. *In:* P.P. Khatiwada and M.S. Ghale (eds.), Proceedings of a Second National Horticultural Research Workshop, Nepal Agricultural Research Council, Khumaltar, Nepal. pp. 218-224.

Chandramohan, S. 2002. Organic farming on cotton + blackgram intercropping system. M. Sc. (Agri.) Thesis, Tamil Nadu Agriculture University, Coimbatore, India.

Charrier, A. 1984. Genetic resources of genes *Abelmoschus* Med. (okra), (English, translation). IBPGR, Rome.

Chaterjee, B., P. Ghanti, U. Thapa and P. Tripathy. 2005. Effect of organic nutrition in spro broccoli (*Brassica aleraceae var. italica* plenck). Vegetable Science 33 (1): 51-54.

Chatterjee, B.N., K.I. Singh, A. Pal and S. Maiti. 1979. Organic manure as a substitute for chemical fertilizers for high yielding rice varieties. The Indian Journal of Agricultural Sciences 49(3): 188-192.

Chauhan, D.V.S. 1972. Vegetable production in India. Ram Prasad and Sons, Agra, 3. 122p.

Chauhan, M.S., N.N. Tripathi, J.C. Duhan and K.S. Vrik. 1979. Rhizoctonia rot of okra and its control. Pesticides 13: 24-25.

Chavan, P.J., Syedimaiz, Rudraksha, G. B., Malewar, G. and Baig, M. I. 1997. Effect of various nitrogen levels through FYM and urea on yield, uptake of nutrients and ascorbic acid content in chilli (*Capsicum annuum* L.). Journal of the Indian Society of Soil Science 45(4): 833-835.

Chawla, S.L. 2006. Effect of irrigation regimes and mulching on vegetative growth, quality and yield of flowers of African marigold. Ph.D. Thesis, Depatment of Horticulture, Maharana Pratap University of Agriculture and Technology, Udaipur.

Chen, Z. 1985. Polythene mulched groundnut development in Guanzhou city. Peanut Science Technology 3: 34–37.

Ching Fang, H. and H. Kvonon. 1994. Effect of organic manures on the growth and yield of sweet pepper. Bulletin of Taichung *District* Agricultural Improvement Station, 42: 1-10.

Choudhary, B. 1979. Vegetables. National Book Trust India. New Delhi. 125p.

Chung, D.H. 1987. Effect of polyethylene film mulching, sulphur application and different levels of nitrogen and potassium on growth, flower stalk elongation, bulbing and leaf tip yellowing of garlic (*Allium sativum*) cv. Enising. Journal of Korean Society of Horticultural Science 28: 1-8.

Cooper, A.J. 1973. Root Temperature and Plant Growth- A Review. Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent, UK.

Dadheech, L.N. 1972. Biological effectiveness of some insecticides and the extent of carbaryl residues in bhendi, (*Abelmoschus esculentus* L.) fruits. Thesis, M. Sc. Agriculture University of Udaipur, Udaipur. 89p.

Daisley, L.E.A., S.K. Chong, F.J. Olsen, L. Singh and C. George. 1988. Effects of surface-applied grass mulch on soil water content and yields of cowpea and eggplant in Antigua. Tropical Agriculture (Trinidad) 65: 300–304.

Damke, M.M., V.J. Kawarkhe and C.V. Patil. 1988. Effect of phosphorus and potassium on growth and yield of chilli. Journal of Research, Punjab Agriculture University 12: 110-114.

Das, D.K., D.C. Choudhury, A. Ghosh, B. Mallikarjuna, N. Suryanarayana and K. Sengupta. 1990. Effect of green manuring, dry weed and black polythene mulching on soil moisture conservation, growth and yield of mulberry and their economics under rainfed condition. Indian Journal of Sericulture 20: 263-272.

Dastane, N.G. 1967. A Practical Manual for Water Use Research, Navabharath Prakasan, Poona, India. 5p.

Dhiman, S.D., H.C. Sharma, D.P. Nondol, O.M. Hari and D. Singh. 1998. Effect of irrigation, methods of crop establishment and fertilizer management on soil proeprties and productivity in rice (*Oryza sativa*) – wheat (*Triticum aestivum*) sequence. Indian Journal of Agronomy 43(2): 208-212.

Dilip, K.G., S.S. Sachin and R. Kumar. 1990. Importance of mulch in crop production. Indian Journal of Soil Conservation 18: 20-26.

Dixit, C.K., A.M. Majumdar. 1995. Effect of mulching on water use efficiency, yield and quality of potato (*Solanum tuberosum* L.). Haryana Journal of Horticultural Science 24: 286-291.

Duiker, S.W. and R. Lal. 1999. Crop residue and tillage effects on carbon sequestration in a Luvisol in central Ohio. Soil Tillage Research 52: 73–81.

Duzyaman, E. 1997. Okra: Botany and Horticulture. *In:* J. Janick (ed.). Horticultural Reviews 21: 41-63.

Duzyaman, E. 2006. Cultivar differences in yield distribution pattern in okra (*Abelmoschus esculentus* (L) Moench). Australian Journal of Agricultural Research 57: 55-63.

El-Shakweer, M.H.A., E.A. El – Sayed and M.S.A. Ewees. 1998. Soil and plant analysis as a guide for interpretation of the improvement efficiency of organic conditioners added to different soil in Egypt. Communication Soil Science Plant Analysis, 29: 2067-2088.

Erenstein, O. 2002. Crop residue mulching in tropical and semi-tropical countries: An evaluation of residue availability and other technological implications. Soil and Tillage Research 67: 115-133.

FAO. 2008. Future strategy and constraints. MFS Series No. 15. ICIMOD, Kathmandu, Nepal. pp: 16-19. Available at: http://www.fao.org (Retrieved on 10th April, 2013).

Fung, H.C., H. Kuonan, C.F. Hsieh. and K.N. Hsu. 1994. Effect of organic manures on the growth and yield of sweet pepper. Bulletin of Taichung *District* Agricultural Improvement Station 42: 1-10.

Gajri, P.R., V.K. Arora and M.R. Chaudhary.1994. Maize growth, response to deep tillage, straw mulching and farmyard manure in coarse textured soils of N.W. India. Soil Use Management 10: 15–20.

Gamze, O., D.K. Mehmet and A. Mehmet. 2005. Effects of salt and drought stresses on germination and seedling growth of pea (*Pisum sativum* L.). Turkish Journal of Agriculture and Forestry 29: 237-242.

Gandhi, N. and G.S. Bains. 2006. Effect of mulching and date of transplanting on yield contributing characters of tomato. Journal of Research, Punjab Agriculture University, India 43(1): 6-9.

Ghuman, B.S. and H.S. Sur. 2001. Tillage and residue management effects on soil properties and yields of rainfed maize and wheat in a subhumid subtropical climate. Soil Tillage Research 58: 1–10.

Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research, 2nd Ed., John Willey and Sons, New York.

Gondane, S. U. and G. L. Bhatia. 1994. Screening of okra genotypes for resistance against root knot nematods. Haryana Journal of Horticulture Science 23: 70-72.

Gondane, S. U., G. L. Bhatia, and P. S. Pratatp. 1995. Correlation studies of yield components in okra (*Abelmoschus esculentus* (L.) Moench). Haryana Journal of Horticulture Science 24(2): 151-156.

Gopal, K., P.V. Deo and J.K. Bhavani. 1960. Influence of mulch on growth and yield of Bhokri grape. Horticulture Advance 4: 83-88.

Gopalakrishnan. 2007. Vegetable crops Publisher, New India Publishing, ISBN, 8189422413, 9788189422417. 343p.

Gopalan. C., B.V. Ramasastri and S. Balasubramanian. 2007. Nutritive Value of Indian Foods. National Institute of Nutrition (NIN), ICMR. New Delhi.

Gowda, N.N.C. and P.M. Gowda. 1981. Effect of inter spacing and cycocel on growth and yield of bhindi. South Indian Horticulture 31: 210-214.

Greenough, D.R., L.L. Black and W.P. Bond. 1990. Aluminum Bhardwaj International Journal of Research on Chemistry and Environment,2 (2) April 2012(8-20) *In:* surfaced mulch: an approach to the control of tomato spotted wilt virus in solanaceous crops. Plant disease 74: 805-808.

Gruhn, P., F. Goletti and M. Yudelman. 2000. Integrated Nutrient Management, Soil Fertility and Sustainable Agriculture. Food, Agriculture, and the Environment Discussion. pp.1-31.

Gupta, A. 1990. Response of spring planted okra to varying levels of irrigation and plant spacing. Vegetable Science 17: 16-19.

Gupta, A. and G.C. Rao. 1979. Studies on the response of okra (*Abelmoschus esculentus* L. Moench) to nitrogen and irrigation. Indian Journal of Horticulture 36: 177-182.

Gupta, J.P. 1985. Mulch is mulch. Intensive Agriculture 22: 16-18.

Gupta, J.P. and G.K. Gupta. 1986. Effect of soil tillage and mulching on soil environment and cowpea seedling growth under arid conditions. Soil Tillage Research 7: 233-240.

Gupta, J.P. and G.N. Gupta. 1987. Response of tomato and okra crops to irrigation and mulch in arid region of India, Agrochemica 31: 183-202.

Gyawali, B.K. 1993. Integrated pest management through indigenous techniques in Nepal. Tamanag (eds.) indigenous management of national resource in Nepal. HMGN/MOA, Winrock International, Kathmandu, Nepal.

Hafeez, A.S.M.G., M.D. Jahangir Kabir, M.Q. Zaman and M.A. Rahim. 2004. Okra cultivation at farmers' field: Input use, productivity and Resource use efficiency. Bangladesh Journal of Agriculture Research 29 (1): 67-72.

Ham, J.M., G.J. Kluitenberg and W.J. Lamont. 1993. Optical properties of plastic mulches affect the field temperature regime. Journal of the American Society for Horticultural Science 118: 188-193.

Hamon, S. and P. Hamon. 1991. Future prospects of the genetic integrity of two species of okra (*Abelmoschus esculentus* and *A. caillel*) cultivated in West Africa. Euphytica, 58: 101-111.

Hamon, S., J.C. Clement, J.M. Leblank and A. de Kochko. 1986. The cultivated okra in West Africa: Collecting missions in Guinea. Plant Genetic Resources newsletter 65: 34-37.

Havlin, J.L., D.E. Kissel, L.D. Maddus, M.M. Claassen and J.H. Long. 1990. Crop rotation and tillage effects on soil organic carbon and nitrogen. Soil Science Society of American Journal 54: 448–452.

Hazra, P. and M.G. Som. 1999. Technology for vegetable production and improvement. Naya Prokash, Calcutta. pp. 319-333.

Hema, L.R., M.B. Shivana, V. Kumar, M. Krishanopra, H.S. Prokash and H.S. Shetty. 1991. Control of seed borne fungi in okra by fungicidal seed treatment. Indian Journal of Agriculture 61(16): 778-782.

Herman, M., M. Makadji and H.H. Daunchit. 1990. Effect of intra-row spacing on time course of growth and fruit yield of okra. Scientia Horticulture 45: 37-48.

Hossain, A.K.M.A. 1995. Homestead vegetables production in Bangladesh. A consultancy report submitted to BARC/BARI-AVRDC-USID.

Hossain, M.D., M.A. Rahman, M.M. Hoque, M.S. Islam and M.A. Salam. 2001. Year round okra production and economic return as influenced by spacing in Barisal region. Bangladesh Journal of Agriculture Research 26 (3): 319-328.

Hossain, M.I., M.S. Rahaman and R. Islam. 2000. Impact study of improved technology of okra production. Bangladesh Journal of Agriculture Research 25(3): 529-540.

Hundal, I.S., K.S. Sandhu, D. Singh and M.S. Sandhu. 2000. Effect of different types of mulching and herbicidal treatments on nutrient uptake in tomato (*Lycopersicon esculentum*). Haryana Journal of Horticulture Science 29: 242-244.

Hussain, S., M. Shajid, N. Amin, A, Shah and I. Zafar. 2006. Response of okra (*Abelmoschus esculentus* (L.) Moench) cultivars to different sowing times Bangladesh Journal of Agriculture Research 1(1): 55-59.

Hutton, M.G. and D.T. Handley. 2007. Effects of silver reflective mulch, white inter-row mulch, and plant density on yields of pepper in Maine. Horticulture Technology 17: 214-219.

IBPGR. 1990. International Board for Plant Genetic Resources, Report on International Workshop on Okra Genetic resources held at the National bureau for Plant Genetic Resources, New Delhi, India.

ICMR. 1980. Nutritive value of Indian Food. National Institute of Nutrition, ICMR, Hyderabad, India.

IPCC. 2001. Climate change 2001. Impacts, Adaptation and Vulnerability- Summary for policy makers, IPCCC, Geneva, Available at: http://www.ipcc.com (Retrieved on 3rd June 2013).

Iremiren, G.O. 1988. Frequency of weeding okra (*Abelmoschus esculentus* L. Moench) for optimum growth and yield. Experimental Agriculture 24: 247-252.

Islam, M.S., M.M. Rahaman, K.A. Bhuiyan and S.K. Adhikary. 2000. Identification of seed borne fungi in okra and their control by fungicidal seed treatment. Bangladesh Journal of Agriculture Research 25(4): 637-641.

Isman, M.Z. and G.R. Port. 1990. Systemic action of neem seed substances against *Pieris brassicae*. Entomol. Exp. Appl. 54: 297-300.

Jack, C.V., W.D. Brind and R. Smith. 1995. Mulching Technology Comm. No. 49, Commnwealth Bulletin of Soil Science.

John, M. 2002. Paraquat –Syngenta's controversial herbicide.

Jones, R.A.C. 1991. Reflective mulch decreases the spread of two non-persistently aphid transmitted viruses to narrow lupin (*Lupinus angustifolius*). Annalogus of applied biology 118: 79-85.

Jones, T.L., U.S. Jones and D.O. Ezell. 1997. Effect of nitrogen and plastic mulch on properties of troup loamy sand and yield of 'Walter' tomatoes. Journal American Society of Horticultural Science 102: 273-275.

K.C., T.B. 1991. Introduction to soil and soil fertility. Institute of Agriculture and Animal Science, Rampur. pp. 41-48.

Kabir, J.M. D., A.S.M. Golam Hafeez, M.A.A. Begum and A.F. Mollah. 2002. Factors influencing okra and ash gourd production in some selected areas of Bangladesh. Bangladesh Journal of Agriculture Research 27(2): 203-210.

Katkar, R.N., A.B. Turkhede, V.M. Solanke and S.T. Wankhade. 2002. Response of cotton to integrated management of various types of organic manures and fertilizers. Crop Research 23(1): 194-197.

Kattimani, S. 2004. Response of chilli (*Capsicum annuum* L.) genotypes to integrated nutrient management. M.Sc. (Agri.) Thesis, University of Agriculture Science, Dharwad, Karnataka, India.

Kelly, J.W., P.H. Adler, D.R. Decoteau and S. Lawrence. 1989. Colored reflective mulches surfaces to control whitefly on poinsettia. Horticulture Science 24: 1045-1049.

Khajeh Hosseini, M., A.A. Powell and I.J. Bingham. 2003. The interaction between salinity stress and seed Vigor during germination of soybean seed. Seed Science Technology 1: 715-725.

Khurshid K., M. Iqbal, M.S. Arif, and A. Nawaz. 2006. Effect of tillage and mulch on soil physical properties and growth of maize. International Journal of Agriculture & Biology 8: 593–596.

Koay, S.H. and S.E. Chua. 1978. Effect of fertilizers on vegetative growth and pod production in okra. Singapore Journal 6: 76-79.

Koni, S.B. 1983. A study on crop residues management in chilli (*Capsicum annuum* L.) production. M.Sc. (Agri.) Thesis, University of Agriculture Science, Dharwad, Karnataka, India.

Koul, O. and M.B. Isman. 1991. Effects of azadirachtin on the dietary utilization and the development of the variegated cutworm *Performa saucier*. Journal of Insect Physiology 37: 591-598.

Kusvuran, 2012. International Journal of Agriculture Biology 14: 3

Lal, H., S.V.S. Rathore and P. Kumar. 1996. Influence of irrigation and mixtalol spray on consumptive use of water, water use efficiency and moisture extraction pattern of coriander. Indian Journal of Soil Conservation 24: 62-67.

Lal, R., D. De. Vleeschauwer and R.M. Nganje. 1980. Changes in properties of a newly cleared tropical Alfisols as affected by mulching. Soil Science Society of American Journal 44: 827–833.

Lee, K.H., C.Y. Cho, S.T. Yoon and S.L. Park. 1990. The effect of nitrogen fertilizer, plant density and sowing date on the yield of okra. Korean Journal of Crop Science 35: 179-183.

Maheshwarappa, H. P., Nanjappa and M. R. Hegde.1997. Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as a intercrop in coconut garden. Ann. Agric. Res. 20(3): 318-323.

Majanbu, I.S., V.B. Ogunlela and M.K. Ahmed.1986. Response of two okra (*Abelmoschus esculentus* L. Moench) varieties to fertilizers: Growth and nutrient concentration as influenced by nitrogen and phosphorus application. Nutrient Cycling in Agroecosystem 8(3): 297-306.

Makinde, E.A and A.A. Ayoola. 2008. Residual influence of early season crop fertilization and cropping system on growth and yield of cassava. American Journal of Agriculture. and Biological Science, 3(4): 712-715. Available at: http://www. scipub.org/fulltext/AJAB/AJAB34712-715.pdf. (Retrieved on 13th March, 2013).

Malawadi, M.N. 2003. Effect of secondary and micronutrients on yield and quality of chilli (*Capsicum annuum* L.). M.Sc. (Agri.) Thesis, University of Agriculture Science, Dharwad, Karnataka, India.

Mallanagouda, B., G.S. Sulikeri, G.B. Murthy and N.C. Prathiba. 1995. Effect of NPK, FYM and companion crops on growth, yield and yield components of chilli. Advance Agriculture Research in India 3: 58-69.

Mayalagu, K. 1983. Influence of different soil amendments on the physical properties of a heavy black soil and yield of groundnut TMV-7 in the Periyar Vaigai command area. Madras Agricultural Journal 70: 304-308.

Mbagwu, J.S.C. and F.A. Adesipe.1987. Response of three okra (*Abelmoschus esculentus* L. Moench) cultivars to irrigation at specific growth stages. Scientia Horticultur 31: 35-43.

Mclaurin, W.J., R.J. Constantin, J.F. Fontenot and D.W. Newsom. 1984. Effects of nitrogen on quality factors of canned okra. Journal of American Society of Horticulture Science 109: 524-526.

Menezes, S.M., D.E. Navais, H.L. Sontos and M.A. Dos.1974. The effect of nitrogen fertilization, plant spacing and mulching on the yield of garlic cultivar Amarante. Revista Ceres 21: 203-211.

Merwin, I.A., D.A. Rosenberger, C.A. Engle, D.L. Rist and M. Fargione. 1995. Comparing mulches, herbicides and cultivation as orchard groundcover management systems. Horticulture technology 5: 151-158.

MoA. 1995. Statistical information on Nepalese agriculture, 1994/95. Agricultural Statistics Division, Singha Durbar, Kathmandu, Nepal.

Mozumder, S.N., M.A. Rouf, A.K.M.Z. Rahman and M.A. Rashid. 2003. Effects of N, P, K, Zn and Mo on the yield and profitability of okra. Bangladesh Journal of Agriculture Research 28(2): 139-147.

Muhammad, A.P., I. Muhammad, S. Khuram and A.U. Hassan. 2009. Effect of mulch on soil physical properties and NPK concentration in Maize (*Zea mays*) shoots under two tillage system. International Journal of Agriculture & Biology 11: 120-124.

Muhammad, R.C., J. Muhammad and Z.M. Tahira. 2007. Yield and yield components of cowpea as affected by various weed control methods under rain fed conditions of Pakistan. International Journal of Agriculture and Biology, 1560- 8530/2007/09-1-120-124.

Mukherjee, D., S. Mitra and A.C. Das. 1991. Effect of organic matter cakes on changes in carbon, nitrogen and microbial population in soil. Journal of Indian Society Soil Science 39: 121-126.

Nagel, D. 1995. Commercial production of okra in Mississippi. Information Sheet of Mississipi State University Cooperation Extension Service 1510:2.

Naik, L.B. 1994. Influence of fertilization and plant spacing on growth and dry matter distribution in okra (*Abelmoschus esculentus* (L.) Moench). Haryana Journal of Horticulture Science 23(1): 61-65.

Nandkarni, K.M. 1927. Indian Meteria Medica. Nadkarni and Co Bombay.

Nath, P.S.V. and D.P. Singh. 1987. Vegetable for the Tropical Region, ICAR, New Delhi. 230p.

Nehra, A.S., I.S. Hooda and K.P. Singh. 2001. Effect of integrated nutrient management on growth and yield of wheat (*Triticurn aestivum* L.) Indian Journal of Agronomy 45: 112-117.

Neupane, F.P. 1989. Crop pest and their control (3rd ed.). Sanjha Prakashan, Kathmandu (in Nepali). 225p.

NHRDF. 2000. Okra. National Horticultural Research and Development Foundation, Bangloore, India. Extension Bull. No.17.

Olasantan, F.O. 1988. Effect of leaf removal on the growth and yield of okra (*Abelmoschus esculentus* L. Moench) and its relevance to leaf harvesting patterns and pest damage. Experimental Agriculture 24: 449-455.

Orozco-S. M., A.O. Lopez, Z.O. Perez. and S.F. Delgadillo. 1994. Effect of transparent mulch, floating row cover and oil sprays on insect populations, virus diseases and yield of cantaloup. Journal of Biological Agriculture and Horticulture 10: 229-234.

Ossom, E.M., P.F. Pace, R.L. Rhykerd and C.L. Rhykerd. 2001. Effect of mulch on weed infestation, soil temperature, nutrient concentration, and tuber yield in *Ipomoea batatus* (L.) Lam. In Papua New Guinea. Tropical Agriculture (Trinidad) 78: 144-151.

Palanisamy, V. and T.V. Karivaratharaju. 1984. Effect of varying plant population on the seed yield and quality of bhendi (*Abelmoschus esculentus* L. Moench). South Indian Horticulture 32: 239-242.

Pandey, U.C. and I.S. Singh. 1970. Effect of nitrogen, plant population and soil moisture regimes on seed production of okra. Vegetable Science 6: 81-91.

Passioura, J.B. 1996. Drought and drought tolerance. Plant Growth Regulation 20(2): 79-83.

Passioura.J.B.2007. The drought environment: physical, biological and agricultural perspectives. Journal of Experimental Botany 58(2): 113-117.

Paustin, K., H.P. Collins and E.A. Paul. 1997. Management controls of soil carbon. *In:* Paul, E. (eds.), SOM in Temperate Agroecosystems: Long Term Experiments in North America, pp: 15–49. CRC Press Inc.

Peter, K.V. 1997. Trends in production, cultivation, processing and storage of chillies. Spice India 10(12): 9-14.

Pimpini, F. 1974. Chemical weed control in a semi-forced crop of gladiolus. Rivista di Agronomia 8: 335-343.

Pradhan, R.B. 1988. Indigenous weeds as protectant against potato tuber moth (Pthorimae operculella) infestation under farmers potato storage condition Proceedings of the National Conference on Science and Technology, April 24-29, 1988. RONAST, Kathmandu, Nepal. pp. 149-152.

Radha Madhav, M., A. Ravikumar and B. Venkateshwarlu. 1999. Residual nutrient content of soil as influenced by organics usage in *kharif* rice. The Andhrapradesh Agriculture Journal 46(1-2): 120-121.

Rahaman, A. 1997. Impacts of different levels of pest management on okra seed production. M.Sc. Thesis. Department of Horticulture. Institute of Postgraduate Studies in Agriculture, Gazipur. pp. 3-5.

Rahman, M.M., S.K. Roy and A. Quasem. 1992. Effect of plant population and nitrogen on the yield and attributes of okra. Bangladesh Agronomy Journal 4(1-2): 7-12.

Rajput, R.K., M. Singh. 1970. Efficiency of different mulches on conserving soil moisture in cotton. Indian Journal of Agronomy 15: 41-45.

Ram, H.H. 1997. Okra. Vegetable Breeding Principles and Practices. Kalyani Publishers, Ludhiyana, India. pp. 208-219.

Ramakrishna, A., C.K. Ong and S.L.N. Reddy. 1991. Integrated weed management for rainfed groundnut. Journal Plant Protection Tropics 8: 111–119.

Rathore, A.L., A.R. Pal and K.K. Sahu. 1998. Tillage and mulching effects on water use, root growth and yield of rainfed mustard and chickpea grown after lowland rice. Journal of Science & Food Agriculture 78: 149–161.

Ravinderkumar and B.K. Srivatsava. 1998. Influence of different mulches on flowering anfruit setting of winter tomato, Crop Research 12: 174-176.

Regmi, B.R and A. Adhikari. 2007. Human Development Report 2007. A case study of Nepal.

Regmi, H.R. 2007. Effect of unusual weather on cereal crops production and household food security. The Journal of Agriculture and Environment. pp. 20-29

Regmi, P.P. and P.L. Karna. 1988. Weeds and other plants of pesticidal values in Nepal. National Conference on Science and Technology (April 24-29), Kathmandu, Nepal. pp. 161-173.

Rekhi, S.S., B.B. Shah and S.B. Aryal. 1990. Vegetable development in Nepal: Present status,

Rodale, R. 1984. Alternative Agriculture. Journal of Soil Water Conservation, 39:294-296. Available at: http://www.jswconline.org/content/349/5/294 (Retrieved on 24th April, 2013).

Sahu, R.C. 1996/1997. An inventory of insecticidal plants of Nepal. Journal of Institute of Agriculture and Animal Science 17-18: 99-115.

Saimbhi, M.S. 1993. Agro-techniques for okra. *In:* K.L. Chadha and G.Kallo (Eds.). Advances in Horticulture 5: 528-536.

Saimbhi, M.S. 1993. Growth Regulators in Vegetables Crops. *In:* K.L. Chadha and G.Kallo (Eds.). Advances in Horticulture 5: 519-633.

Sanwal, S.K., K. Lakminarayana, R.K. Yadav, N. Rai, D.S. Yadav and B. Mousumi. 2007. Effect of organic manures on soil fertility, growth, physiology, yield and quality of turmeric. Indian Journal of Horticulture 64(4): 444-449.

Sarker, M.M.H. 1996. Studies of anthracnose disease on okra. Thesis, M.Sc. Department of Plant Pathology. Bangladesh Agricultural Universities, Mymensingh, pp.50-52.

Saroa, G.S. and R. Lal. 2003. Soil restorative effects of mulching on aggregation and carbon sequestration in a Miamian soil in Central Ohio. Land Degrade Development 14: 481–493.

Saxena, R.C. 1989. Insecticides from neem, pp. 110-135. In J. T. ARNASON, B.J.R. PHILOGENE & P. MORAND (eds.9). Insecticides of plant origin. ACS Symposium Series No. 387. American Chemical Society, Washington, DC.

Schalk J. M., C.S. Creigaton, R.L. Fery, W.R. Sitterly, R.W. Dewis, T.L. McFadden, and D.A.Y. Augustine.1979. Reflective film mulches influences insect control and yield in vegetables. Journal American Society of Horticultural Science 104: 759-762.

Schippres, R.R. 2000. African indigenous vegetables and overview of cultivated species.Natural Resources Institute, Chathaam, UK. pp. 89-98.

Schmutterer, H. 1990. Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. Annual Review of Entomology 35: 271-297.

Sendurkumaran, S., S. Natarajan and S. Thamburaj. 1998. Effect of organic and inorganic fertilizers on growth, yield and quality of tomato. South Indian Horticulture 46(3-4): 203-205.

Sharma, A.K. 2001. A Handbook of Organic Farming, Agrobios (India), Jodhpur.

Sharma, A.R. and B.N. Mittra. 1991. Effect of different rates of application of organic. Journal of Agricultural Science (Cambridge) 117: 313-318.

Sharma, B.R. and S.K. Arora. 1993. Improvement of okra. *In:* K.L. Chadha and G.Kallo (Eds.). Advances in Horticulture 5: 343-364.

Sharma, G. 2005. Organic Agriculture in Nepal: An Analysis in to Status, Policy, Technology and Psychology." *In:* Sharma, G. and P.B. Thapa (Eds.) Proceeding of National Workshop on Organic Agriculture and Food Security, December 13-15, 2005, Kathmandu, Nepal.

Sharma, J.P. 1970. Effect of different soil moisture regime, nitrogen and plant densities on growth, yield and quality of bhindi. Ph.D. thesis, Agra University, Agra, India.

Sharma, N.K. and P.L. Bhalla. 1995. Influence of Intregated nutrient Management on growth, yield and economics in okra. Vegetable Science 22 (1): 1-4.

Shashidhara, G.B. 2000. Integrated nutrient management in chilli (*Capsicum annuum* L.) under Northern Transitional Zone of Karnataka. Ph.D. Thesis, University of Agricultural Sciences, Dharwad, Karnataka, India.

Shrestha, G.K. 1986. Response of summer okra to dates of planting and mulching under Chitwan conditions. Nepalese Journal of Agriculture 17: 17-21.

Singh, J. and B.S. Saharan. 1994. The response of okra varieties to different dates and methods of sowing- A Note. Haryana Journal of Horticulture Science 23 (1): 90-93.

Singh, K. and R.P. Gangwar. 1972. Effect of mulching in the production of potato. Journal of Haryana Horticultural Science 1: 39–45.

Singh, K. and R.P. Singh.1965. Nitrogenous fertilizers in relation to growth and fruiting of okra (*Abelmoschus esculentus* (L.) Moench). Indian Journal of Horticulture 22: 340-344.

Singh, K., R.N. Vashistha, M.L. Pandita and B.R. Batra. 1976. Effect of mulching on growth, and yield of cucurbits under rain fed condition. Journal of Haryana Horticultural Science 5:87–91

Singh, S., A.B. Mandal and T. Ram.1990. Physico-chemical changes in developing fruits of okra. Indian Journal of Plant physiology, 33:266-268.

Singh, S.B., K. Singh and S.P. Singh. 1985. Chemical weed control in seed crop of okra in Haryana. Haryana Journal of Horticulture Science 14: 127-171.

Sivanappan, R.K., C.R. Muthukrishnan, P. Natrajan and S. Ramdas. 1974. The response of bhindi (*Abelmoschus esculentus* L. Moench) to the drip system of irrigation. South Indian Horticulture 22: 98-100.

Sood, B.R. and V.K. Sharma. 1996. Effect of intercropping and planting geometry on the yield and quality of forage maize, Forage Research, 24(4): *pp.*190-192

Sriramachandrasekharan, M.V., G. Ramanathan and M. Ravichandran. 1996. Effect of organic manures on the availability of nutrients in rice rhizosphere soil. *Oryza* 33: 126-131.

Subbaiah, K., J. Helkaih, V. Ravikumar and Rajagopal. 1982. Effect of combined application of organic and inorganic fertilizers on the yield and nutrition uptake of MDU chilli. South Indian Horticulture 30: 45-47.

Subbarao, G.V., R.M. Wheeler, L.H. Levine and G.W. Stutte. 2001. Glycinebetaine accumulation, ionic and water relations of red-beet at contrasting levels of sodium supply. Journal of Plant Physiology 158: 767-776.

Subramanian, S., M. Rajeswari and T. Chitdeswari. 2000. Effect of organic fertilizer on soil moisture conservation in rainfed vertisol. Madras Agriculture Journal 88: 345-347.

Subramanyam, B.V., G. Lal and R.P. Tiwari. 1992. Effect of nitrogen and Gibberellic acid on growth and yield of okra cultivar Parvani Kranti. Vegetable Science 19(1): 102-106.

Sudhakar, G. 2000. Studies on to identify crop wastes/lowland weed as alternate source to organics to sustain the productivity of rice based system. Ph. D. Thesis, Tamil Nadu Agriculture University, Coimbatore, India.

Sultana, N., M.A. Kashem, M.S. Alam, K. Yashim and N.N. Khanam. 1997. Biochemical changes in leaves constituents of okra due to lady's finger yellow vein mosaic virus. Bangladesh Journal of Agriculture Research 22 (2): 161-166.

Suresh, V.V. 2000. Effect of nitrogen and potassium on yield and quality parameters of Byadagi chilli (*Capsicum annuum* L.). M. Sc. (Agri.) Thesis, University of Agriculture Science, Dharwad, Karnataka, India.

Sutagundi, R.H. 2000. Effect of mulches and manures on growth and yield of chilli (*Capsicum annuum* L.). M. Sc. (Agri.) Thesis, University of Agriculture Science, Dharwad, Karnataka, India.

Thakur, M.R. and S.K. Arora. 1986. Okra and vegetable crops in India. *In:* T. K. Bose and M. G. Som. (Eds.). Naya Prokash, Calcutta.

Thakur, R.B., S.K. Chaudhary and G. Jha. 1999. Effect of combined use of green manure crop and nitrogen on productivity of rice (*Oryza sativa*) – wheat (*Triticum aestivum*) system under lowland rice. Indian Journal of. Agronomy 44(4) : 664-668.

Thapa, R.B., F.P. Neupane and R.R. Adhikari. 1994. Efficacy of some insecticides against the cotton jassid, *Amrasca biguttula biguttula*, Ishida, on okra. Journal of Institute of Agricultur and Animals Science 15: 105-106.

Thompson, H.C. and W.C. Kelley. 1957. Vegetable crops, 5th Edition, McGraw Hill, New York. pp. 561-563.

Tindall, H.D. 1983. Vegetables in the Tropics. McMillan AVI 33. pp. 325-327

Tiwari, S.K., B.P. Jain, S.P. Singh and V.S. Bramhachari. 1985. Integrated method of weed control in okra (*Abelmoschus esculentus* L. Moench). Pesticides 19: 70-72.

VDD. 1991. Kitchen gardening manual. Vegetable Development Division. Division of Agriculture Development, Kathmandu, Nepal.

Velayudhan, K.C. and M. P. Upadhaya. 1994. Collecting okra, egg plant and their wild relatives in Nepal. Plant Genetic Resources Newsletter 97: 55-57.

Velumani, N.P. 1976. Studies on seed production and seed maturation in Bhendi (*Abelmoschus esculentus* (L.) Moench). Thesis M.Sc. Tamil Nadu Agricultural University, Coimbatore. 102p.

Velumani, N.P. and K.R. Ramaswami. 1980. Studies on fruit development and maturation in (*Abelmoschus esculentus* (L.) Moench). Indian Journal of Horticulture, 37(3):283-285.

Vos, J.G.M. and N. Sumarni. 1997. Integrated crop management of hot pepper (*Capsicum* spp.) under tropical lowland conditions. Effects of mulch on crop performance and prediction. Journal of Horticultural Sciences 72: 415-424.

Wallace, R.W. and R.R. Bellinder. 1992. Alternative tillage and herbicide options for successful weed control in vegetables. Journal of Horticultural Sciences 27: 745-749.

Waterer, D.R. 2000. Effect of soil mulches and herbicides on production economics of warm-season vegetable crops in a cool climate. Horticulture Technology 10: 154-159.

Wullschlenger, S.D. and D.M. Oosterhuis. 1991. Osmotic adjustment and the growth response of seven vegetable crops following water-deficit stress. Horticulture Science 26: 1210-1212.

Yadav, A.K. and S.M. Mowade. 2004. Organic manures and compost. In : Organic Farming - A Ray of Hope for Indian Farmer.

Yadav, S.K. and B.S. Dhankhar. 1999. Performance of Varsha Uphar cultivar of okra (*Abelmoschus esculentus* (L.) Moench) as affected by the sowing dates and plantgeometry. Vegetable Science 26(2): 180-182.

Yawalkar, K.S. 1995. Vegetable Crops of India, Agri-Horticultural Publishing House, Nagpur. 56p.

Yubakdhoj, G.C. and B. Ranabhat. 2001. Efficacy of Botanical Pesticides to Soybean hairy caterpillar. Journal of Institute of Agriculture and Animal Science 21-22: 233-237.

APPENDICES

Appendix 1. Monthly meteorological data during cropping season (March 2013 to August 2013), Dumkauli, Nawalparasi, Nepal, 2013

Months	Temperature (^oC)		Rainfall
	Max.	Min.	
March	31.27	17.04	13.00
April	34.04	19.67	0.00
May	34.13	23.75	27.85
June	33.33	25.58	31.15
July	33.47	34.21	47.18
August	33.28	25.66	65.65

Source: Meteorological station, Dumkauli, Nawalparasi, Nepal, 2013

Appendix 2. Physio-chemical properties of the soil at Pithauli, Nawalparasi, Nepal, 2013

Soil parameters	Value	Indicator
pH	5.65	Moderately acidic
Organic matter (OM)	0.3	Low
Total N_2 %	0.05	Low
P_2O_5 kg ha^{-1}	176	High
K_2O kg ha^{-1}	556	High
Texture		Silt Loam

(Source: Soil science lab (Nepal Agriculture Research Center, Khumaltar, Nepal, 2013)

Appendix 3. Analysis of variance showing mean square for plant height of okra crop on Mulching and FYM during spring summer-season at Pithauli, Nawalparasi, Nepal, 2013

Source	df	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	15.50	3.80	6.02	128.57	219.53
Factor A (Mulching)	1	20.40 NS	575.53**	710.53**	2980.03**	5502.65**
Factor B (FYM)	4	9.82 NS	56.95*	370.32**	1484.52**	2068.53**
AB (Mulching×FYM)	4	4.37 NS	41.63 NS	28.70 NS	52.31 NS	29.89 NS
Error	18	7.28	19.86	18.30	47.20	33.93
CV %		13.64 %	10.00 %	5.85 %	6.99 %	4.84 %

** indicates, significantly difference at *P<0.001*), * indicates significantly difference at *P<0.05* level of probability, abbreviation: DF indicates degree of freedom, NS indicates non significance, CV means Coefficient of variation and DAS means days after sowing

Appendix 4. Analysis of variance showing mean square for number of leaves per plant of okra crop on Mulching and FYM during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Source	df	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Replication	2	0.48	15.75	18.24	12.13	32.32
Factor A (Mulching)	1	0.01 NS	59.92**	236.88**	309.76**	226.32**
Factor B (FYM)	4	0.20 NS	7.71 NS	47.84**	51.00**	36.10**
AB (Mulching×FYM)	4	0.25 NS	1.95 NS	6.22 NS	4.42 NS	2.60 NS
Error	18	0.35	4.97	6.06	4.70	6.99
CV %		7.44 %	10.00 %	7.56 %	6.29 %	9.13 %

* indicates significantly difference at $P<0.05$ level of probability, abbreviation: DF indicates degree of freedom, NS indicates non significance, CV means Coefficient of variation and DAS means days after sowing

Appendix 5a. Analysis of variance showing mean square for yield and yield attributes of okra crop on mulching and FYM during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Source	df	No. of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)
Replication	2	6.99	6.20	0.01	0.74
Factor A (Mulching)	1	232.41**	16.55**	0.15**	1.12 NS
Factor B (FYM)	4	37.05**	5.50*	0.02*	1.56 NS
AB (Mulching×FYM)	4	5.44 NS	0.81 NS	0.03*	1.16 NS
Error	18	4.67	1.41	0.01	0.63
CV %		13.64 %	8.52 %	5.38 %	6.55 %

** indicates, significantly difference at $P<0.001$), * indicates significantly difference at $P<0.05$ level of probability, abbreviations: DF indicates degree of freedom, NS indicates non significance, CV means Coefficient of variation and DAS means days after sowing

Appendix 5b. Analysis of variance showing mean square for yield and yield attributes of okra crop on mulching and FYM during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Source	DF	No. of picking	Yield per plant	Yield
Replication	2	0.45	788.45	3.51
Factor A (Mulching)	1	223.04**	41888.78**	186.05**
Factor B (FYM)	4	53.01**	8911.57**	39.59**
AB (Mulching×FYM)	4	0.71 NS	1812.14 NS	8.05 NS
Error	18	2.22	789.53	3.51
CV %		13.13 %	14.49 %	14.49 %

* indicates significantly difference at $P<0.05$ level of probability, abbreviation: DF indicates degree of freedom, NS indicates non significance, CV means Coefficient of variation and DAS means days after sowing

Appendix 6. Analysis of variance showing mean square for soil moisture percentage of okra crop on mulching and FYM during spring-summer season at Pithauli, Nawalparasi, Nepal, 2013

Source	df	Before mulching	10 DAM	20 DAM	30 DAM	At harvest
Replication	2	0.07	3.10	1898.96	5.78	72.83
Factor A (Mulching)	1	0.83 NS	1274.53**	61.92 NS	576.23**	233.02 NS
Factor B (FYM)	4	0.45 NS	215.29**	235.71 NS	235.50**	21.25 NS
AB (Mulching×FYM)	4	3.35 NS	22.43*	446.82 NS	22.03**	49.30 NS
Error	18	4.45	5.15	638.62	2.86	73.21
CV %		15.54 %	10.21 %	48.02 %	6.32 %	13.51 %

** indicates, significantly difference at $P<0.001$), * indicates significantly difference at $P<0.05$ level of probability, abbreviation: DF indicates degree of freedom, NS indicates non significance, CV means Coefficient of variation and DAM means days after mulching

Appendix 7. Showing weekly market price of the okra during month of Ashad, 2070 (June and July, 2013 of Narayangarh whole sell market

Week	Price (NRs)
1st	25
2nd	25
3rd	15
4th	15
Mean	20

Appendix 8. Labour and input cost for okra cultivation with and without mulching and different levels of FYM during spring summer-season at Pithauli, Nawalparasi, 2013

Treatments	Labour cost (Rs.)	Seed cost (Rs.)	FYM cost (Rs.)	Mulching cost (Rs.)
No mulching × FYM 0 Mg ha^{-1}	70,371	4500	0	0
No mulching × FYM 10 Mg ha^{-1}	70,371	4500	10,000	0
No mulching ×FYM 20 Mg ha^{-1}	70,371	4500	20,000	0
No mulching ×FYM 30 Mg ha^{-1}	70,371	4500	30,000	0
No mulching ×FYM 40 Mg ha^{-1}	70,371	4500	40,000	0
Mulching × FYM 0 Mg ha^{-1}	70,371	4500	0	66,667
Mulching × FYM 10 Mg ha^{-1}	70,371	4500	10,000	66,667
Mulching × FYM 20 Mg ha^{-1}	70,371	4500	20,000	66,667
Mulching × FYM 30 Mg ha^{-1}	70,371	4500	30,000	66,667
Mulching × FYM 40 Mg ha^{-1}	70,371	4500	40,000	66,667

Appendix 9. Total returns, total cost of production, net returns and B/C ratio of okra with and without mulch and different FYM levels during spring-summer season at Pithauli, Nawaparasi, Nepal, 2013

Treatments	Total returns (Rs.)	Total cost of Production (Rs.)	Net Returns (Rs.)	B/C Ratio
No mulching × FYM 0 Mg ha^{-1}	138,800	144,444	-5,644	0.96
No mulching × FYM 10 Mg ha^{-1}	209,540	154,444	55,096	1.36
No mulching ×FYM 20 Mg ha^{-1}	191,860	164,444	27,416	1.17
No mulching ×FYM 30 Mg ha^{-1}	231,660	174,444	57,216	1.33
No mulching ×FYM 40 Mg ha^{-1}	272,140	184,444	87,696	1.48
Mulching × FYM 0 Mg ha^{-1}	274,460	211,111	63,349	1.30
Mulching × FYM 10 Mg ha^{-1}	247,200	221,111	26,089	1.12
Mulching × FYM 20 Mg ha^{-1}	314,800	231,111	83,689	1.36
Mulching × FYM 30 Mg ha^{-1}	294,460	241,111	53,349	1.22
Mulching × FYM 40 Mg ha^{-1}	411,140	251,111	160,029	1.64

BIOGRAPHICAL SKETCH

The author was born on 18th December, 1974 at Piple V.D.C. Chitwan as first son of Mr. Shiva Raj Oli and Mrs. Kul Kumari Oli. He completed his secondary education from Gadyauli Secondary School, Piple, Chitwan and completed his S.L.C. from S.L.C. Board of Nepal in the year 1991 with first division. Then, he completed his I. Sc. in Agriculture from Institute of Agriculture and Animal Science (IAAS), Paklihawa campus (T.U.) in 1993. He completed his B.Sc. in Agriculture from IAAS, Rampur with major subject soil conservation and watershed management in first division in 1998. The author has joint Master degree in IAAS, Rampur on 2012 A.D.

After the completion of B.Sc. in Agriculture, he started his professional career in agriculture, livelihoods and social development sectors in different national and international non government organizations and bilateral projects like Rural Reconstruction Nepal (RRN), Development Project Service Center (DEPROSC-Nepal), Lutheran World Federation (LWF-Nepal), Forum for Rural Welfare and Agriculture Development (FORWARD-Nepal) and Rural Village Water Resource Management Project (RVWRMP II) During his professional career, he developed training manuals on agriculture and social mobilization for the benefit of community people and served as a development worker for the welfare of pro-poor people of remote areas of Nepal.

The author is participated in various training such as proposal and project writing, participatory monitoring and evaluation and right based approach in human right and he is also good trainer on subject matter of agriculture, right to food and food security, livelihoods, micro enterprises and social mobilization.

Author