"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"

M.Sc. (Ag.) THESIS

By

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"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"

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Bhimavarapu Sreenivasulu

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Dedicated

To my beloved, first teacher

Shri Pamidi Pitchaiah garu

(Late)

Ponduru

CERTIFICATE - I

This is to certify that the thesis entitled **"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"** Submitted in partial fulfilment of the requirements for the degree of "**Master of Science in Agriculture"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Bhimavarapu Sreenivasulu** under my guidance and supervision. The subject of the thesis has been approved by student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published / published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

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CERTIFICATE - II

This is to certify that the thesis entitled **"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"** submitted by **Bhimavarapu Sreenivasulu** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfillment of the requirements for the degree of **M.Sc. (Ag.)** in the **Department of Horticulture** has been approved by the external examiner and student's Advisory Committee after oral examination.

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LIST OF ABBREVIATIONS

Abbreviations	Full form
%	Percent
AICRP	All India Co-Ordinated Research Project
ATER	Area Time Equivalent Ratio
B:C	Benefit Cost ratio
cm	Centimeter
DAP	days after planting
DAS	days after sowing
DAT	days after transplanting
Day^{-1}	per day
DBM	Diamond Back Moth
EFY	Elephant Foot Yam
$Plant^{-1}$	per plant
CF	Cassava Foliage
GM	Green Manure
GMR	Gross Money Returns
FAO	Food and Agricultural Organization
J2S	Second Stage Juveniles
LER	Land Equivalent Ratio
MPTS	Multi Purpose Tree System
NHB	National Horticulture Board
OM	Organic Manure
RDF	Recommended Dose of Fertilizers
SP	Sweet Potato
Ha^{-1}	per hectare
g	Gram
kg	kilo gram
RBD	Randomized Block Design
RH	Relative Humidity
t	tones
NPK	Nitrogen, Phosphorus, Potassium
MOP	Muriate of potash
SSP	Single Super Phosphate

Abbreviations	Full form
RMP	Relative Membrane Permeability
Rs	Rupees
YER	Yield Equivalent Ratio
Viz	Namely
mt	Million tones
Fig	Figures
FYM	Farm yard manure
et al	and co worker/other
^{0}C	Degree Celsius
m	Meter
@	at the rate of
SSD	sun shine duration
mm	Millimeter
NS	Non significant

Introduction

CHAPTER- I

INTRODUCTION

Increasing production in all spheres is imperative to meet the growing demand of the population in terms of food, fodder, fiber, fuel, timber and industrial raw materials. The need is increasing to produce more and more from less and less of land and water both in quantity and quality; and time. The agricultural production is no longer profitable despite higher investment. The efforts made so far were generally concentrated in improving the crop productivity on a single crop/ enterprise basis without much attention towards the associated areas that support or influence the crop growth (system as a whole). The declining sustainability of our agricultural systems can be traced to the exploitation of resources without conservation for sustenance and profits. An approach in system basis is the need of the hour for overall sustainable development. The aspects of efficient use of resources with conservation, growth with equity and sustainability are the difficult tasks to accomplish given the background of agricultural diversity and stubborn traditions attached to agriculture in India. The strategy in terms of finding alternate cropping systems that can meet the above necessities for sustainable agriculture development of the country is the need of the hour. Adoption of new cropping system is one of the ways to achieve the sustainability. When we consider adoption of new cropping system, we can think of integration of tuber crop with flower crop for sustainable higher productivity, better quality, more profits and employment. Intercropping is an age old practice of growing simultaneously two or more crops in the same piece of land. It is a technique of crop intensification in both time and space wherein the competition between crops may occur during a part or whole of crop growth period. It has been a common practice followed by the farmers of India, Africa, Sri Lanka and West Indies (Andrews and

Kassam, 1976). The basic idea of intercropping is not only that two or more crop species grown together can exploit the resources better than either of them grown separately, but, also to cover the inherent risks in agriculture and more so, under dry land conditions are buffered to some extent and is called as 'biological insurance' (Ayyangar and Ayyar, 1942; Singh and Katyal, 1966 and Ayyar, 1963).

Sweet potato (*Ipomoea batatas* (L) Lam), is a member of the convolvulaceae family. *Ipomoea batatas* (L) Lam is a Allohexaploid having 2n= 6x=90 chromosomes. South America has been widely recognized as the center of origin. It is propagated by 3-4 nodded, non- edible 20-25cm length fresh vine cuttings. It can come to harvest within 100-120 days after planting.

Sweet potato is grown for its starchy roots and immature leaves, which are used for human consumption (Hazra et al., 2011), animal feed (Lebot, 2009) and, to some extent, for industrial purposes (Woolfe, 1992). The crop is regarded as the most important root or tuber of the tropics because of flexibility in planting and harvesting schedules in frost free areas, short cropping season, use of non-edible parts for planting, non-trellising habit and low requirement for soil nutrients (Martin, 1985). Sweet potatoes also produce more edible energy than any other major food crops (194 MJ ha^{-1} day^{-1}; Woolfe,1992), are more productive with in short periods of time on marginal lands (Ray and Ravi, 2005) and play an important role in the economy of poor households (Nath et al., 2007). The crop is also used for the production of fuel, textiles, paper, cosmetics, glucose, adhesives and potable alcohol (Wu and Bagby, 1987; Ukom et al., 2009). Sweet potato is regarded as the 7^{th} most important food crop in the world (FAO, 2009). It is produced largely in Asia, with over 82% of the world production, followed by Africa, with 13.98% (FAO 2009). China is a major producer with 75.44% of the global production grown over 45.35% of the global area

(FAO, 2009). Among the 82 developing countries, 40 count sweet potato among the first five of their most important food crops (Elameen et al., 2008). Although the crop is assuming greater significance owing to the ever-increasing population, its importance is still underestimated and, unlike most staples, fails to attract sufficient attention of agricultural researchers throughout the tropics and subtropics.

In Chhattisgarh, the sweet potato production is gradually decreased; the production is 32,410 tons during the year of 2009-2010, with share of 2.77%. It occupied 5th place in India. Among many reasons for decreasing area and production of sweet potato in India as well as in Chhattisgarh are, low net profit from sole sweet potato crop, low marketable tubers from sole sweet potato crop and sweet potato based cropping system (The sweet potato based cropping systems are cassava, maize, beans, pigeon pea and chillies). Among the biotic constraints the sweet potato weevils (*Cylas formicarius* in Asia and Latin America and *Cylas brunneus* and *Cylas puncticolis* in Africa) are the most devastating insect pests of the crop worldwide causing economic damage when the weather is dry (Bourke, 1985). Sweet potato weevils are responsible for lower yields and marketable tubers. Tuber damage by weevils can reach up to 90% and relatively minor damage can both reduce yield and render infested tubers unmarketable owing to the presence of feeding marks and oviposition holes (Sutherland, 1986; Korada et al., 2010). Other deleterious symptoms are offensive odours due to the presence of terpenes produced by the insects (Sato et al., 1981) and to a raised level of phenolic compounds (Padmaja and Rajamma, 1982). Chemical control of this insect pest is very costlier and not much effective. Therefore, through cultural practices, it can be reduced and gain tuber yield and quality can be achieved.

A marigold, African Marigold (*Tagetes erecta*), French Marigold (*Tagetes patula*) belongs to a family Compositae and the Origin is Mexico and South America.

The Marigolds are one of the easiest annual flowers to cultivate and have wide adaptability to different soil and climatic conditions. All these favourable points make Marigold one of the most popular annual flowers in India. For garden display as well as for commercial cultivation.

In Chhattisgarh, little work has been done on intercropping of Sweet potato and Marigold. The past studies indicated that intercropping of Marigold can be effectively utilized to reduce the pest problem in Sweet potato. The Marigold can be used as multipurpose flower crop. It can be used as companion plantings, naturally reduce the pest problem, can be used as antagonistic plants, can produce chemicals in their roots that are toxic and, or /repellent to phytonematodes, root damaging insects, can be used as trap crop, can trap the pest from target crop and also gives additional income from flower yield of marigold. There is a possibility of increase in marketable tuber yields and net profit in intercropping system.

Therefore looking to the above facts, the present investigation "STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS" was conducted during rabi season of 2011- 12 at Horticultural Research cum Instructional Farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur with following objectives:

1. To study the effect of inter cropping of marigold on growth and yield of sweet potato,
2. To find out suitable inter cropping combination of sweet potato and marigold,
3. To study the effect of inter cropping of marigold on marketable yield of sweet potato, and
4. To work out the economics of inter cropping of marigold in sweet potato.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Review of literature pertaining to intercropping in sweet potato, their performance, yield advantages in intercropping and economics are presented in this chapter. The literature on intercropping of marigold in sweet potato and its impact on tuber growth, tuber yield and weevil control is not sufficient, hence the related literature on other crops have been reviewed in this chapter and presented under the following heads:

2.1. Intercropping and its importance in Horticulture

2.2. Intercropping and its impact on growth and yield

2.3. Intercropping on better economic returns

2.4. Intercropping on pest control

2.1 Intercropping and its importance in Horticulture

Ayyangar and Ayyer (1942) said intercropping is an age-old practice of growing simultaneously two or more crops on the same piece of land. Intercropping is mainly practiced to cover the risk of failure of one of the component crops due to vagaries of weather or pest and disease incidence.

Aiyer (1949) reported that the resources with regard to plant nutrients present in the soil or added to it as manures were utilized to the fuller extent in mixed stand than when component crops were grown separately. The crops with varying root depth, tap different layers of soil for plant nutrients and moisture. The periodical return and distribution of labour requirement throughout the year is of great help to the resource poor cultivators.

Donald (1963) opined that species of contrasting habit, both morphologically and Physiologically would together be able to exploit the total environment more

effectively than monoculture. If two species grown together are mutually beneficial, then there is cooperation. On the contrary, competition results when they tend to be mutually harmful and this competition is mainly for water, nutrients and light. The relationships of cooperation and competition are density dependent. At low densities there is cooperation and at high densities the active competition comes into existence.

Andrews (1970) gave general criteria to obtain increased returns from intercropping 1) Intercrop competition must be less than intra crop competition 2) The arrangement and relative number of contributing crop plants will affect the expression of the differences in competition 3) The effect of competition between crops is greatly alleviated when their demands on the environment occur at different times 4) The legumes may be necessary component crops under conditions of poor fertility.

Willey and Roberts (1976) reported light as a more important factor when better temporal use of resources was to be achieved due to better distribution of leaf area over time. It is observed that crop mixtures provide insurance against risk and give stable returns even under unfavorable weather conditions. The major way the crop mixture can achieve greater stability is from the compensation of one component crop when other fail or grow poorly, because of drought, pest or diseases. But, when two species are grown separately as sole crops, there is no possibility of this compensation. Intercropping would ensure low yield fluctuations than sole cropping even under unfavorable conditions.

Willey (1979) said the yield advantage in intercropping occurs because component crops differ in their use of growth resources. In terms of competition, this means that in some way the component crops are not competing for exactly the same overall resources and thus intercrops competition is less than intra-crop competition. Maximizing the intercropping advantage is therefore matter of maximizing the degree

of complementarity between the component crops and minimizing intercrop competition. The main way that complementarity can occur when the growth patterns of the component crops differ in time. Advantage occurs where the only differences between component crops are of time rather than of crop type.

Rao and Willey (1980) stated that the crop mixtures would also stabilize returns over seasons as they provide more than one commodity and can act as buffer against frequent price changes in any one of the component crops. Price fluctuations are quite common in countries like India, where 40 per cent of agricultural produce comes from rain fed agriculture.

Swaminathan (1980) stated that intercropping system should be based on complimentarity between the companion crops and the component of complimentarity are a) Efficient interception of sunlight b) Ability to tap the nutrients and moisture from different depths of soil c) Non-overlapping susceptibility to pests and diseases d) Introduction of legumes to promote biological nitrogen fixation and increase protein availability.

Willey *et al.* (1986) worked on advantages in intercropping system are mainly because of differential use of growth resources by the component crops. The main way for complementarity to occur is when the growth patterns of component crops differ in time. The yield advantages in intercropping system are associated with a fuller use of environmental resources overtime.

2.2 Intercropping and its impact on growth and yield

2.2.1 Intercropping of Sweet potato with other crops

Cruz and Cadiz (1977) carried out an experiment with eight cropping systems involving 5 crops planted continuously in 1974 to determine the annual productivity of each cropping system. The intercropped systems produced higher dry matter than

monocultures. The most productive system was corn + sweet potato and the lowest dry soybean alone. Among the crops, corn produced the highest dry matter yield, while green soybean intercropped with sweet potato had the lowest. Corn grain yield was reduced by 20% when intercropped with peanut, and 42% when intercropped with sweet potato. Sweet potato root yield was reduced by 12% when intercropped with green soybean, and 5% with corn. Peanut pod yield was reduced by 31% when inter cropped with corn.

Evangelio and Rosario (1981) conducted an experiment on sweet corn and sweet potato grown under three different cropping treatments. Double rows spaced at 0.3m with interval row spacing of 1.0m appeared to be the optimum treatment combination with a mean yield of 21.99 t ha^{-1}. Under this scheme, yield increases of 75% and 66% were noted in sweet potato, respectively. Land equivalent ratio (LER) was significantly affected by cropping systems.

Oswald *et al.* (1985) observed that in intercropping, decrease in tuber weight is greatest when shade is imposed at the end of the growing season and least at the beginning.

Robertws-Nkrumah *et al.* (1986) observed that the tuberization is almost absent at 74% shade and severely affected at 55% and not much affected at 25% shade (100% is fulshade).

Chujoy and Ona (1990) conducted an experiment on shade tolerance of sweet potato inter crop with maize. Sweet potato clones were screened for shade tolerance resulting from an intercrop with maize. Clones selected for root yield were compared to the unselected ones. This result suggests that clones selected for yield under full sunlight may also be the best under shade.

Frsesco (1990) evaluated different leguminous crops intercropped with sweet potato and examined their planting time relative to that of sweet potato to increase the productivity of sweet potato-based intercropping systems. Two soybean varieties (AGS 66 and AGS 129), one vegetable soybean (AGS 292), one mungbean (VC 3890 A) were intercropped with sweet potato (TN 67). Among legumes, mungbean was dominated by sweet potato because of its slow initial growth. Mungbean was more suited for intercropping with sweet potato than other legumes. Results of the combined yield indicated that late planting in spring is not suitable for sweet potato-legume intercropping compared to that in other planting seasons in previous trials.

Carandang and Curayag (1994) studied the inter cropping of sweet potato with sitao and soybean. The results revealed that the agronomic performance of the legume intercrop planted under single and double rows between the rows of sweet potato did not vary significantly in terms of plant height at harvest, air-dry matter yield and grain yield except for the air-dry matter yield of bush sitao. The double row planting of bush sitao between rows of sweet potato obtained a significantly higher air-dry matter yield compared to those of the single row planting. The agronomic performance of sweet potato showed that the length of the vines and the number of non-marketable and marketable roots under the different cropping systems did not vary significantly. The yield performance of the main crop, however, suggested that double row planting of either bush sitao or soybean intercrop tended to affect root production in sweet potato.

Lorica *et al.* (1997) used MPTS as hedgerows and sweet potato as alley crop in an agro forestry system. The growth and yield of sweet potato under different MPTS hedgerows significantly increase as compared with the growth and yield of the

same without hedgerows. Soil chemical properties such as K, P, and OM significantly improved.

Sauti *et al.* (2004) conducted an experiment on inter cropping of sweet potato with maize and sorghum, they observed significantly increase the total yield and marketable tubers in sweet potato when compared to sole Sweet potato crop.

Nedunchezhiyan *et al.* (2007) conducted field experiments to evaluate the performance of sweet potato varieties as intercrop in a coconut garden under rainfed conditions in sandy loam soil. The variety 'Pusa Safed' produced maximum vine length and number of leaves per plant. However, maximum fresh shoot weight was recorded in the variety Sree Bhadra. The variety 'Samrat' had higher yield attributes (number of tubers per plant, tuber length, mean tuber girth and tuber yield per plant) and yield. The tubers of 'Samrat' and 'Pusa Safed' had higher dry matter and starch content, whereas a local genotype had higher total sugars. Sweet potato varieties did not impart any adverse effect on coconut palm. The variety Samrat may be recommended for intercropping in coconut gardens.

Joomjantha and Wanapat (2008) studied the effect of various kinds of intercropping on yields and nutritive value of cassava foliage at 3 months of age. The cultivation treatments were: four rows of cassava without intercropping (control treatment, 4CF); four rows of cassava + two rows of *Phaseolus calcaratus* (4CF+2PC); four rows of cassava + two rows of sweet potato (4CF+2SP), and four rows of cassava + one row of *Phaseolus calcaratus* and one row of sweet potato (4CF+1PC+1SP). Cassava was planted on ridges. All foliages were initially harvested at 3 months after planting. The results showed that intercropping of cassava foliage with two rows of sweet potato significantly increased cassava foliage yield when compared with control and other intercropping treatments.

Ossom and Rhykerd (2008) conducted an experiment in Swaziland to determine the effects of intercropping a fixed plant population of sweet potato with varying ground nut populations on the yield of sweet potato tubers. When sweet potato (33.000plants ha^{-1}) was intercropped with 100,000 plants ha^{-1} of ground nut, tuber yields showed 54% increase.

Patel (2010) conducted an experiment at Navasari, on intercropping tuber crops in Sapota orchard. There were significant differences with respect to plant height and yield among different treatments. The plant height and yield of different tuber crops were maximum when they were sown as a sole crop and given 100% RDF. Regarding plant height,the length of sweet potato vines grown in sapota orchard and given 100% RDF were as good as the sole crops. Similarly, the yield of elephant foot yam grown as a sole crop received 100% RDF gave maximum yield but the crop grown in sapota orchard yielded as much as the sole crop.

Singh (2010) conducted an experiment at Faizabad, on intercropping tuber crops in Aonla. It is apparent from data presented that the sole crop of elephant foot yam, sweet potato and Cassava with their respective RDF gave yield of 26.20, 23.80 and 30.50 t ha^{-1} percentage decreases in the yield of tuber crops in intercropping with RDF over sole crop were 11.83, 19.96 and 11.97% in elephant foot yam, sweet potato and Cassava respectively. It was 41.98, 44.12 and 38.03 % in respective crops with half RDF.

Ijoyah and Jimba (2011) studied the effects of planting methods, planting dates and intercropping systems on sweet potato-okra yields. The result obtained showed that the greatest intercrop yields of sweet potato and okra were obtained when both crops were planted at the same time using the raised flattened top bed planting method. In both years, highest land equivalent ratio (LER) values of 1.97 and 2.00

and a greater percentage of land area saved (49.2 % and 50.0 %) were obtained when planting of sweet potato and okra was done at the same time using the ridge planting method. However, irrespective of the planting method used, it was advantageous to have both crops in mixture. The implication of study therefore, showed that to achieve optimal intercrop yields of sweet potato and okra, planting of both crops should be done at the same using the ridge planting method and could therefore be recommended for Makurdi location, Nigeria.

Nedunchezhiyan (2011) conducted field experiments at Dumduma, Bhubaneswar, to assess the sweet potato based strip intercropping systems with respect to productivity, nutrient uptake, competition and economic parameters. Sweet potato (*Ipomoea batatas* L.) + pigeonpea [*Cajanus cajan* (L.) Millsp.] strip intercropping system recorded significantly higher root equivalent yield (13.53 t ha^{-1}) compared to other cropping systems except sole sweet potato. The total yield gain in sweet potato + pigeonpea system was 28.8% and 24.7% over sweet potato + rice (*Oryza sativa* L.) and sweet potato + ragi (*Eleusine coracans* L.) strip intercropping system.

2.2.2 Intercropping of tuber crops (other than sweet potato) with other crops

Nedunchezhiyan (2005) conducted field experiment at Bhubaneswar, to assess the production and energy-use efficiency of various greater yam (*Dioscorea alata*) based intercropping systems. Greater yam was planted at normal (90 × 90 cm), paired (60/120 × 90 cm) and skipped rows (90/180 × 90 cm) with 1, 2 and 3 rows of maize (*Zea mays* L.), sorghum [*Sorghum bicolor* (L.) Moench] and pigeonpea [*Cajanus cajan* (L.) Millsp.] respectively as intercrop. Sole greater yam was planted as control. The maximum tuber-equivalent yield (18.7 t ha^{-1}), land-equivalent ratio (1.37) and production efficiency (89.2 kg $ha^{-1}day^{-1}$) were obtained with maize as an intercrop in

greater yam (normal planting), Thus, maize was the best intercrop (1 row) with greater yam planted at normal rows (90 cm × 90 cm).

Chattpadhyay *et al.* (2006) conducted field experiment with five levels of NPK (kg ha^{-1}) viz., 75:25:75; 100:50:100; 125:75:125; 150:100:150 and 175: 125:175, to find out their effect on growth and yield of elephant foot yam and also to study the effect of intercrop on the growth of main crop. The results revealed that fertilizer schedule comprising 175:125:175 NPK (kg ha^{-1}) may be recommended for obtaining higher yield of elephant foot yam grown as intercrop in the young arecanut plantation without hampering the growth of main crop.

Singh *et al.* (2007) conducted an experiment on intercropping of potato (*Solanum tuberosum* L.) and sugarcane (*Saccharum officianarum* L.). They have concluded that the intercropping of these crops results in increased productivity per unit area and time for both these crops, hence results in better returns.

Al-dalain (2009) experiment carried out to determine the effect of intercropping of maize with potato on potato growth and on the productivity and Land Equivalent Ratio (LER) of potato and maize. As for productivity, results indicated that the total productivity of each unit area using intercropping system was higher than the productivity of the sole crop, with superiority of treatments with 2.38 plant m^{-2} of maize and 4.76 plant m^{-2} of potato where mean yield of 44 ton ha^{-1}, while, the productivity in the other treatments were 36 and 37.8 ton ha^{-1}. LER showed positive influence using the intercropping system compared to the sole cropping, as it shown in the LER values, which were higher (1.43-1.55) in intercropping compared to (1) in the sole cropping.

Mehta *et al.* (2010) conducted field experiment on effect of intercropping system on growth; yield and system productivity was conducted at National Research

Centre on Seed Spices, Ajmer, Rajasthan. The experiment comprised of 13 treatments viz., sole coriander, sole onion, sole garlic, sole carrot, coriander + garlic (1:1), coriander + garlic (1:2), coriander + garlic (2:2), coriander + carrot (1:1), coriander + carrot (1:2), coriander + carrot (2:2), coriander + onion(1:1), coriander + onion (1:2) and coriander + onion (2:2). They observed that coriander + carrot in 1:1 ratio is best for realizing higher system productivity and profitability.

Nedunchezhiyan (2010) conducted field experiment to find out the effect of mulching and graded doses of fertilizer on yield and nutrient uptake of greater yam + maize intercropping system. Conspicuous increase in yield of greater yam (21.0%) and maize (10.3%) was observed with the application of 2 t ha^{-1} dried farm waste as mulch. Mulching increased 20.6% N, 25.9% P and 20.3% K higher uptake than no mulching in greater yam + maize intercropping system. Increased availability of mineral nutrition in mulched field due to favourable hydrothermal regimes in rhizosphere along with mineralization of mulched materials was responsible for this higher uptake.

Singh (2010a) conducted an experiment in IGKV,Raipur, on identification of suitable intercrops in taro/arvi. Among intercropping combinations (Taro + Cowpea, Taro + French bean, Taro +Turmeric, Taro +Ginger), Taro + Turmeric 1:2 proved best taro tuber yield 15.84 t ha^{-1} and Turmeric rhizome yield 19.09 t ha^{-1}.

Suja *et al.* (2010) while working on intercropping of cassava with two types of Cowpea (vegetables and grain types) the application of fertilizer 'N' could be reduced to half. He proved superior results in intercropping system in case of fresh tuber yield, tuber totals biomass production, as well as harvest index.

Rao (2010) observed significantly highest yield (43.64 t ha^{-1}) when Elephant Foot Yam intercropped with Turmeric (1:2) which was on par with Elephant Foot

Yam intercropped with Ginger (1:1) and (1:2) with the yield of 39.24 & 38.93 t ha^{-1} respectively, at Kovvur, A.P.

Singh (2011) conducted an experiment at Faizabad, on intercropping spice crops in elephant foot yam. Yield of elephant foot yam and spice crops in different treatments as well yield of sole crop (t ha^{-1}) was recorded and on the basis of prevailing cost of spices in local market, the equivalent elephant foot yam yield was observed and statically analyzed to draw conclusion and it was noted that treatment T3 (Elephant foot yam + turmeric (1:2)) recorded maximum equivalent yield of 39.19 t ha^{-1} which was significantly superior than other treatment.

Singh (2011) conducted an experiment at Dholi, on intercropping in EFY (Cv.Gajendra) with other spice crops viz., turmeric and ginger and noted different level of growth attributing characters and yield among different intercropping under test. EFY + Ginger at 1:1 ratio was found to be most suitable combination for enhancing plant height (51.53cm), plant girth (12.46cm), canopy length (87.46cm) and corm yield (51.41t ha^{-1}) as compared to sole crop 46.50 cm, 11.85 cm, 85.76 cm and 39.24 t ha^{-1}, plant height, plant girth, canopy length and corm yield, respectively. On the basis of yield equivalent ratio (YER), EFY + ginger (1:2) was found most economical (68.70 t ha^{-1}) followed by same treatment at 1:1 ratio (64.53 t ha^{-1}) with CB ratio of 1:1.78 and 1:2.43, respectively over sole crop.

2.2.3 Intercropping of other crops

Kaul *et al.* (1996) reported when mulberry was intercropped with different eight vegetables *viz.*, cauliflower, knolkhol, methi, peas, potato, radish, spinach and turnip. The experiment revealed that under intercropping, inter crop can be taken up without any harm to mulberry plant.

John and Mini (2005) conducted an experiment on intercropping of Okra +cowpea. Intercropping at 60 cm x 45 cm recorded the highest okra equivalent yield, lower weight of weeds from the inter space and highest gross return during both the seasons. In addition, highest net return and per day return were also recorded from the same treatment during the second season. The result revealed the scope of above combination as an economically viable, biologically suitable and sustainable cropping system to increase the productivity of vegetables.

Arya *et al.* (2011) recorded variations in growth and yield performances of trees as well as annual crops grown in combination under tree-crop farming. Plant growth and yield of all component crops were higher when grown under conjugation as compared to their sole croppings. Under integrated model, there was 50–53% increase in yield (84.60 to 86.52 q ha^{-1}) of ber over its sole cropping (56.32 q ha^{-1}).

2.3 Intercropping on better economic returns

2.3.1 Intercropping of Sweet potato with other crops

Kim *et al.* (1992) worked on intercropped sweet potato with maize. Results indicated that (1) the optimum planting density of maize in intercrop with sweet potato was 20,000-20,800 plants ha^{-1} with two spacing of 2.5 m x 0.4 m or 1.2 m x 0.8 and 2 plants $hill^{-1}$. (2) Sweet potato varieties suitable for intercropping were HL4, CLT 13, VSP5, Norin 37, H84-4, H85-6, H86-1, VSP1, NO38 and Hoang Long. (3) Highest profit was obtained when maize was sown 7 days before to 7 days after planting sweet potato. (4) Intercrop at the density of 20,000 maize plants was the most

profitable treatment. Also the intercrop had a higher efficiency than mono crop sweet potato or maize intercrop.

Kuruppuarachchi (1996) conducted an experiment to determine feasibility of potato inter-cropping under Kalpitiya condition and estimated the economic gains and losses of this combination against mono crop potato. The sweet-potato intercrop was planted four weeks ahead, four weeks later and simultaneously with potato. Planting sweet-potato simultaneously or four weeks later than potato increased the yield of potato. The yield increment ranged from 37-41%. On the other hand, the yield of potato was reduced when sweet-potato was planted four weeks ahead of potato. The yield of sweet-potato was reduced when it was planted four weeks ahead or simultaneously with potato but slightly increased when planted four weeks later than potato gave the highest computed income of Rs 300,800 ha^{-1}. This amount is 72% higher than mono-culture potato or 429% higher than mono-culture sweet-potato.

Prasad (2010) conducted an experiment at Ranchi, on intercropping of tuber crops in mango orchards. Elephant foot yam with 100% RDF in Mango orchard showed significantly superior yield of 37.76 t ha^{-1} which was numerically followed by elephant foot yam with 50% RDF (31.16 t ha^{-1}), Sweet potato with 100% RDF (19.91 t ha^{-1}) and cassava @ 100% RDF (18.27 t ha^{-1}). Economics study of mean of three years and treatments reveals that EFY with 100% RDF is the most remunerative treatment planted as intercrop in mango orchard with net income of Rs. 1, 28,800 followed by again EFY with 50% RDF (Rs. 83,600), Colocasia with 100% RDF (Rs. 62,020), Colocasia with 50% RDF (Rs. 49,620) and sweet potato with 100% RDF (Rs. 49,480).

2.3.2 Intercropping of marigold with other crops

Raut and Paradkar (2003) carried field experiment at J.N.K.V.V, Jabalpur, (M.P), to study the effect of flower plant based intercropping system on yield and sweet corn equivalent yield in terms of GMR of sweet corn. Among the seven intercropping systems, sweet corn+ marigold big (1;1) recorded the highest sweet corn equivalent yield of 99.28 q ha^{-1}, GMR of Rs 49893 ha^{-1}. Intercropping system is recommended for increasing per capita income of the growers in Chindwara region instead of grain/sweet corn sole crop cultivation.

Vaipuri et al. (2007a) conducted an experiment to find out the effect of unconventional greenmanures as intercrops on the nutrient uptake and yield of associate hybrid cotton. Four cropping systems viz, sole cotton, cotton + marigold (*Tageetus erectus* L.), cotton + sesamum (*Sesamum indicum* L.) and cotton + sunnhemp (*Crotolaria juncea* L.) . The results revealed that intercropping marigold in two rows in between cotton rows and incorporating it on 30 DAS had contributed ultimately more nutrient uptake of cotton in both summer and winter crops. Sunnhemp and sesamum had moderate and low effects, respectively on soil available nutrients and cotton uptake thus marigold outweighing other green manures in all the stages right from growth, physiology to soil fertility and crop uptake. Higher nutrient uptake of cotton had contributed more kapas and lint yield of cotton intercropped with marigold in two rows in between cotton rows and incorporating it on 30 DAS.

Srinivasan and Deveraj (2008) conducted field studies to investigate the effect of a plant growth promoting rhizobacterium, *Pseudomonas fluorescens*, egg parasitic fungus, *Paecilomyces lilacinus*, neem cake and marigold intercrop in different combinations, on root-knot nematode, *Meloidogyne incognita* and root tuber yield in medicinal coleus. Integration of strategies such as stem cutting dipping in

0.1% *P. fluorescens* + soil application of neem cake @ 400 kg ha^{-1} + growing marigold as intercrop followed by their biomass incorporation during earthing up increased the yield (22.7–30.0%) and reduced the root-knot nematode population (71.2–73.8%) superiorly, followed by the integration of *P. fluorescens* + marigold intercrop, which were almost equally effective. The economic returns per investment were higher in *P. fluorescens* + marigold intercrop (6.4–8.8 benefit: cost ratio).

Hussain *et al.* (2010) conducted an experiment on economics of marigold as trap crop in tomato. Tomato equivalent yield was more in 3:1 combination which recorded 24557.14 and 28399.99 kg ha^{-1} followed by 6:1 combination which recorded 22974.14 and 26565.97 kg ha^{-1}, respectively. It is concluded that 3:1 combination (Tomato: marigold) was the best treatment followed by 6:1 and 9:1 combinations. Whereas, the sole crop proved the least effective treatment.

Kumar *et al.* (2011) conducted an experiment on intercropping of marigold with baby corn resulted in significantly higher grain maize equivalent yields as compared to sole stands under pure organic conditions. Among different spatial arrangements, 2:1 additive series of tagetes in case of both grain maize and baby corn resulted in better yield of both the crops and baby corn + tagetes 2:1 intercropping system was found to be best intercropping systems resulting in 152 per cent higher maize equivalent yield over sole stand of maize with a, net returns of (Rs 58616 ha^{-1}) and benefit: cost ratio of (1.81).

2.3.3 Intercropping of tuber crops (other than sweet potato) with other crops

Tikader and Sen (1991) conducted an experiment on intercropping of ginger and field pea in mulberry garden. Ginger was sown in between the rows of mulberry during April-May and field pea was sown during November. The experiment revealed

that under intercropping the cost of cultivation goes down due to common cultural operations applied in both crops which in turn result in higher profit and little or no adverse effect on the yield of sole mulberry crop.

Mandal (1993) reported that intercropping of potato and maize in Mulberry garden can be done in between the two rows. The distance between the rows is 20"and 24" and plant to plant distance is 4" and 5", respectively. Potato was sown during winter and maize was grown during pre-monsoon season. It has been observed that due to intercropping, mulberry leaf yield never reduces and at the same time farmers get a good income.

Dhruv and Lal (2004) conducted field experiment to evaluate seven potato based cropping systems.The systems were: paddy –potato sunflower/mentha/bottlegourd/onion/sesame, Green manure (GM) - potato - sunflower and GM - potato + *rabi* maize intercropping. GM increased potato tuber yield in the system. Whereas paddy grain yield was higher after bottlegourd/sesame than after sunflower grown in summer. Among the summer crops, bottlegourd and onion performed better than sesame or sunflower in term of potato equivalent yield. Paddy - potato - bottlegourd was the most remunerative system and produced highest potato equivalent yield (539 q ha^{-1}) followed by paddy - potato - onion (517 q ha^{-1}) and paddy - potato - mentha (502 q ha^{-1}). Production efficiency of paddy - potato - onion system was highest, (180 kg ha^{-1} day^{-1}), while land use efficiency was highest in paddy - potato - mentha/onion systems.

Dua *et al.* (2005) conducted an experiment at Shimla to evaluate different row ratios and cropping geometry in potato (*Solanum tuberosum* L.) + French bean (*Phaseolus vulgaris* L.) intercropping system. The potato was a dominant species when it was sown in lesser proportion than French bean, whereas French bean

dominated potato in intercropping when its proportion was equal or less than that of potato. All the intercropping treatments showed yield advantage (LER &gt1) over the sole cropping. On the basis of land-equivalent ratio (1.4975) and compensation ratio (CoRa = 4.95; CoRb = 1.90), the maximum advantage from the intercropping of potato +French bean was obtained when planted in 2:2 row ratio with 100% population density of each crop.

Verma *et al.* (2008) conducted an experiment on coconut based intercropping system at Jagadalpur, with treatment involving, T1=coconut (control), T2=coconut+steivia, T3=coconut + amahaldi, T4=coconut +sarpagandha, T5=coconut+tikhur and T6=coconut +patchouli. The B: C ratio was maximum with tikhur intercropping (2.28) followed by amahaldi (2.06) and patchouli (0.99), whereas minimum B:C ratio was found under stevia intercropping (0.31). The income of coconut as sole crop is low in country but with the intercropping with different economical crops proves coconut cultivation beneficial.

Prasad (2011) conducted an experiment at Ranchi on intercropping spice crops in elephant foot yam. The present investigation has been formulated to trace out the feasibility of spices to be intercropped to the elephant foot yam for the remunerative cultivation. On the basis of first year trial conducted during 2010-11, it was observed that for obtaining more yields equivalent Elephant Foot Yam + Turmeric (1:2) is the most suited option (71.61 t ha^{-1}) followed by Elephant Foot Yam + Ginger (1:2) [68.72 t ha^{-1}]. However, statistically most of the treatments were found at par.

Roy and Hore (2011) carried out an experiment with two bio-fertilizers (Azospirillum and AM Arbuscular mycorrhizal fungi) and four organic manures (compost, vermicompost, phosphocompost and mustard cake) for turmeric cultivated in arecanut plantations. The maximum projected yield (28.94 t/ha) was observed with

vermicompost + Azospirillum + AM, followed by compost + Azospirillum + AM (26.93 t ha^{-1}) as compared to 24.11 t ha^{-1} under inorganic management. Economic assessment of different treatments revealed that maximum return was realized from vermicompost + Azospirillum + AM (Rs. 1, 79,712/-) followed by compost + Azospirillum + AM (Rs. 1, 64,571/-) as compared to Rs. 93,808/- under inorganic management. The B: C ratio of the above three treatments were 1.86, 1.89 and 1.14, respectively.

2.3.4 Intercropping of other crops

Gawade *et al.* (2004) studied the effect of intercrops on yield and monetary returns of cabbage in rabi seasons of 1995–96, 1996–97 and 1997–98. The pooled data of three years revealed that the combined yield of cabbage + palak was found to be significantly higher than the remaining crop combinations. The land equivalent ratio was highest in cabbage + methi than the remaining combinations. The highest monetary returns of Rs. 101760.43 were recorded by cabbage + palak while the same combination recorded the highest net profit.

Prakash *et al.* (2007) conducted field experiment at Almora, to find out the most productive and remunerative relay intercropping of tomato (*Lycopersicon esculentum* Mill. nom. cons.) or french bean (*Phaseolus vulgaris* L.) in maize (*Zea mays* L.), garden pea (*Pisum sativum* L. var. arvense poir.) in tomato or french bean, and french bean in garden pea. Results showed that relay intercropping of maize (green cobs) + tomato + garden pea + french bean, and maize (green cobs) + french bean + garden pea + french bean proved significantly superior in terms of maize grain-equivalent yield (71.3 and 51.5 t ha^{-1}), and net returns (Rs 2,39,558 and Rs 1,52,624 ha^{-1}) than maize (green cobs) – garden pea (18.8 t ha^{-1} and Rs 48,020 ha^{-1}) and french bean – garden pea (30.7 t ha^{-1}, and Rs 94,021 ha^{-1}) sequential cropping.

Agarwal *et al.* (2010) conducted an experiment on intercropping trial in Cauliflower (*Brassica oleracea* L. var. *botrytis*) cv. Snowbll-16 with the aim to find out the best intercropping system with better growth, yield and economic potential. Cauliflower intercropped with black cumin, Ajowan, Fenugreek and Marigold. Growth parameters very well showed that at the preliminary stages of growth, different intercropping treatments remained insignificant in all the growth parameters where as at later stages of growth i.e. at 45 and 60 DAT, All intercrops tried were significantly influenced and enhanced the growth parameters. At harvest maximum yield was achieved with T3 (cauliflower + Fenugreek) 16.58 t/ha followed by 14.80t ha^{-1} with T4 (Cauliflower +Marigold).

Ganajaxi *et al.* (2010) revealed that intercropping of French bean and maize did not affect the yield of maize significantly compared to sole maize. While French bean yield was reduced significantly in intercropping. French bean had greater radiation use efficiency in intercropping than in sole cropping. Here intercropping increased production per unit area per unit time without affecting the production of main crop to a greater extent. All the maize/legume intercroppings were having significantly higher LER (1.31 to 1.81), maize equivalent yield (67 to 140q ha^{-1}), net return (Rs10, 000 to 17, 000 ha^{-1}) and B: C ratio than the sole maize.

2.4 Intercropping on pest control

2.4.1 Intercropping of Marigold for control of Sweet potato weevil

Anonymous (2010) conducted a field trial at Bagalkot, on management of sweet potato weevil through barrier crop with 8 treatments. Among the various treatments, the treatment consisting of border row of marigold at all side resulted in significantly higher tuber yield per plot and hector (31.23 kg and 43.38 t ha^{-1}). Further it is relevant to note that the magnitude of weevil infestation (17.31 per

cent) and weevil population per kg of infected tuber (25.33) was lower due to above treatment.

Satyanarayana (2010) conducted an experiment at A.P.H.U, Rajendranagar, on effect of barrier crops on control of sweet potato weevil. The results on the effect of barrier crops (Yam Bean and marigold) indicated that planting of sweet potato with marigold as alternate planting is the best effective treatment to reduce the weevil infestation among the non-chemical treatments followed by yam bean planting, which have similar trend in reducing the weevil infestation.

Bhagwat (2011) conducted an experiment at Dapoli, on barrier crops (yam bean and marigold) in management of sweet potato weevil. Tuber infestation due to sweet potato weevil varied significantly from 18.82 to 37.81 per cent among different barrier crops as against 43.61 per cent in control (sole crop).The treatments T6 (paired rows of sweet potato and one row of marigold) and T5 (alternate rows of sweet potato and marigold) recorded significantly minimum tuber infestation than rest of the treatments with 18.82 and 21.46 per cent infestation.

Tarafder (2011) conducted an experiment at Kalyani on management of sweet potato weevil through barrier crops (yam bean and marigold). He indicated that planting of sweet potato with marigold as border crop plays excellent role to reduce the weevil infestation among the treatments followed by alternate planting with marigold and border crop of yam bean which have similar trend in reducing the damage by weevil. The marketable tuber yield was high in the plots of sweet potato with 1:1 ratio of marigold followed by the plots of sweet potato with border row. The alternate row of marigold (2:1), was at par with sweet potato and yam bean (2:1 ratio). The alternate row (1:1) with marigold was reasonably better than the planting in 2:1 fashion and the combination with sweet potato and marigold

was found better than other treatments where the marketable root yield was recorded high.

2.4.2 Other intercropping systems in control of Sweet potato weevil

Yoku *et al.* (1992) observed effects of four sweet potato inter cropping systems on the population density of sweet potato weevils. Percentage of damaged tubers ranged from 2.6% to 14.0% in inter cropped sweet potato, to 21.9% in the sweet potato monoculture. Intercropped sweet potato, however, had lower yields, from 0.8t h^{-1} to 2.9 t h^{-1} compared with 7.0 t h^{-1} in the sweet potato monoculture.

Nedunchezhiyan *et al.* (2010) studied at the Regional Centre of Central Root Crops Research Institute,Dumduma, Bhubaneswar to evaluate strip cropping involving sweet potato (*Ipomoea batatas* L.) on soil moisture conservation, weevil infestation and crop productivity.Growing sweet potato retained more moisture in the soil compared to other food crops. Strip cropping of sweet potato along with rice (*Oryza sativa* L.), ragi (*Eleusine coracana* L.), maize (*Zea mays* L.) and red gram (*Cajanus cajan* (L.) Millsp.) improved soil moisture storage in the soil profile compared to solecrops. Under strip cropping, rice, ragi, maize and red gram produced 12.3%, 4.5%, 8.3% and 33.0% greater yield relative to sole cropping. Strip intercropping in sweet potato reduced the root infestation by sweet potato weevil (*Cylas formicarius*). Less percentage of weevil damaged roots were found in sweet potato + maize strip intercropping followed by sweetpotato + red gram strip intercropping

Singh (2010b) conducted an experiment in Chhattisgarh on surveillance of diseases and pests of tuber crops. He reported the sweet potato damaged 40% tubers by the incidence of sweet potato weevil.

Singh (2010) conducted an experiment in Dholi, on management of sweet potato weevil through intercrops. Among different intercrops (Sweet potato + Coriander, Sweet potato + Chillies, Sweet potato + Garlic), sweet potato + coriander at 1:1 ratio recorded lowest tuber infestation (8.7%) caused by sweet potato weevil and gave highest marketable tuber yield (15.8 t ha^{-1}) which was statistically at par with same crop at 2:1 ratio (10.4% tuber infestation & 14.6 t ha^{-1} tuber yield) . The sole crop cv. Cross-4 suffered most (20.9%) and recorded lowest marketable tuber yield (11.7 t ha^{-1}).

2.4.3 Intercropping of Marigold in other crops in control of pests.

Patel and Patel (2001) carried out an investigation in Gujarat to test the management of stunt, root-knot and reniform nematodes in bidi tobacco nursery. Root-knot disease was significantly reduced till 63 DAS in the treatments of sebufos alone and its combinations with sunnhemp or French marigold.

Gopinatha *et al.* (2002) conducted an experiment on efficacy of bio-control agent *Verticillium chlamydosporium* Goddard, neem cake, marigold and carbofuran against root-knot nematode *Meloidogyne* incognita on tomato were tested by applying individually and in combinations. Amongst treatments all components individually recorded maximum plant growth and minimum galls and egg masses, which were statistically on par. In combinations, *V. chlamydosporium*+carbofuran, marigold +carbofuran, *V. chlamydosporium* + marigold recorded maximum plant growth and minimum galls and egg masses, which were statistically on par. These treatments also recorded maximum number of fruits per plant and yield per plot.

Kishore and Lal (2002) carried out investigation for four years and noted that the effect of different intercroppings against diamondback moth *Plutella xylostella*(L.)

on cabbage was: lucerne > garlic > tomato > marigold > mustard. Lucerne proved the most effective intercrop against diamondback moth, *P. xylostella*.

Go´mez-Rodr´gue *et al.* (2003) evaluated the effect of marigold intercropped with tomato on *Alternaria solani* on conidial density and tomato leaf damage in vivo, as well as microclimatic changes, compared to tomato intercropped with pigweed and monocropped tomato. They found that intercropping with marigold induced a significant reduction in tomato early blight with three mechanisms ie 1) Allelopathic effect of marigold on *A. solani* conidia germination, 2) Altering the microclimatic conditions around the canopy and 3) Physical barrier against conidia spreading. When intercropped with marigold than intercropped with pig weed and mono cropped tomato.

Kumar *et al.* (2005) studied different intercrops, marigold, mustard and sweet potato against root-knot nematode, (*Meloidogyne incognita)* infesting vegetables like tomato, okra and brinjal in vegetable-based cropping systems. Among the different intercrops evaluated, marigold intercropped with different vegetables reduced the nematode population in soil, number of galls, egg masses per root system, number of eggs per egg mass and root-knot index as compared to growing of vegetables alone continuously.

Sundararaju (2005) conducted an experiment at Tamilanadu on banana cv. Nendran (AAB) intercropping with African marigold. Maximum reduction in root-lesion index and nematode population was noticed, where *Tagetes erecta* was grown as an intercrop and on par with chemical treatment, whereas, maximum population was recorded in untreated control plants. The yield of banana increased significantly to 12.5 and 12 kg plant^{-1} in plants treated with chemical pesticides and intercropped

with *Tagetes* respectively but the use of marigold as an intercrop in banana field warrants more economical and ecofriendly compared to chemical nematicides.

Gajanana *et al.* (2006) conducted an experimant in tomato using African marigold as a trap crop, root dipping of seedlings in Imidacloprid, soil application of neem,/pongamia cake, spraying of botanicals like pongamia soap and biopesticide like Ha NPV has been found effective in both insect as well as disease management. The IPM technology has been found economically viable as the yield on IPM farms has been found higher by about 46 per cent, cost of cultivation has been less by about 21 per cent and the net returns have been higher by 119 per cent.

La Mondia (2006) observed that marigold crop increased tuber yield and reduced *P. penetrans,* in the second potato crop after a single year of rotation. Plots previously planted to marigolds had reduced *P. penetrans,* and the area under the disease progress curve and increased tuber yield in potato

Singh and Datta (2006) carried out field experiment on intercropping marigold with gladiolus at the Botanical Garden, National Botanical Research Institute, Lucknow. It was found that gladiolus paired system (20/60) was significantly superior to conventional planting practice in the production of cormels and spikes. Marigold being the dissimilar growth pattern did not have any detrimental effect on the productivity of gladiolus crop. Intercropping of marigold with gladiolus paired system gave an additional yield than the pure cropping of gladiolus paired system. The net income due to the intercropping was almost two fold higher than the pure cropping of conventional practice at 40x15 cm plant spacing.

Vaiyapuri *et al.* (2007b) conducted field experiments at Agricultural Research Station, Bhavanisagar, Tamil Nadu, India to find out the effect of unconventional green manures as intercrops on the pest incidence and yield of associate hybrid cotton

during the year 2003 to 2004. Four cropping systems viz, sole cotton, cotton + marigold *(Tageetus erectus* L.), cotton + sesamum (*Sesamum indicum* L.) and cotton + sunnhemp (*Crotolaria juncea* L.) were tested. The results revealed that intercropping with marigold in two rows in between cotton rows and incorporating it on 30 DAS had contributed ultimately less incidence of pests and more kapas and lint yield of cotton securing higher yield advantage in both summer and winter crops Sunnhemp and sesamum had moderate and low effects, respectively on pest management.

Kamunya *et al.* (2008) conducted experiments to evaluate integrated pest management for the control of root knot nematodes in tea. The first series involved evaluation of several control options involving intercropping tea with marigolds (*Tagetes minuta*), and the use of a nematicide Furadan® 5G and potash fertilizer. The severity of knotting was reduced in treatments with Furadan® 5G, *T. minuta* and potash by 28.7, 24.3 and 44%, respectively, over the 2-year study period. The *T. minuta* intercrop, however, retarded tea development.

Wang *et al.* (2009) conducted an experimant on allelopathic effects of leaf leachates and residues of *Jatropha curcas* amended into soil were determined on the growth, relative membrane permeability (RMP) and the proline content of marigold (*Tagetes erecta*) seedlings. The application of leaf leachates of *J. curcas* in the soil significantly inhibited the shoot and root length of marigold compared to unamended soils. The leaf leachates increased the RMP and proline content in the roots of marigold seedling.

Cerruti *et al.* (2010) conducted research on the use of marigolds (*Tagetes* spp.) In some instances using marigold was reported to be more effective than nematicides or soil fumigants and in other instances it had a negative impact on cash crop growth

and yield. For nematode suppression, yet limited cover cropping with marigold is being practiced in commercial operations. Worked on release of allelopathic compound α-terthienyl by marigold that is allelopathic to many species of plant parasitic nematodes.

Deveraj *et al.* (2011) conducted an experiment on effect of root exudates of pre planted marigold inter cropped with tomato in regulating the hatching behavior of root-knot nematode. Marigold cultivars significantly reduced the number of second-stage juveniles (j2s) in subsequent tomato compared to the tomato-tomato control.

Cuijpers *et al.*(2009) conducted a field experiment in an organic greenhouse, an innovative cropping system (the so-called 'Köver' system) was tested. In the Köver system, the following treatments were compared: (1) Sweet pepper 'Derby' on rootstock 'Capital', (2) fallow, (3) Marigold (*Tagetes patula*) 'Single Gold' (brand name: Ground Control) and (4) the densely planted rootstock *Capsicum annuum* 'Snooker'. At the end of the season, the number of *Meloidogyne* juveniles was significantly reduced by fallow, *Tagetes* and 'Snooker' treatments, compared with the sweet pepper crop.

2.4.4 Other intercropping systems on control of pests

Jimenez and Poveda (2009) worked on control of potato tuber moth by using repellents and attractants. To control this pest they tested the oviposition interference (repellence) of eight aromatic plants and the oviposition stimuli (attractiveness) of eight potato varieties. In the field, they tested the effectiveness of the single and combined use of repellent and attractive stimuli on herbivore damage and tuber production of potato plants and compared the efficacy of these treatments to conventional management systems that employed insecticides. The combined use

reduced the number of damaged tubers and increased the weight of undamaged tubers relative to the untreated plots.

Hormchan *et al.* (2009) conducted an experiment on intercropping with okra, Sunflower and Cluster bean in cotton to determine the population of leaf hopper. The populations of leaf hopper (*Amrasca biguttula* Ishida) were recorded from top and bottom leaves 30, 60 and 75 DAP (days after planting) and expressed as an average number /2 leaves. The plots with trap crops were found to decrease in a number of leaf hoppers while yields increased comparing to the sole cotton in every variety / line.

Bediako *et al.* (2010) conducted an experiment to evaluate the effectiveness of intercropping cabbage with non-host crops in reducing the effect of the diamondback moth pest on cabbage. The treatments were cabbage-tomato intercrop, cabbage-pepper intercrop, cabbage-onion intercrop, pure cabbage stand sprayed with chlorpyrifos (Dursban) a synthetic insecticide and a pure cabbage stand that was not sprayed (control). Cabbage plants intercropped against the DBM pests recorded significantly higher growth and yield and less pest damage compared with controls. Intercropping cabbage with onion, tomato or pepper was found to be as effective as spraying the cabbage with chlorpyrifos. Cabbage intercropped with onion and tomato produced lower leaf and head damage and higher yield than those intercropped with pepper.

Ram and Singh (2010) conducted an experiment on impact of seven intercropping system of non host plants with tomato on the incidence of fruit borer at Dehradun, Uttarakhand. The results obtained from study indicated that the incidence of fruit borer *Helicoverba armigera* Hub, was found minimum when tomato intercropped with coriander, Kasuri Fenugreek, Barley, Carrot, Mustered, and Dill in

2:1 row ratio. Among the inter crops, minimum incidence was noticed in tomato+ coriander (0.94 larvae plant^{-1}) and tomato fenugreek (1.26 larvae plant^{-1}) over sole (3.68 larvae plant^{-1}), lower fruit damage was observed in tomato + mustard (24.49% w/w and 25.32% n/n), tomato + coriander (25.63% w/w and 26.61% n/n) and tomato + fenugreek (26.12% w/w and 27.30% n/n) over sole (37.35% w/w and 38.29 n/n). However highest equilent yield was recorded in tomato coriander (296.66 q ha^{-1}), tomato + barlui (211.07 q ha$^{-1)}$, and tomato + mustard (209.61 q ha^{-1}) intercropping systems as compared to sole tomato (199.48 q ha^{-1}).

Singh *et al.* (2010) conducted research at BHU, Varanasi, on brassica based intercropping system, mustard + cereals and pulses intercropping in relation to management of irrigation, fertilizer, genotypes and crop geometry. Intercropped oilseeds and pulses crop may have the potential for a more efficient use of resources compared to sole crop. Intercrops are considered as less susceptible to pests and diseases and may inhibit weeds more efficiently resulting in enhanced yields and profitability.

Cai *et al.* (2011) conducted an experiment on effects of intercropping on the growth and development of the diamondback moth (Plutella *xylostella)* and investigated over five generations in a laboratory in Fuzhou, China. The treatments included intercropping Chinese cabbage (*Brassica chinensis*), with garlic (*Allium sativum*) and lettuce *(Lactuca sativa*) and the monoculture of Chinese cabbage as control. The larval stage was significantly longer for the intercropping treatments compared to control. Intercropping affected pupal weight but not the percentage of successful larvae population. Pupaet ended to be 10 to 15% larger in the intercropping treatments for three of the five generations. The increase in size, pupa mortality was

significantly higher with intercropping. Our findings suggest that intercropping can suppress the DBM populations in a long period rather than in a short term.

Kumar *et al.* (2011) conducted an experiment on intercropping of soybean with maize and noted significant reduction in the population of *Digitaria sanguinalis*, the most predominant weed (45.7%) and increase in the grain yield of maize by 60.9% over unweeded solid maize. Intercropping of soybean with maize (1:1) in combination with pre-emergence metolochlor at 1.0 kg ha^{-1} resulted in significantly higher grain yield of maize with additional yield of soybean by reducing the population and dry weight of weeds.

Materials and Methods

CHAPTER- III

MATERIALS AND METHODS

The investigation entitled **"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L). Lam) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"** was conducted during rabi season of 2011-12 in the experimental field of AICRP on Tuber crops at Horticultural Research cum Instructional Farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The chapter deals with concise descriptions of the materials and methodology used during the course of investigation.

3.1 Climate and weather conditions

Raipur is located in central part of Chhattisgarh at latitude 21.6^0 N and longitude 81.36^0 E and an altitude of 289.56 meters above the mean sea level. Climatologically Raipur is characterized as slightly moist hot zone. An average annual rainfall of 1326 mm is generally received and mostly concentrated during the period from June to September. The major portion of the rainfall is received by south-western monsoon. The May and December is the hottest and coolest months of the year, respectively. In general, weekly maximum temperature goes up to 46^0 C during the summer season and minimum temperature falls up to 6^0C during the winter season.

3.2 Weather condition during experimentation

The meteorological observations during the investigation have been presented in Table 3.1 and Fig 3.1.

Weekly meteorological observations from January, 1st, 2012 to May, 6^{th}, 2012 were recorded by the Department of Agrometeorology, College of Agriculture, IGKV

Raipur (C.G.). During the crop period the maximum temperature varies between 22.8^{0}C to 40.8^{0}C whereas, minimum temperature ranges between 10.5^{0}C to 25.5^{0}C. The maximum and minimum relative humidity varied between 96 to 14 per cent whereas, the bright sunshine varied from 0.9 to 10.4 hours day^{-1} and evaporation rate varied from 1.8 and 11.1 mm. The total rain fall 76.3 mm was recorded during the crop period in 6 rainy days.

3.3 Experimental site

The experimental site was located at the experimental field of AICRP on Tuber crops located at Horticultural Research cum Instructional Farm, Department of Horticulture, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) where all facilities are available including irrigation and drainage.

3.4 Soil of the experimental field

The soil of the experimental field was sandy-loam in texture which is locally known as "*Matasi*" (Inceptisols) having the pH 7.5. The physico-chemical properties of experimental soil have been given in Table 3.2.

Table 3.1: Weekly meteorological data during crop growth period

Week No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)		Evapo-ration (mm)	Sun Shine (hours)	Rain fall(mm)
				I	II			
1	Jan 01-07	26.3	18.7	96	72	1.8	0.9	34.1
2	08-14	22.8	11.0	94	39	2.8	6.7	20.6
3	15-21	26.9	10.5	86	31	3.5	9.0	0
4	22-28	25.7	12.5	86	42	2.8	5.2	0
5	29-04	25.4	13.1	87	47	2.6	4.5	0
6	Feb 05-11	29.7	12.3	78	27	3.7	9.1	0
7	12-18	30.1	16.2	85	44	3.8	7.9	0
8	19-25	33.2	14.9	78	25	4.5	9.3	0
9	26-04	33.5	15.2	77	21	5.2	8.4	0
10	Mar 05-11	33.6	15.9	71	19	6.6	8.8	0
11	12-18	34.6	17.5	70	21	6.5	8.0	0
12	19-25	37.9	17.4	68	19	7.5	8.9	0
13	26-01	38.4	20.1	57	16	7.4	8.1	0
14	April 02-08	39.2	23.5	57	21	9.3	8.2	6.4
15	09-15	39.6	23.9	57	20	10.0	8.6	9.2
16	16-22	40.2	24.8	48	16	9.5	9.2	0
17	23-29	39.1	25.2	68	25	9.8	8.5	6.6
18	30-06	40.8	25.5	59	14	11.1	10.4	0

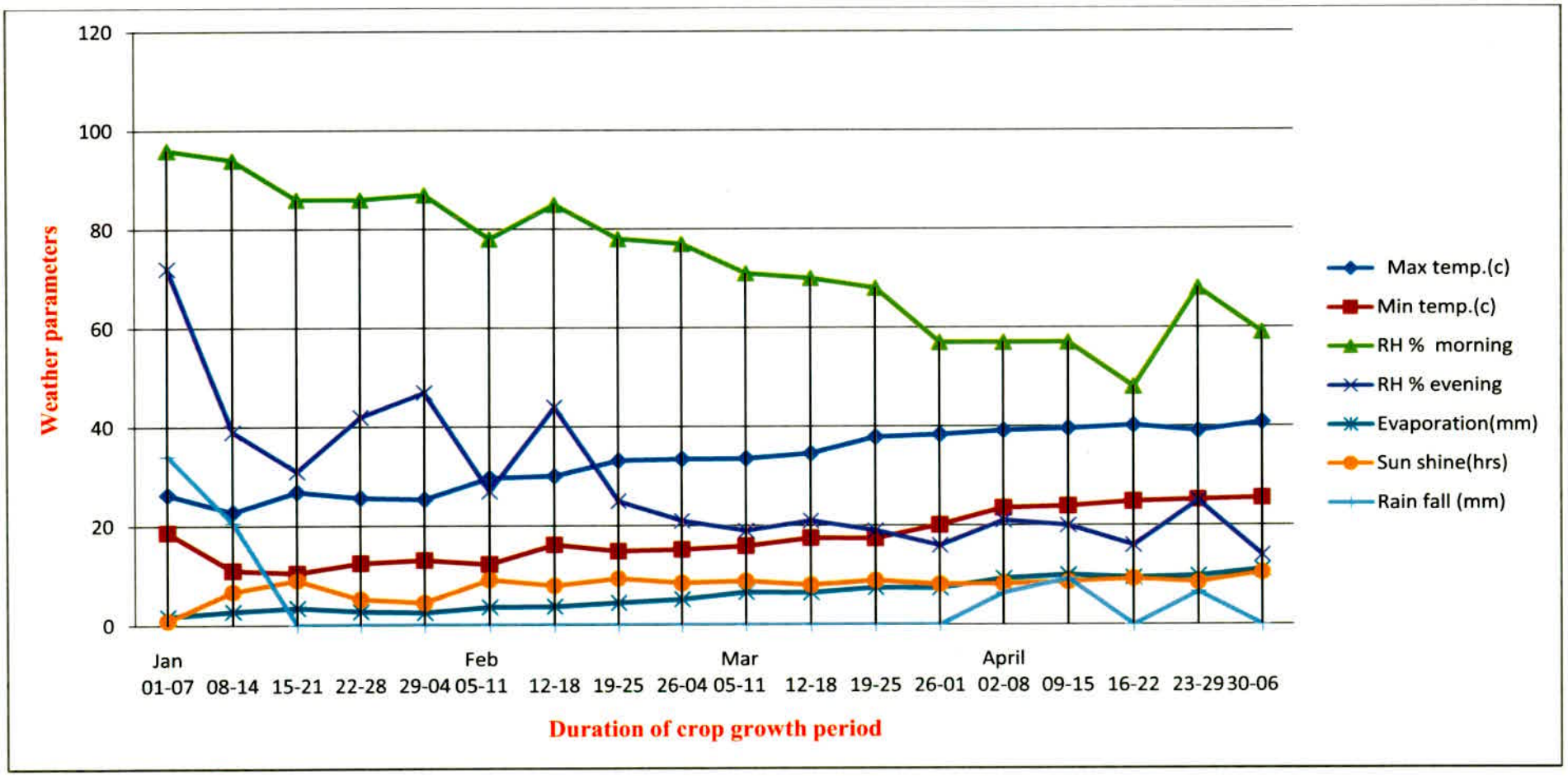


Fig.3.1: Weekly meteorological data during the crop growth period (Jan 2012 –April 12)

Table 3.2: Physico-chemical properties of the soil

Particulars	Values	Rating	Method used
A. Physical Properties			
1. Mechanical composition			
Sand (%)	54.18	-	International Pipette method (Black, 1965)
Silt (%)	21.34	-	
Clay (%)	24.48	-	
Texture/class		Sandy-loam (*Inceptisols*)	
B. Chemical composition			
1. Organic carbon (%)	0.50	Medium	Walkley and Black's rapid titration method (Jackson, 1967)
2. Available N (kg ha^{-1})	330.0	Medium	Alkaline permanganate method (Subbiah and Asija, 1959)
3. Available P (kg ha^{-1})	20.0	High	Olsen's method (Olsen *et al.*, 1954)
4. Available K (kg ha^{-1})	400.0	High	Flame photometric method (Jackson, 1967)
5. pH (1:2.5 soil: water)	7.5	Neutral	Digital pH meter

3.5 Cropping history

The field selected for experimental purpose was situated in vegetable farm area. During the last two years Taro-vacant-Sweet potato cropping system was adopted with recommended package of practices.

3.6 Experimental details

The experiment was laid out in a Randomized Block Design (RBD) for eleven treatments with three replications. The treatments were allocated to different plots by using random method (Gomez and Gomez, 1984). The plan of layout has been depicted through Fig 3.2.

3.7 Cultural operation

The schedule of various cultural operations carried out during the course of investigation is given in Table 3.5.

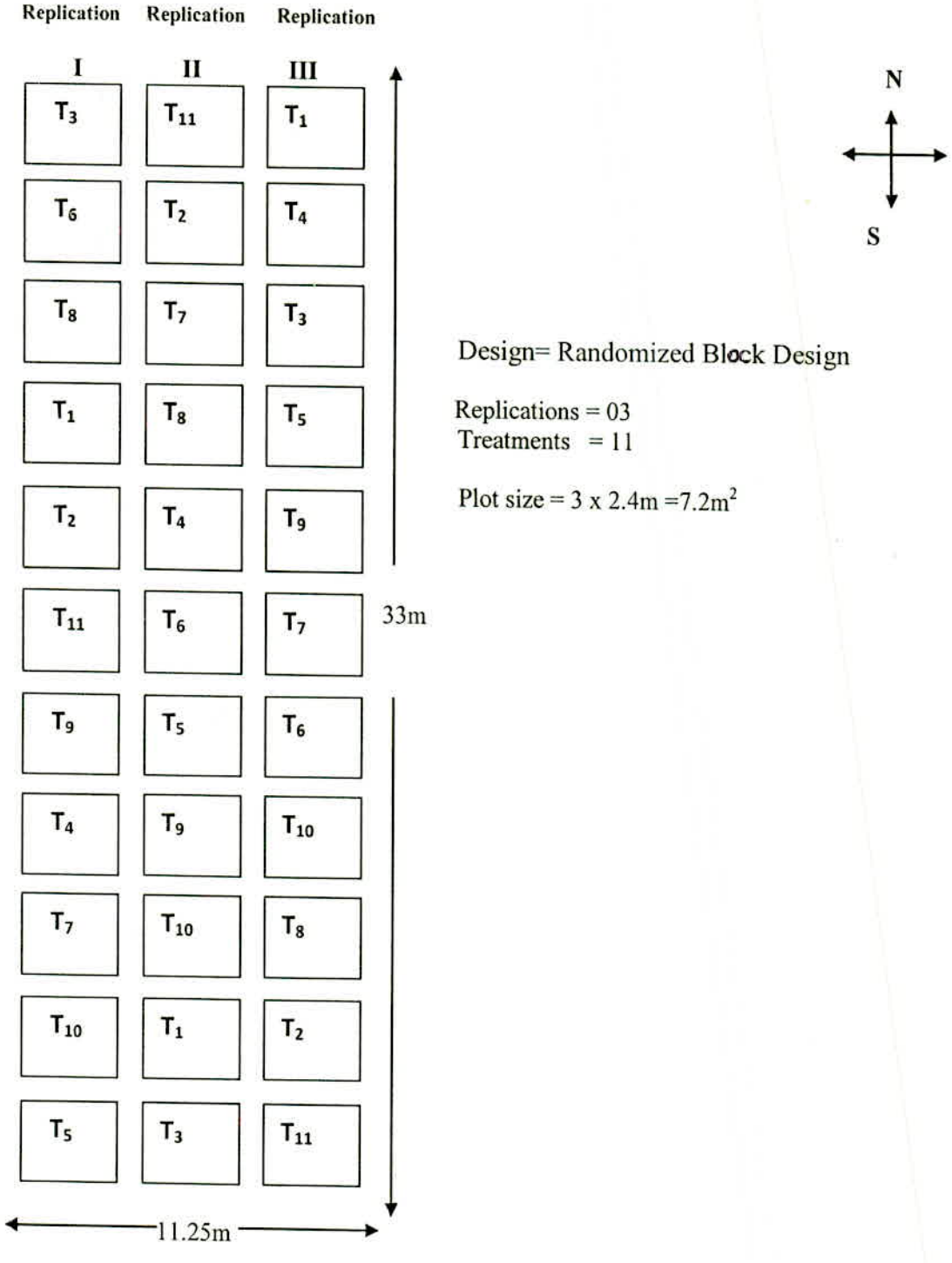


Fig. 3.2: Lay out plan of Experiment

Table 3.3: Treatment details

S.No.	Rotation	Intercropping
1.	T1	Sole crop sweet potato
2.	T2	Sole crop marigold (African type)
3.	T3	Sole crop marigold (French type)
4.	T4	Sweet potato + Marigold (African type) 1:1 Row ratio
5.	T5	Sweet potato + Marigold (African type) 1:2 Row ratio
6.	T6	Sweet potato + Marigold (French type) 1:1 Row ratio
7.	T7	Sweet potato + Marigold (French type) 1:2 Row ratio
8.	T8	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)
9.	T9	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)
10.	T10	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)
11.	T11	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)

Table 3.4: Experimental details

Main Crop	Sweet potato (*Ipomoea batatas* (L). Lam) cv; Indira Madhur
Inter Crop	Marigold, *Tagetes erecta* (African type) and *Tagetes patula* (French type)
Design	Randmized Block Design (RBD)
Method of planting	Ridge and Furrow method
Number of treatments	11
Number of replications	03
Number of plots	33
Plot size	3 x 2.4 m
Gross size of the experimental area	371.25 m^2
Net size of the experimental area	237.6 m^2
Gaps between two replications	0.75 m
Gaps between two plots	0.60 m
Spacing for sweet potato	0.60 x 0.20 m
Spacing for marigold	0.30 x 0.20 m
Date of planting	05/01/2012
Date of harvesting	04/05/2012

Table 3.5: Cultural operations

S. No.	Cultural Operations	Date
1.	Field preparation	
a.	Ploughing	2nd January 2012
b.	Rotavator and levelling	3rd January 2012
2.	Layout of experiment	4thJanuary 2012
3.	Planting and basal dose of fertilizer application	5th January 2012
4.	1st Irrigation	6th January 2012
5.	Irrigation (11 numbers) schedules during the experiment.	15th,25th - January 5th,16th, 26th - February 6th, 16th, 26th - March 7th,17th,27th, - April -2012
6.	Gap filling	15th January 2012
7.	Top dressing of Fertilizers	5th February 2012 6th March 2012
8.	Weeding, hand hoeing, earthimg up twice at the time of fertilizers application	5th Feb 2012 6th March 2012
9.	Flowers picking from inter crop (7 times)	23rd February 2012 6th,15th,25th March2012 4th,20th April 2012 1st May 2012
10.	Harvesting Sweet potato	4th May 2012

3.8 Field preparation

Field was prepared for planting by ploughing with mould bold plough followed by two cross harrowing and was leveled with help of "pata" then the field was divided into thirty three plots by keeping provision for irrigation channels and distance to mark different replications as well as plots as shown in lay out plan (Fig.3.2). Well rottened FYM was applied in all the plots in equal quantity (18 kg $plot^{-1}$) so that; it may be applied @ 250 q ha^{-1}. It was well mixed with the soil and ridges were prepared at 60 cm apart in each plot. The five ridges were formed per each plot. The height of ridges was kept 20 cm.

3.9 Procurement of planting material

2o cm length Sweet potato (cv: Indira Madhur) fresh vine cuttings were procured from neighbour AICRP on tuber crops field and 30 days aged marigold seedlings were procured from Horticulture nursery, IGKV, Raipur.

3.10 Planting

The simultaneous planting done for both inter crop as well as main crop at January 5, 2012. The Sweet potato vine cuttings were planted on ridges with vertical planting and a position of cutting lies above the ground with a spacing of 20 cm between two plants. The Marigold seedlings were planted on both sides of a ridge, one side of a ridge and on ridge with spacing of 20 cm and 10 cm on the basis of treatment.

Sole Sweet potato (T1)

Sole Marigold African type (T2)

Sole Marigold French type (T3)

Sp + Marigold African type 1:1 row ratio (T4)

Sp + Marigold French type 1:1 row ratio (T6)

Plate.3.1: General views of treatments at 30 DAP

Sp + Marigold African type 1:2 row ratio (T5)

Sp + Marigold French type 1:2 row ratio (T7)

Sp + MGA alternate plantation on ridge 20 cm (T8)

Sp + MGF alternate plantation on ridge 20 cm (T9)

Sp + MGA alternate plantation on ridge 10 cm (T10)

Sp + MGF alternate plantation on ridge 10 cm (T11)

Plate.3.2: General views of treatments at 30 DAP

3.11 Fertilizer application

Fertilizers applied at 100% RDF for both intercrop as well as main crop. Sweet potato, being a high yielding and highly nutrient exhaustive crop, requires large doses of nutrients. Nitrogen, Phosphorus and Potassium are the major nutrients affects growth, development and yield of Sweet potato. Applied FYM 250 q ha^{-1} at the time of field preparation. Recommended dose of NPK to sweet potato was 75:50:75 kg ha^{-1} and for marigold 80:40:40 kg ha^{-1}. Therefore, these fertilizers applied in the form of Urea, SSP and MOP respectively. For sweet potato, full dose of phosphorus, half dose of potassium and $1/3^{rd}$ nitrogen at the time planting, half dose of potassium, $1/3^{rd}$ dose of nitrogen applied 30 days after planting along with weeding and earthing up and remaining $1/3^{rd}$ nitrogen applied 60 days after planting along with second time weeding and earthing up. For marigold, recommended dose of NPK applied in two split doses. A full dose of phosphorus, potassium and half dose of nitrogen applied at the time of planting and remaining half dose of nitrogen applied 30 days after planting along with weeding and earthing up.

All the three fertilizers used for basal as well as top dressing were mixed before application and the mixture was applied near the base of plant. Then it was mixed with the help of a small '*kudari*' (hand hoe). After that applied light irrigation.

3.12 Gap filling

Gap filling was done ten days after plantation to maintain good population in both sweet potato and marigold.

3.13 Weeding and earthing up

Weeding and earthing up were done during top dressing of fertilizers at 30 days and 60 days after planting.

3.14 Irrigation

The 1st irrigation was provided at one day after planting at regular interval of 10 days. Irrigation was given by ridge and furrow method.

3.15 flowers picking from inter crop

Fully opened marigold flowers are picked without pedicel at evening times. Totally seven pickings were done in entire crop period.

3.16 Harvesting

The crop was harvested when it was fully matured i.e. 120 DAP. Harvesting was done by using spade, manually. At the time of digging care was taken for digging injury to tubers.

3.17 Observations recorded

In sweet potato, the observations of different growth parameters and yield parameters were recorded on five randomly selected competitive plants from each plot in each replication. The observations on growth attributes namely vine length plant^{-1}, vine weight plant^{-1}, number of tubers plant^{-1}, weight of tubers plant^{-1}, marketable tuber yield kg plot^{-1} and tones ha^{-1}, weevil infested tubers kg plot^{-1} and tones ha^{-1}, total tuber yield kg plot^{-1}and tones ha^{-1}, observations were recorded at the time of harvesting. In intercrop, loose flower yield recorded kg plot^{-1} and q ha^{-1}.

Land preparation

planting

Weeding

Watering

Marigold harvesting

Sweet potato harvesting

Grading of Sweet potato tubers

Plate. 3.3: Different types of field operations during experimentation

Plate. 3.4: General views of experimental field

The method adopted to record different observations on growth as well as yield attributing traits are given below in detail.

3.17.1 Observations in sweet potato

3.17.1.1 Vine length (cm plant^{-1})

Vine length from the ground level to the growing tip of the plant was recorded from the five selected randomly plants from each plot in each replication and then the mean vine length were worked out at harvesting time in cm.

3.17.1.2 Vine weight (g plant^{-1})

This observation was recorded on randomly selected five competitive plants from each plot at harvesting. Portion of the shoot *i.e.* a part of the plant which was the above ground level, was separated from the plant with the help of knife or sickle and it was weighed and noted as fresh vine weight plant^{-1} in g.

3.17.1.3 Number of tubers (plant^{-1})

Total number of tubers was counted from each of the five selected plants from each treatment in each replication and expressed as mean number of tubers per plant.

3.17.1.4 Fresh weight of tubers (g plant^{-1})

This observation was recorded on randomly selected five competitive plants from each plot and each replication at the time of harvesting. The fresh weight of the tubers per plant after thoroughly washing with water was recorded as fresh weight of tuber (g plant^{-1}).

3.17.1.5 Total tuber yield (t ha^{-1})

Total tuber yield was recorded on individual plot at each replication at the time of harvest in kg plot^{-1}. Later it was converted in tones per hectare.

3.17.1.6 Weevil damaged tuber yield (t ha^{-1})

Weevil damaged tubers separated from total tubers and damaged tuber yield was recorded on individual plot at each replication at the time of harvest as weevil damaged tuber yield in (kg $plot^{-1}$). Later it was converted in (t ha^{-1}).

3.17.1.7 Marketable tuber yield (t ha^{-1})

After removal of weevil damaged tubers and very small tubers from total tuber yield recorded marketable tubers yield on individual plot at each replication at time of harvest in (kg $plot^{-1}$). Later it was converted in (t ha^{-1}).

Marketable tuber yield = Total tuber yield - Weevil damaged tubers and very small tubers

3.17.2 Observations recorded in intercrop (marigold):

3.17.2.1 Flower yield (q ha^{-1})

Flowers are harvested without pedicel with 10 to 12 days interval in individual plot at each replication and recorded in (kg $plot^{-1}$). Later it was converted in (q ha^{-1}).

3.18 Assessment of yield advantage in intercropping system:

3.18.1 Land Equivalent Ratio (LER)

It is defined as the relative land area under sole crops that is required to produce the yields obtained in intercropping at the same level of management (Willey, 1979). It is calculated as follows.

$$LER = \frac{\text{Yield of sweet potato in intercropping system}}{\text{Yield of sole sweet potato}} + \frac{\text{Yield of marigold in intercropping system}}{\text{Yield of sole marigold}}$$

3.18.2 Area Time Equivalent Ratio (ATER)

The limitation in the use of LER is the emphasis on the land area without consideration of time the field is dedicated to production. To correct this deficiency, the LER was modified by Hiebsch and McCullum (1987) to include the duration of

time of crop present on the land from planting to harvest. This method is known as the area time equivalent ratio (ATER). ATER was calculated according to formula given by Hiebsch and McCullum (1987).

$$ATER = \frac{(RYc \times tc) + (RYp \times tp)}{T}$$

Where,

RY = Relative yield of species c and p

$$= \frac{\text{Yield of intercrop hectare}^{-1}}{\text{Yield of monocrop hectare}^{-1}}$$

t = duration (days) for species c and p

T = duration (days) of the intercropping system

3.18.3 Sweet potato equivalent yield (kg ha^{-1})

The sweet potato equivalent yield of intercropping system was calculated by taking into account the tuber and flower yield of component crops and the prevailing market price of both sweet potato and marigold as

$$\text{EY of sweet potato} = \frac{\text{Tuber yield of Sweet potato (kg ha}^{-1}) \times \text{Marketable price of tuber (Rs kg}^{-1})}{\text{Marketable price of tuber (Rs kg}^{-1})} + \frac{\text{Flower yield of marigold (kg ha}^{-1}) \times \text{Marketable price of marigold (Rs kg}^{-1})}{\text{Marketable price of tuber (Rs kg}^{-1})}$$

3.18.4 Per cent increased in equivalent yield over sole sweet potato

It was calculated by the below formula

$$\% \text{ of increased in EY yield over sole Sp} = \frac{\text{EY of intercrop} - \text{yield of sole crop Sp}}{\text{Yield of sole crop Sp}} \times 100$$

Where,

EY = Equivalent Yield, Sp = Sweet potato

3.19 Economic evaluation of the treatment

3.19.1 Cost of cultivation

The cost of cultivation was worked out treatment-wise taking into account, the prices of inputs that were prevailing at the time of their use and selling price for marigold flowers, sweet potato tubers. As per prevailing market price were taken into account.

3.19.2 Gross return

The total monetary value of economic produce from the sweet potato and marigold raised in cropping system is calculated based on the local market price Rs ha^{-1}.

3.19.3 Net return

The net profit per hectare was calculated by deducting the cost of cultivation Rs ha^{-1} from gross returns Rs ha^{-1}.

Net returns= Gross returns – Cost of cultivation

3.19.4 Benefit cost ratio

It was worked out as follows.

$$\text{B: C ratio} = \frac{\text{Net returns (Rs. ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.20 Statistical analysis

The data collected for different characters were processed and analyzed by the method of analysis of variance given by Gomez and Gomez (1984) for randomized block design.

Table 3.6: ANOVA TABLE

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F_C	F_t
Replication	(r-1)	RSS	MSR	MSR / MSE	
Treatment	(t-1)	TrSS	MST	MST / MSE	
Error	(r-1)(t-1)	ESS	MSE		
Total	(rt-1)				

Where,

r = Replication

t = Treatment

SSR = Sum of square for replication

SST = Sum of square for treatment

SSE = Sum of square for Error

MSR = Mean sum of square for replication

MST = Mean sum of square for treatment

MSE = Mean sum of square for error

Fc = F value calculated

Ft = F value from table

SEm± = $\sqrt{V_E / r}$

SEd = $\sqrt{2xV_E / r}$

Where,

V_E = Error variance

CD = SEd x't' at 5% error degree of freedom

CV = Ems/ GM x 1

Sole Sweet potato (T1)

Sole Marigold African type (T2)

Sole Marigold French type (T3)

Sp + Marigold African type 1:1 row ratio (T4)

Sp + Marigold French type 1:1 row ratio (T6)

Plate.3.5: General views of treatments at 115 DAP (before harvesting of Sweet potato)

Sp + Marigold African type 1:2 row ratio (T5)

Sp + Marigold French type 1:2 row ratio (T7)

Sp + MGA alternate plantation on ridge 20 cm (T8)

Sp + MGF alternate plantation on ridge 20 cm (T9)

Sp + MGA alternate plantation on ridge 10 cm (T10)

Sp + MGF alternate plantation on ridge 10 cm (T11)

Plate.3.6: General views of treatments at 115 DAP (before harvesting of Sweet potato)

Results and Discussion

CHAPTER-IV

RESULTS AND DISCUSSION

The present chapter deals with experimental findings and discussion obtained during the course of investigation on **"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L). Lam) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"** conducted during rabi season of 2011-12 in the experimental field of AICRP on Tuber Crops at Horticultural Research cum Instructional Farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The observations recorded on various aspects of study revealed some interesting facts, which are briefly discussed in this chapter. The experimental findings are statistically analyzed and are presented in appropriate tables, graphs and few are also depicted through figures. The experimental finding of present investigation has been summarized under the following heads.

4.1 Studies on sweet potato

4.1.1 Vine length (cm plant^{-1})

Vine length of sweet potato differed significantly due to different treatments of Sweet potato + Marigold intercropping. The observation of vine length was recorded at harvest and the data are presented in Table 4.1 and illustrated through Fig 4.1

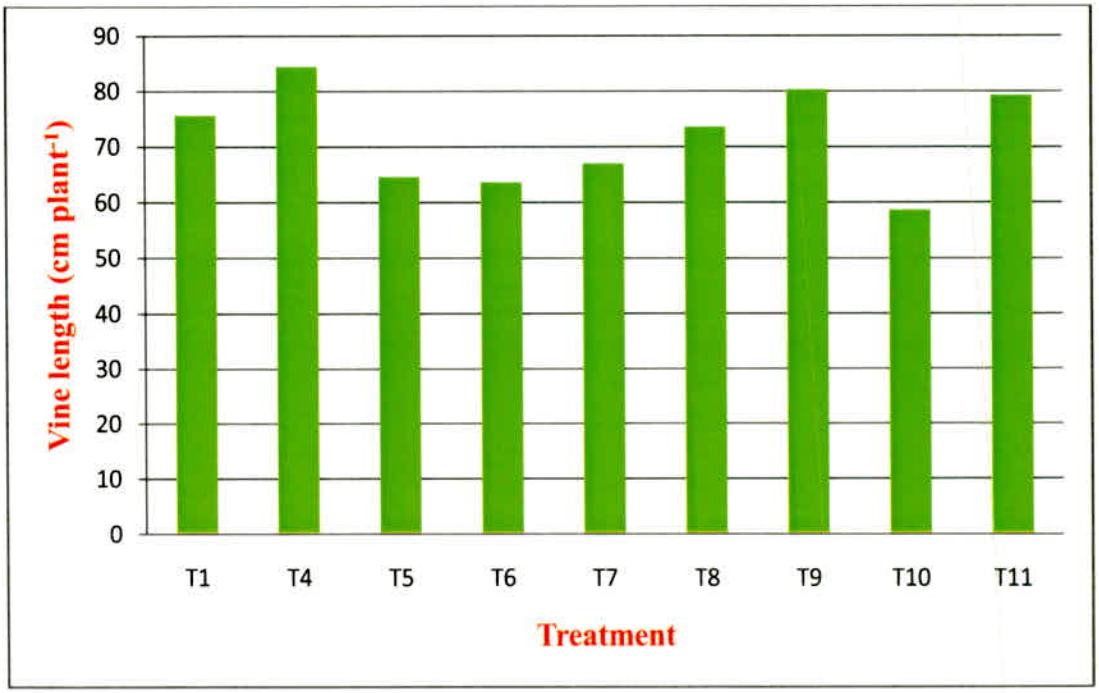
The data reveal that the highest average vine length (84.40 cm plant^{-1}) was recorded in Sweet potato + Marigold African type 1:1 row ratio (T4), which was significantly superior over others, but it was at par to Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9) (80.20 cm plant^{-1}) and Sweet potato + Marigold French type alternate planting on ridge 10 cm spacing (T11) (78.13

cm plant^{-1}). The minimum vine length (58.53 cm plant^{-1}) was recorded in Sweet potato + Marigold African type alternate planting on ridge 10 cm spacing (T10). The vine length (75.53 cm plant^{-1}) was noted in sole crop Sweet potato treatment (T1).

Similarly Nedunchezhiyan *et al.* (2007) reported that highest vine length was recorded in "Pusa Safed" variety of sweet potato in coconut intercropping system.

Table 4.1: Effect of Sweet potato + Marigold intercropping on vine length of Sweet potato (cm plant^{-1})

	Treatment	Vine length of sweet potato (cm plant^{-1})
T1-	Sole crop sweet potato	75.53
T2-	Sole crop marigold (African type)	-
T3-	Sole crop marigold (French type)	-
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	**84.40**
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	64.53
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	63.60
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	66.93
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	73.53
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	80.20
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	**58.53**
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	78.13
	SEm±	**2.22**
	CD (P=0.05)	**6.66**
	CV%	**5.36**



T1- Sole crop sweet potato

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig 4.1: Effect of Sweet potato + Marigold intercropping on vine length of Sweet potato (cm plant^{-1})

4.1.2 Vine weight (g plant^{-1})

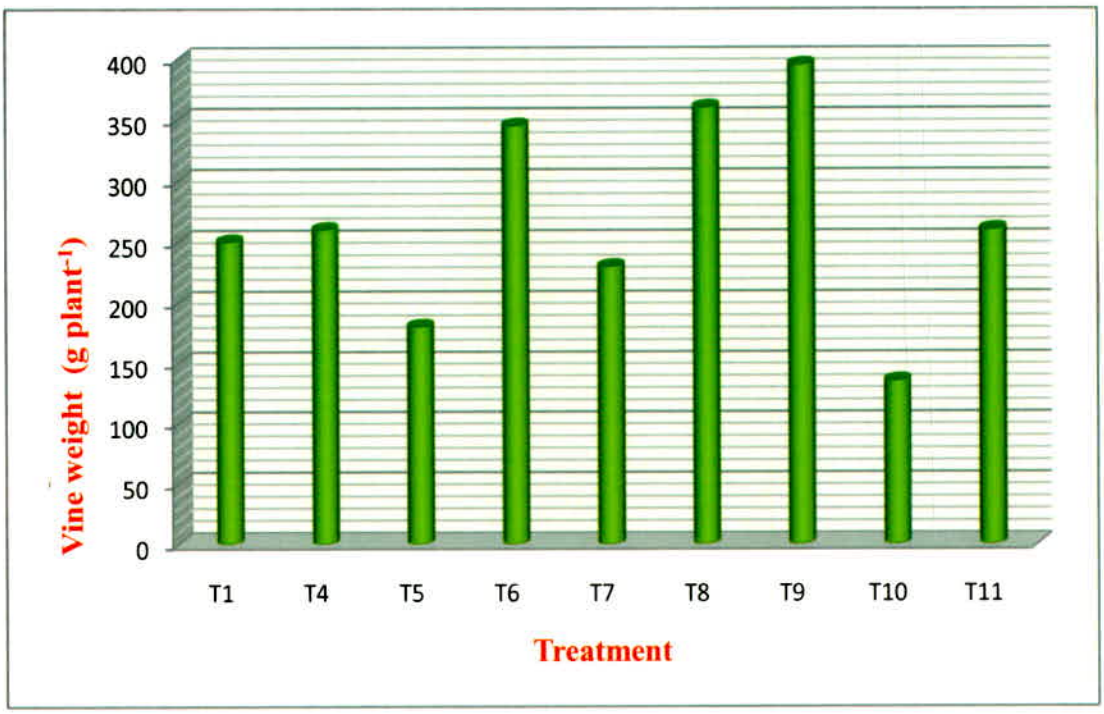
The vine weight of Sweet potato was significantly affected by different treatments of Sweet potato + Marigold intercropping. The observations on vine weight was recorded at harvest and the data are presented in Table 4.2 and illustrated through Fig 4.2

The maximum vine weight (395 g plant^{-1}) was recorded in Sweet potato + Marigold French type alternate planting on ridge with 20 cm spacing (T9), which was significantly superior over all other treatments. Treatments Sweet potato + Marigold African type alternate planting on ridge with 20 cm spacing (T8) and Sweet potato + Marigold French type 1:1 row ratio (T6) recorded vine weight of 360 and 347 g plant^{-1}, respectively. Significantly the lowest vine weight (135g plant^{-1}) was recorded in Sweet potato + Marigold African type alternate planting on ridge with 10 cm spacing (T10). The vine weight in sole crop Sweet potato was recorded 250g plant^{-1}.

This result was also supported by Nedunchezhiyan *et al.* (2007) who noted the highest vine weight in "Sree Badra" variety of sweet potato in coconut intercropping system.

Table 4.2: Effect of Sweet potato + Marigold intercropping on vine weight of Sweet potato (g plant^{-1})

	Treatment	Vine weight of sweet potato (g plant^{-1})
T1-	Sole crop sweet potato	250
T2-	Sole crop marigold (African type)	-
T3-	Sole crop marigold (French type)	-
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	260
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	180
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	345
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	230
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	360
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	**395**
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	**135**
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	260
	SEm±	**4.58**
	CD (P=0.05)	**13.72**
	CV%	**2.96**



T1- Sole crop sweet potato

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

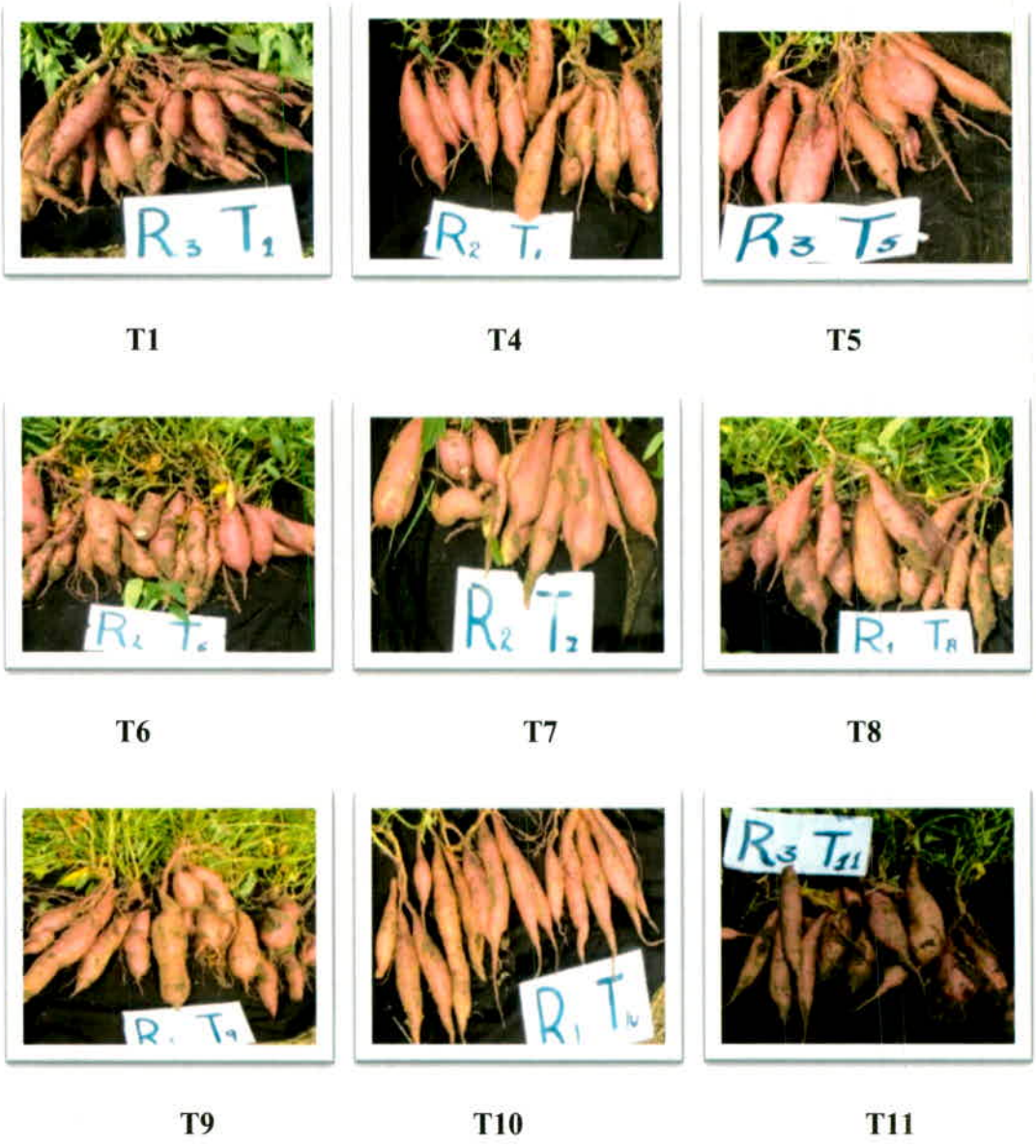
T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig.4.2: The effect of Sweet potato + Marigold intercropping on vine weight of Sweet potato (g plant^{-1})



T1 T4 T5

T6 T7 T8

T9 T10 T11

Plate 4.1: Randomly selected five plants tubers of Sweet potato harvested under different treatments

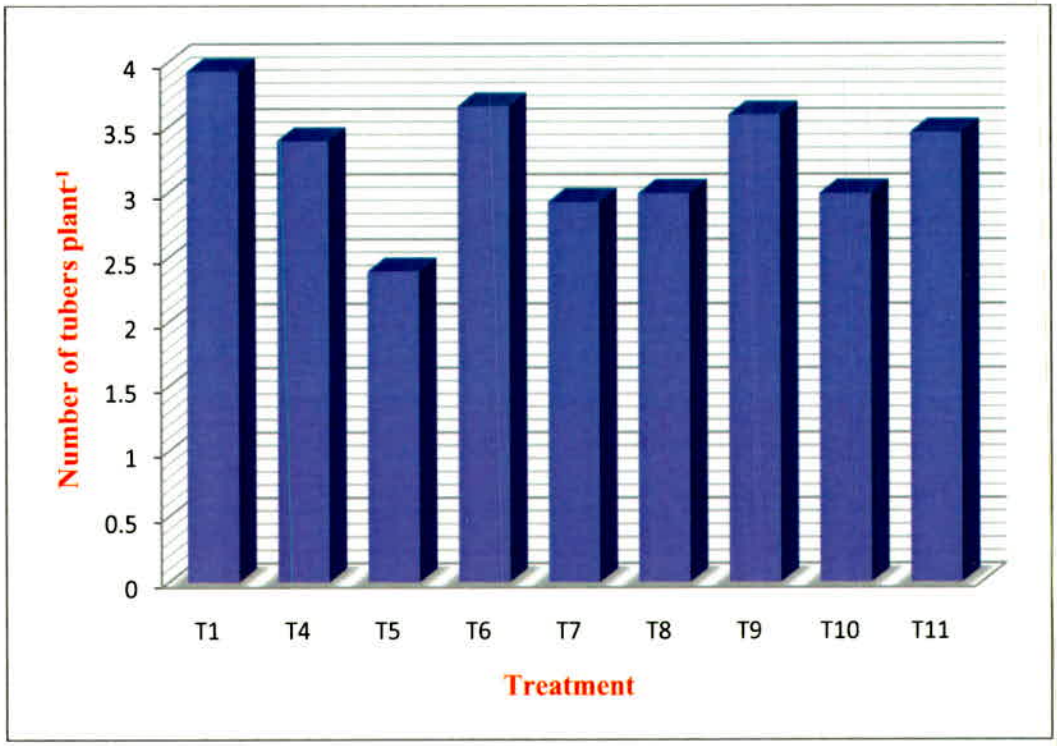
4.1.3 Number of tubers plant^{-1}

The number of tubers plant^{-1} was recorded at harvest and data are presented in Table 4.3 and illustrated in Fig 4.3. The number of tubers plant^{-1} was found non-significant. The maximum number of tubers (3.93 tubers plant^{-1}) was recorded in sole crop Sweet potato (T1), followed by Sweet potato + Marigold French type1:1 row ratio (T6), (3.66 tubers plant^{-1}), Sweet potato + Marigold French type alternate planting on ridge with 20 cm spacing (T9),(3.60 tubers plant^{-1}), Sweet potato + Marigold French type alternate planting on ridge 10 cm spacing (T11), (3.47 tubers plant^{-1}), Sweet potato + Marigold African type 1:1 row ratio (T4), (3.40 tubers plant^{-1}), Sweet potato + Marigold African type alternate planting on ridge 20 cm spacing (T8), (3.00 tubers plant^{-1}), and Sweet potato + Marigold French type 1:2 row ratio (T7), (2.93 tubers plant^{-1}). The least number of tubers (2.40 tubers plant^{-1}) was noted in Sweet potato + Marigold African type 1:2 row ratio (T5).

The results was also supported with findings of Tarafder (2011) at Kalyani, who reported that the highest number of tubers plant^{-1} was recorded in alternate rows of sweet potato + marigold 1:1ratio i.e., 28.33 tubers five plants^{-1} and 27.66 tubers five plants^{-1} in sole sweet potato.

Table 4.3: Effect of Sweet potato + Marigold intercropping on number of tubers of Sweet potato plant^{-1}

	Treatment	No of tubers of sweet potato plant^{-1}
T1-	Sole crop sweet potato	**3.93**
T2-	Sole crop marigold (African type)	-
T3-	Sole crop marigold (French type)	-
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	3.40
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	**2.40**
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	3.66
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	2.93
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	3.00
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	3.60
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	3.00
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	3.47
	SEm±	**0.38**
	CD (P=0.05)	**NS**
	CV%	**20.07**



T1- Sole crop sweet potato

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig 4.3: Effect of Sweet potato + Marigold intercropping on number of tubers of Sweet potato plant^{-1}

4.1.4 Fresh weight of tubers (g plant^{-1})

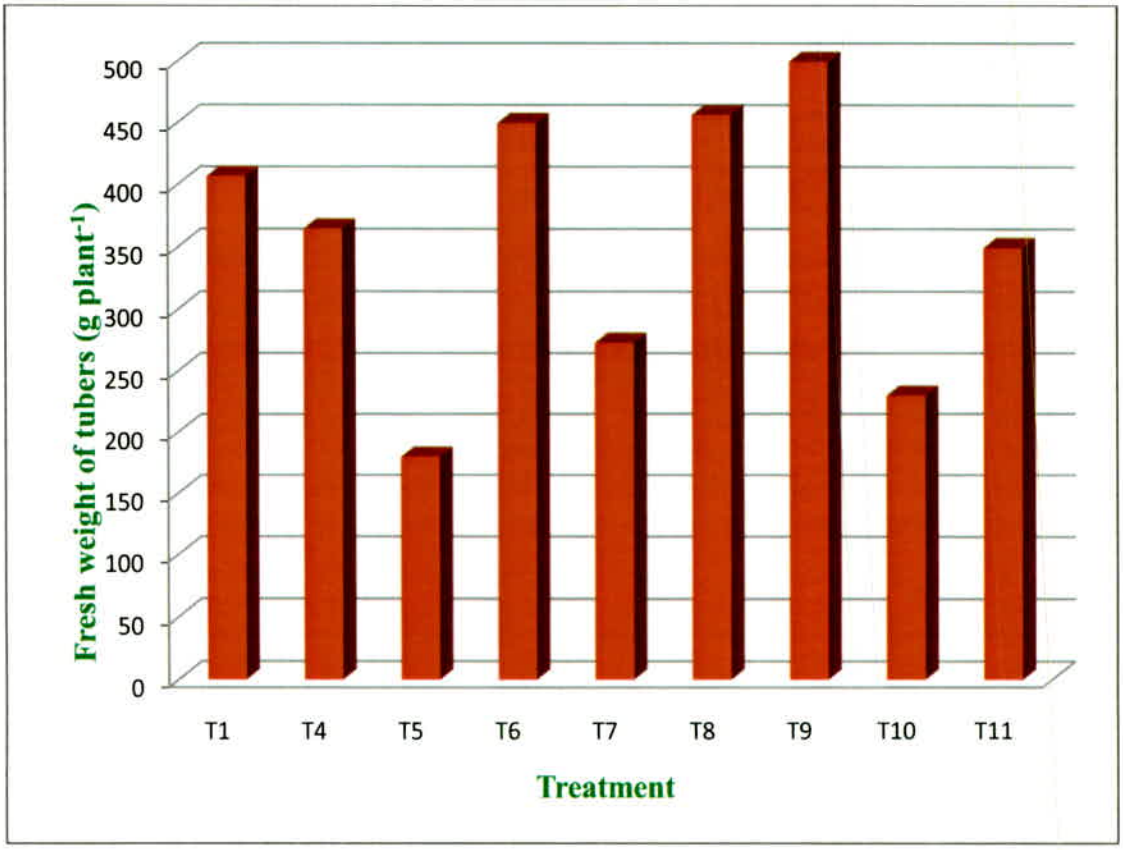
The fresh weight of Sweet potato tubers (g plant^{-1}) differed significantly due to different treatments of Sweet potato + Marigold intercropping. The observation on fresh weight of tubers (g plant^{-1}) was recorded at harvest and the data are presented in Table 4.4 and illustrated through Fig 4.4.

Significantly the highest fresh weight of Sweet potato tubers (500g plant^{-1}) was recorded in Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9), which was significantly superior over others and significantly lowest fresh weight of Sweet potato tubers (180g plant^{-1}) was noted in Sweet potato + Marigold African type 1:2 row ratio (T5).

The present result was in confirmity with the finding obtained by Anonymous (2010) who conducted a field trial at Bagalkot, on management of sweet potato weevil through barrier crops and Nedunchezhiyan *et al.* (2007) on sweet potato intercrop in a coconut garden.

Table 4.4: Effect of Sweet potato + Marigold intercropping on fresh weight of tubers of Sweet potato (g plant^{-1})

	Treatment	Fresh weight of sweet potato (g plant^{-1})
T1-	Sole crop sweet potato	407.00
T2-	Sole crop marigold (African type)	-
T3-	Sole crop marigold (French type)	-
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	365.00
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	**180.00**
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	450.00
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	273.30
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	456.67
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	**500.00**
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	230.00
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	350.00
	SEm±	**8.85**
	CD (P=0.05)	**26.53**
	CV%	**4.29**



T1- Sole crop sweet potato

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig 4.4: Effect of Sweet potato + Marigold intercropping on fresh weight of tubers of Sweet potato (g plant^{-1})

4.1.5 Total tuber yield (kg plot^{-1} & t ha^{-1})

It is clear from the Table 4.5 and Fig 4.5, that the total tuber yield (kg plot^{-1} & t ha^{-1}) of Sweet potato differed significantly due to different treatments of Sweet potato + Marigold intercropping.

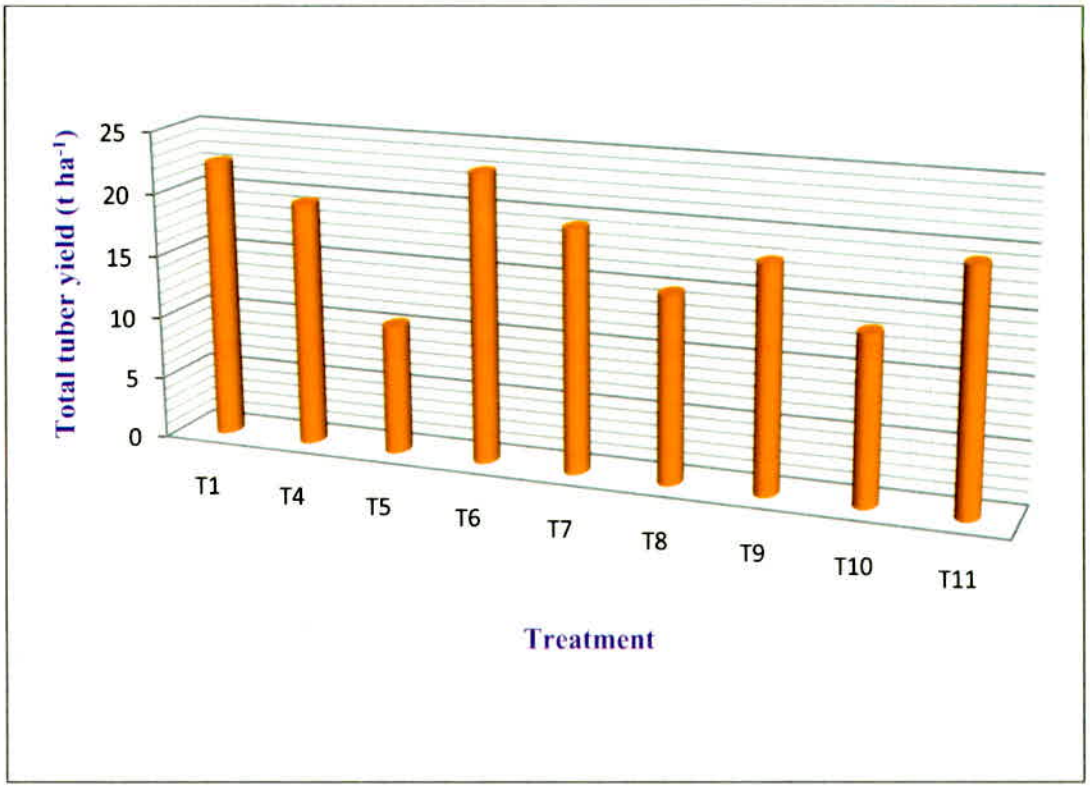
The highest total tubers yield (23.12 t ha^{-1}) was recorded in Sweet potato + Marigold French type 1:1 row ratio (T6) which was significantly superior over others, but it was at par to sole crop Sweet potato (T1) (22.38 t ha^{-1}). Significantly the lowest total tuber yield (10.43t ha^{-1}) was noted in Sweet potato + Marigold African type 1:2 row ratio (T5). Considerably higher total tuber yield (19.60 t ha^{-1}) was noted in Sweet potato + Marigold African type 1:1 row ratio (T4), (19.44 t ha^{-1}) in Sweet potato + Marigold French type 1:2 row ratio (T7), (19.28 t ha^{-1}) in Sweet potato + Marigold French type alternate planting on ridge 10 cm spacing (T11) and (18.06 t ha^{-1}) in Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9). Similar trend was noted in case of total tuber yield plot^{-1}.

The Sweet potato + Marigold French type intercropping combinations shows a considerably better total tuber yields over Sweet potato + Marigold African type intercropping combinations.

Similar results was also obtained by Evangelio and Rosario (1981) who recorded the production of 21.99 t sweet potato ha^{-1} under inter cropping system. Sauti *et al.* (2004) reported higher sweet potato production in intercropping system than sole crop. Prasad (2010) reported Sweet potato tuber yield of 19.91 t ha^{-1} with 100% RDF in intercropping system. Singh (2010) reported) total tuber yield of 20.9 t ha^{-1} in sole sweet potato crop. Anonymous (2010) at Bagalkot, noted higher total tuber yield in intercropping system than sole Sweet potato crop.

Table 4.5: Effect of Sweet potato + Marigold intercropping on total tuber yield of Sweet potato (kg plot^{-1} & t ha^{-1})

	Treatment	Total tuber yield of sweet potato (kg plot^{-1})	Total tuber yield of sweet potato (t ha^{-1})
T1-	Sole crop sweet potato	16.10	22.38
T2-	Sole crop marigold (African type)	-	-
T3-	Sole crop marigold (French type)	-	-
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	14.11	19.60
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	**7.51**	**10.43**
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	**16.65**	**23.12**
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	14.00	19.44
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	10.82	15.02
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	13.00	18.06
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	9.71	13.49
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	13.90	19.28
	SEm±	**0.61**	**0.85**
	CD (P=0.05)	**1.83**	**2.55**
	CV%	**8.21**	**8.21**



T1- Sole crop sweet potato

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig 4.5: Effect of Sweet potato + Marigold intercropping on total tuber yield of Sweet potato (t ha^{-1})

Sp + Marigold French type 1:1 row ratio (T6) *

Sole Sweet potato (T1)

Sp + Marigold African type 1:1 row ratio (T4)

Sp + Marigold French type 1:2 row ratio (T7)

Sp + Marigold African type 1:2 row ratio (T5) *

Plate 4.2: Effect of Sweet potato + Marigold intercropping on total tuber yield of Sweet potato

4.1.6 Weevil damaged tuber yield (kg plot^{-1}&t ha^{-1}) and % of weevil damaged tuber of Sweet potato

The weevil damaged tuber yield of sweet potato (t ha^{-1}) differed significantly due to different treatments of Sweet potato + Marigold intercropping. The observations on weevil damaged tuber yield kg plot^{-1}, t ha^{-1} and % of weevil damaged tubers of Sweet potato was recorded at the time of harvesting and the data are presented in Table 4.6, and Fig 4.6.

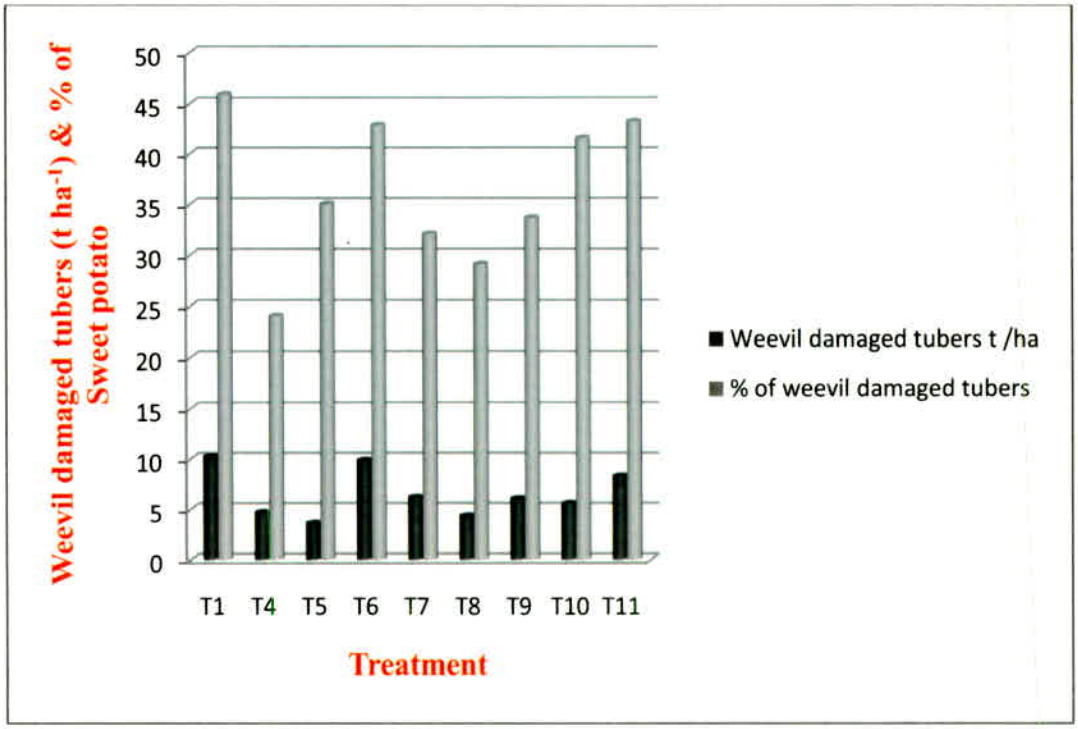
The data reveal that the significantly highest weevil damaged tuber yield (7.41kg plot^{-1} and 10.29 t ha^{-1}) and percentage of weevil damaged tubers (45.96%) was recorded in sole crop Sweet potato (T1), which was significantly higher over other treatments, but it was at par to Sweet potato + Marigold French type 1:1 row ratio (T6) (7.14kg plot^{-1}, 9.92 t ha^{-1} & 42.88%). Remarkably the higher weevil damaged tuber yield (6.17kg plot^{-1}, 8.33 t ha^{-1} & 43.23%) was noted in Sweet potato + Marigold French type alternate planting on ridge 10 cm spacing (T11). Significantly the lowest weevil damaged tuber yield (2.63kg plot^{-1}, & 3.65 t ha^{-1}) was recorded in Sweet potato + Marigold African type 1:2 row ratio (T5); however, the lowest percentage (24.09 %) of weevil damaged tubers was noted in Sweet potato + Marigold African type 1:1 row ratio (T4). It can be noted from the above finding that the lower weevil damaged tuber yield was recorded in Sweet potato + Marigold African type intercropping treatment combinations as compared to Sweet potato + Marigold French type intercropping treatment combinations and sole crop Sweet potato.

The present result was in conformity with the finding obtained by Bhagwat (2011) at Dapoli, who reported that tuber infestation due to sweet potato weevil varied significantly from 18.82 to 37.81 per cent among different barrier crops as against

43.61 per cent in control (sole sweet potato crop). Anonymous (2010) reported at Bagalkot, that tuber weevil infestation varied significantly from 17.31 to 37.16 per cent among different barrier crops as against 37.50 per cent in control (sole sweet potato crop) and Singh (2010b) reported that in Chhattisgarh, the sweet potato damage was 40% tubers by the incidence of sweet potato weevil.

Table 4.6: Effect of Sweet potato + Marigold intercropping on Weevil damaged tuber Yield of Sweet potato (kg plot^{-1}, t ha^{-1}) and % of damaged tubers

	Treatment	Weevil damaged tubers yield of Sweet potato (kg plot^{-1})	Weevil damaged tubers yield of Sweet potato (t ha^{-1})	% of weevil damaged tubers of Sweet potato
T1-	Sole crop sweet potato	**7.41**	**10.29**	**45.96**
T2-	Sole crop marigold (African type)	-	-	-
T3-	Sole crop marigold (French type)	-	-	-
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	3.40	4.72	**24.09**
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	**2.63**	**3.65**	35.04
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	7.14	9.92	42.88
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	4.50	6.25	32.13
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	3.15	4.38	29.15
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	4.38	6.09	33.71
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	4.04	5.61	41.59
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	6.17	8.33	43.23
	SEm±	**0.43**	**0.57**	
	CD (P=0.05)	**1.28**	**1.71**	
	CV%	**15.51**	**15**	



T1- Sole crop sweet potato

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig 4.6: Effect of Sweet potato + Marigold intercropping on Weevil damaged tuber yield t ha^{-1}) and % of Weevil damaged tubers of Sweet potato.

Sweet potato weevil Grub and Adult

Weevil damaged tuber

Sole Sweet potato (T1) *

Sp + Marigold African type 1:1 row ratio (T4) *

Sp + Marigold French type 1:1 row ratio (T6)

Sp + Marigold French type alternate planting on ridge 10 cm (T11)

plate 4.3: Effect of Sweet potato + Marigold intercropping on weevil damaged tubers of Sweet potato

4.1.7 Marketable tuber yield (kg plot^{-1} & t ha^{-1})

Marketable tuber yield of Sweet potato differed significantly due to different treatments of Sweet potato + Marigold intercropping. The observation on marketable tuber yield (kg plot^{-1} & t ha^{-1}) was recorded at harvest and the data are presented in Table 4.7 and Fig 4.7.

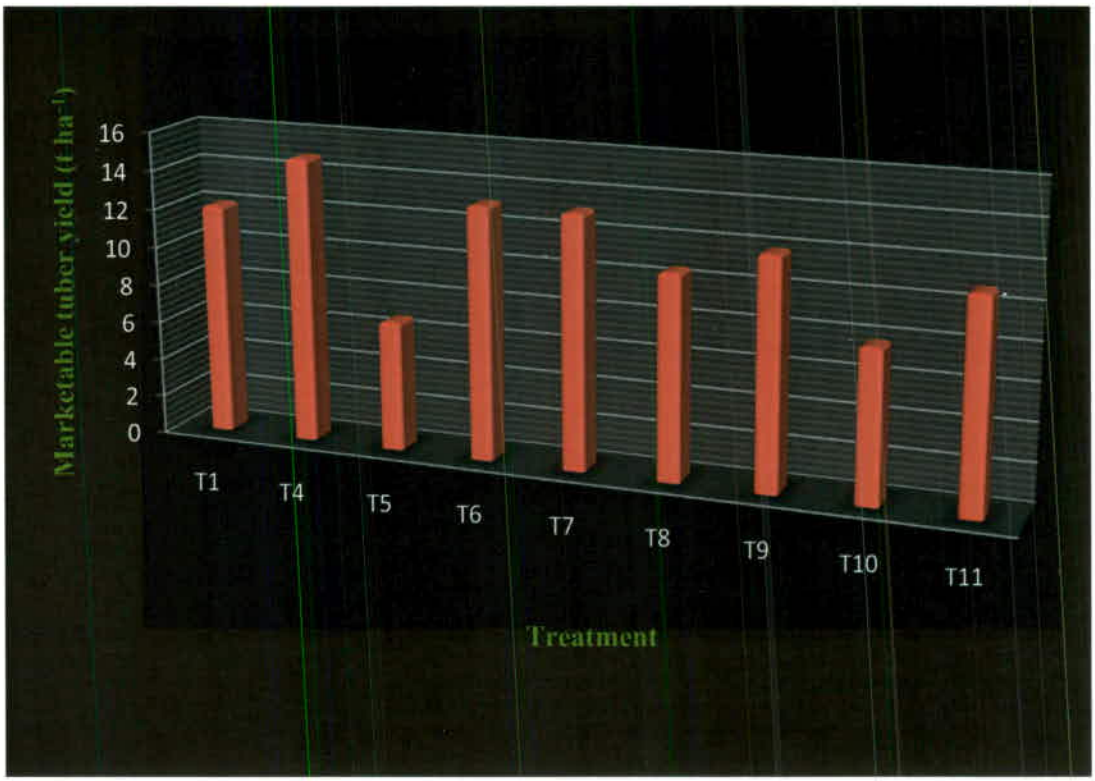
Marketable tuber yield (10.71 kg plot^{-1} & 14.88 t ha^{-1}) was recorded in Sweet potato + Marigold African type 1:1 row ratio (T4), which was significantly superior over others, but it was at par to Sweet potato + Marigold French type 1:1 row ratio (T6) (9.51kg plot^{-1}&13.21 t ha^{-1}) and Sweet potato +Marigold French type 1:2 row ratio (T7) (9.50 kg plot^{-1} & 13.19 t ha^{-1}). Significantly the lowest marketable tuber yield (4.88 kg plot^{-1}& 6.77 t ha^{-1}) was recorded in Sweet potato + Marigold African type 1:2 row ratio (T5).

It can be inferred from the above data that the higher marketable tuber yield in Sweet potato was noted in Sweet potato + Marigold French type intercropping treatment combinations as compared to Sweet potato + Marigold African type intercropping combinations except Sweet potato+ Marigold African type 1:1 row ratio (T4).

Above finding under the study are in close proximity with the finding of Tarafder (2011), who observed the alternate row (1:1) with marigold was reasonably better than the planting in 2:1 fashion and the combination with sweet potato and marigold was found better than other treatments where the marketable root yield was recorded high. Singh (2010) observed 11.7 t ha^{-1} of marketable tuber yield in sole crop sweet potato.

Table 4.7: Effect of Sweet potato + Marigold Intercropping on Marketable tuber yield of Sweet potato (kg plot^{-1} & t ha^{-1})

	Treatment	Marketable tuber yield of Sweet potato (kg plot^{-1})	Marketable tuber yield of Sweet potato (t ha^{-1})
T1-	Sole crop sweet potato	8.70	12.09
T2-	Sole crop marigold (African type)	-	-
T3-	Sole crop marigold (French type)	-	-
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	**10.71**	**14.88**
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	**4.88**	**6.77**
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	9.51	13.21
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	9.50	13.19
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	7.66	10.64
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	8.62	11.97
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	5.79	8.04
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	7.88	10.95
	SEm±	**0.59**	**0.82**
	CD (P=0.05)	**1.78**	**2.47**
	CV%	**12.62**	**12.62**



T1- Sole crop sweet potato

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig 4.7: Effect of Sweet potato + Marigold Inter cropping on Marketable tuber yield of Sweet potato (t ha^{-1})

Sp + Marigold African type 1:1 row ratio (T4) *

Sole Sweet potato (T_1)

Sp + Marigold French type 1:1 row ratio (T6)

Sp + Marigold French type 1:2 row ratio (T7)

Sp + Marigold African type 1:2 row ratio (T5) *

Plate 4.4: Effect of Sweet potato + Marigold on marketable tuber yield of Sweet potato

.2 Studies in Marigold

4.2.1 Flower yield (kg plot^{-1} & q ha^{-1})

Flower yield of Marigold (kg plot^{-1} & q ha^{-1}) differed significantly due to different treatments of Sweet potato + Marigold intercropping. The data are presented in Table 4.8 and Fig 4.8.

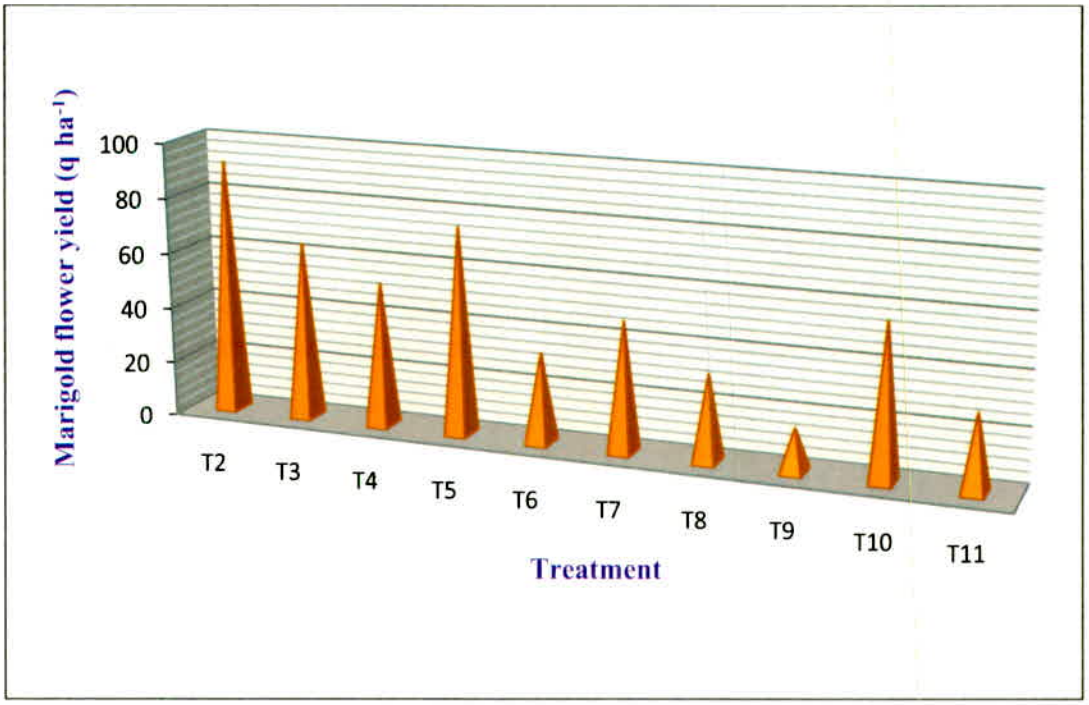
The data reveal that the significantly highest flower yield (6.64 kg plot^{-1} & 92.21 q ha^{-1}) was recorded in sole Marigold African type (T2). Significantly the lowest flower yield (1.15kg plot^{-1} & 15.90 q ha^{-1}) was noted in Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9). Among inter crop treatments the maximum flower yield (5.43 kg plot^{-1} & 75.46 q ha^{-1}) was noted in Sweet potato + Marigold African type 1:2 row ratio (T5).

From the above findings it is obvious that relatively the higher flower yield was noted in Sweet potato + marigold African type intercropped treatment combinations than Sweet potato + Marigold French type intercropped treatment combinations.

Similar trend was also found by Raut and Paradkar (2003), Hussain *et al.* (2010) and Kumar *et al.* (2011).

Table 4.8: Effect of Sweet potato + Marigold intercropping on flower yield of Marigold (kg plot^{-1} & t ha^{-1})

	Treatment	Flower yield of Marigold (kg plot^{-1})	Flower yield of Marigold (q ha^{-1})
T1-	Sole crop sweet potato	-	-
T2-	Sole crop marigold (African type)	**6.64**	**92.21**
T3-	Sole crop marigold (French type)	4.65	64.64
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	3.77	52.42
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	5.43	75.46
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	2.40	33.32
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	3.44	47.73
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	2.32	32.16
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	**1.15**	**15.90**
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	4.07	56.58
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	2.02	28.12
	SEm±	**0.15**	**2.14**
	CD (P=0.05)	**0.46**	**6.35**
	CV%	**7.43**	**7.42**



T2- Sole crop Marigold African type

T3- Sole crop Marigold French type

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig 4.8:Effect of Sweet potato + Marigold intercropping on flower yield of Marigold (q ha^{-1})

Sole Marigold African type (T2) *

Sole Marigold French type (T3)

Sp + Marigold African type 1:2 row ratio (T5)

Sp + Marigold French type alternate planting on ridge 20 cm *

Total Marigold flower yield (3rd harvesting)

Total Marigold flower yield (4th harvesting)

Plate 4.5: Effect of Sweet potato + Marigold on flower yield of Marigold

4.3 Assessment of yield advantage in intercropping system

4.3.1 Land Equivalent Ratio (LER)

The data on LER as affected by different Sweet potato+ Marigold intercropping treatment combinations are presented in Table 4.9.

The sweet potato intercropping with marigold recorded higher LER when compared to the sole crop of sweet potato and sole crop of marigold two types. Among intercropping treatments, the highest LER (1.61) was recorded in Sweet potato + Marigold French type 1:2 row ratio (T7). The least LER (1.02) was recorded in Sweet potato + Marigold African type alternate planting on ridge 20 cm spacing (T8).

Similar trend was also found by Ijoyah and Jimba (2011) and they obtained the highest land equivalent ratio (LER) values of 1.97 and 2.00 in sweet potato and okra intercropping respectively. Similar finding was also noted by Dua *et al.* (2005), Al-dalain (2009) recorded LER 1.43 and 1.55 in Maize + Potato intercropping system.

4.3.2 Area Time Equivalent Ratio (ATER)

Area Time Equivalent Ratio (ATER) was also affected by Sweet potato + Marigold intercropping and the data are presented in Table 4.9.

The highest ATER (1.58) was recorded in Sweet potato + Marigold French type 1:2 row ratio (T7) whereas, the least ATER (1.01) was noted in Sweet potato + Marigold African type alternate planting on ridge 20 cm spacing (T8).

4.3.3 Sweet potato equivalent yield (kg ha^{-1})

Intercropping of sweet potato with marigold influenced the sweet potato equivalent yield (kg ha^{-1}) and the data are presented in Table 4.9.

The highest Sweet potato equivalent yield (20122 kg ha^{-1}) was recorded in Sweet potato + Marigold African type 1:1 row ratio (T4). Among the treatments, the

least Sweet potato equivalent yield (6464 kg ha^{-1}) was recorded in sole Marigold French type (T3). The data also reveal that equivalent yields of all the intercropped treatments were superior to sole crop treatments.

4.3.4 Per cent increase in equivalent yield over sole Sweet potato

Intercropping of sweet potato with marigold influenced the increased % of sweet potato equivalent yield over sole crop Sweet potato and the data are presented in Table 4.9.

The impact of Sweet potato + Marigold intercropping on increased per cent in equivalent yield over sole crop Sweet potato was shown variously. The highest per cent (66.39%) of increased equivalent yield over sole crop Sweet potato was noted in Sweet potato+ Marigold African type 1:1 row ratio (T4). The least per cent (- 46.55%) of increased equivalent yield over sole crop Sweet potato was noted in sole crop Marigold French type (T3).

4.4 Economic evaluation of the treatment

4.4.1 Cost of cultivation

The Cost of cultivation of treatment ha^{-1} is given in Table 4.10 and illustrated through Fig 4.9.

The cost of cultivation varied from Rs. 47,553 ha^{-1} to Rs. 76,622 ha^{-1} under different treatments. The maximum (Rs.76, 622 ha^{-1}) cost of cultivation was registered under treatment Sweet potato + Marigold African type 1:2 row ratio (T5) and Sweet potato + Marigold French type 1:2 row ratio (T7) recording similar values, this was followed by treatments Sweet potato + Marigold African type 1:1 row ratio (T4), Sweet potato + Marigold French type 1:1 row ratio (T6), Sweet potato + Marigold African type alternate planting on ridge 10cm spacing (T10) and Sweet potato + Marigold French type alternate planting on ridge 10 cm spacing (T11) recording similar cost of cultivation of Rs 63,007 ha^{-1}. The minimum cost of

cultivation (Rs 47,553 ha^{-1}) was recorded under treatment sole crop Sweet potato (T1).

4.4.2 Gross return

The effect of intercropping of sweet potato with marigold was analysed for gross return (Rs. ha^{-1}) and the values are presented in Table 4.10 and illustrated through Fig 4.9.

The gross returns range between (Rs. 64,640 ha^{-1}) to (Rs. 2, 01, 2,20 ha^{-1}). The highest gross return (Rs. 2, 01,2,20 ha^{-1}) was recorded in Sweet potato + Marigold African type 1:1 row ratio (T4), followed by Rs 1, 79,670 ha^{-1} in treatment Sweet potato + Marigold French type 1:2 row ratio (T7) and Rs. 1, 65,400 ha^{-1} in treatment Sweet potato + Marigold French type 1:1 row ratio (T6). The least gross return was recorded in sole crop Marigold French type (T3).

4.4.3 Net return

The data on net return as influenced by intercropping of sweet potato with marigold are presented in Table 4.10 and illustrated through Fig 4.9.

The net return ranged between Rs. 13,831 ha^{-1} to Rs. 1, 38, 2,13 ha^{-1}. The highest net return (Rs. 1, 38, 213 ha^{-1}) was noted in Sweet potato + Marigold African type 1:1 row ratio (T4), followed by Rs.1,03,048 ha^{-1}in treatment Sweet potato + Marigold French type 1:2 row ratio (T7), Rs.1,02,393 ha^{-1} in treatment Sweet potato + Marigold French type 1:1 row ratio (T6) was recorded. The lowest net return (Rs. 13,831 ha^{-1}) was recorded in sole crop Marigold French type (T_3). In sole crop Sweet potato (T1) the net return Rs.73, 377 ha^{-1} was recorded.

4.4.4 Benefit Cost ratio (B: C)

The benefit cost ratio as influenced by intercropping of sweet potato with marigold data are presented in Table 4.10.

The highest B: C ratio (2.20) was recorded in Sweet potato + Marigold African type 1:1 row ratio (T4), followed by 1.73 in treatment Sweet potato + Marigold African type alternate planting on ridge 20 cm (T8) and 1.67 in treatment Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9). The lowest B: C ratio (0.27) was recorded in sole marigold French type (T3).

Similar trend was obtained by Singh (2011) at Dholi, on intercropping highest CB ratio of 1:1.78 and 1:2.43, over sole crop.

Table 4.9: Effect of Sweet potato + Marigold on LER, ATER, Sp-EY (kg ha^{-1}) & % Increase in yield over sole sweet potato

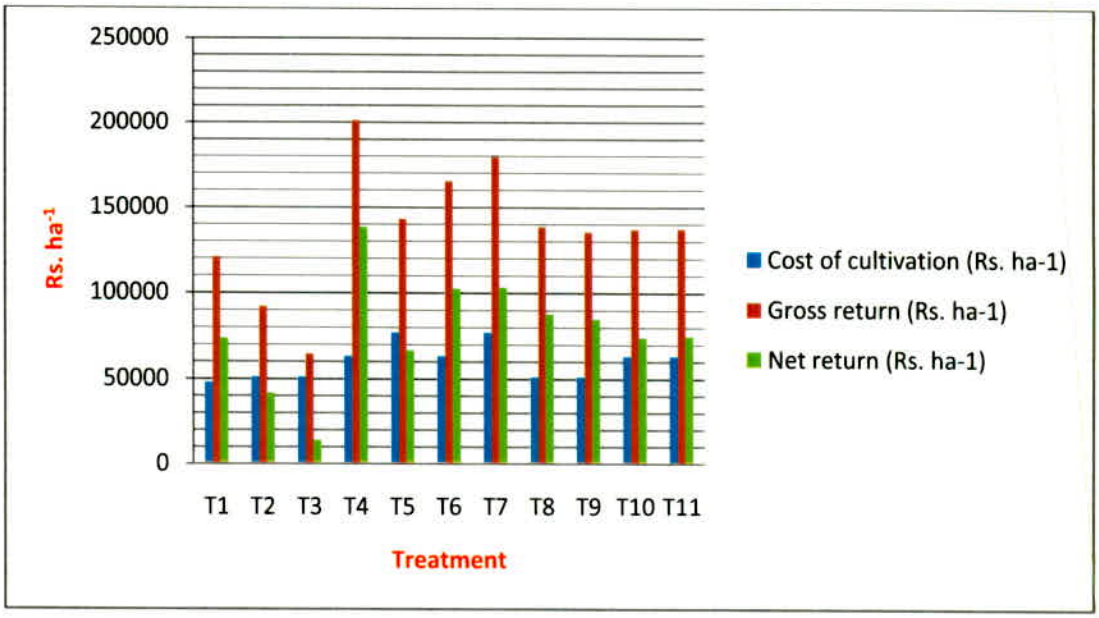
	Treatment	LER	ATER	SP-EY(kg ha^{-1})	% increased in yield over sole Sp
T1-	Sole crop sweet potato	1	1	12093	-
T2-	Sole crop marigold (African type)	1	1	9221	-23.75
T3-	Sole crop marigold (French type)	1	1	**6464**	**-46.55**
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	1.44	1.42	**20122**	**66.39**
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	1.28	1.25	14318	18.40
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	1.55	1.53	16540	36.77
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	**1.61**	**1.58**	17967	48.57
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	**1.02**	**1.01**	13859	14.62
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	1.05	1.04	13557	12.11
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	1.22	1.19	13701	13.30
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	1.30	1.28	13751	12.88

Selling Rate kg^{-1} **Sweet potato – Rs.10/-** **Marigold – Rs. 10/-**

Table 4.10: Effect of Sweet potato + Marigold intercropping on Economic evaluation of the Treatment

	Treatment	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net profit (Rs ha^{-1})	B:C ratio
T1-	Sole crop sweet potato	47553	120930	73377	1.54
T2-	Sole crop marigold (African type)	50809	92210	41401	0.81
T3-	Sole crop marigold (French type)	50809	**64640**	**13831**	**0.27**
T4-	Sweet potato + Marigold (African type) 1:1 Row ratio	63007	**201220**	**138213**	**2.20**
T5-	Sweet potato + Marigold (African type) 1:2 Row ratio	76622	143180	66558	0.87
T6-	Sweet potato + Marigold (French type) 1:1 Row ratio	63007	165400	102393	1.63
T7-	Sweet potato + Marigold (French type) 1:2 Row ratio	76622	179670	103048	1.35
T8-	Sweet potato + Marigold (African type) alternate planting on ridge (20 cm spacing)	50827	138590	87763	1.73
T9-	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	50827	135570	84743	1.67
T10-	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	63007	137010	74003	1.17
T11-	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	63007	137510	74853	1.18

Selling Rate kg^{-1} **Sweet potato-Rs.10/-** **Marigold-Rs.10/-**



T1- Sole crop Sweet potato

T2- Sole crop Marigold African type

T3- Sole crop Marigold French type

T4- Sweet potato+ Marigold African type 1:1 row ratio

T5- Sweet potato+ Marigold African type 1:2 row ratio

T6- Sweet potato+ Marigold French type 1:1 row ratio

T7- Sweet potato+ Marigold French type 1:2 row ratio

T8- Sweet potato+ Marigold African type alternate planting on ridge 20 cm spacing

T9- Sweet potato+ Marigold French type alternate planting on ridge 20 cm spacing

T10- Sweet potato+ Marigold African type alternate planting on ridge 10 cm spacing

T11- Sweet potato+ Marigold French type alternate planting on ridge 10 cm spacing

Fig. 4.9: Effect of Sweet potato + Marigold intercropping on Economic evaluation of the Treatment

Summary, Conclusion and Suggestions for Future Research Work

CHAPTER-V

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH WORK

The present findings obtained during the course of investigation on **"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L). Lam) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"** conducted during rabi season of 2011-12 in the experimental field of AICRP on Tuber Crops at Horticultural Research cum Instructional Farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) are summarized in the present chapter. The experiment was laid out in randomized block design with three replications and eleven treatment combinations. The Sweet potato + Marigolds were simultaneously planted on 5th January 2012 and Sweet potato was harvested on 4th May 2012. The obsevations recorded during the study are summarized below:

1. Significantly the highest average vine length (84.4 cm plant^{-1}) of sweet potato was obtained in Sweet potato + Marigold African type 1:1 row ratio (T4), which was significantly superior over others, but it was at par to Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9) (80.20 cm plant^{-1}) and Sweet potato + Marigold French type alternate planting on ridge 10 cm spacing (T11) (78.13cm plant^{-1}). Significantly the minimum vine length (58.53 cm plant^{-1}) was recorded in Sweet potato + Marigold African type alternate planting on ridge 10 cm spacing (T10).

2. The maximum vine weight (395g plant^{-1}) was recorded in Sweet potato + Marigold French type alternate planting on ridge with 20 cm spacing (T9), which was significantly superior over all other treatments. The treatments Sweet potato +

Marigold African type alternate planting on ridge with 20 cm spacing (T8) and Sweet potato + Marigold French type 1:1 row ratio (T6) recorded vine weight of 360 and 347 g plant^{-1}, respectively. Significantly the lowest vine weight (135g plant^{-1}) was recorded in Sweet potato + Marigold African type alternate planting on ridge with 10 cm spacing (T10).

3. The number of tubers plant^{-1} was not affected by Sweet potato + Marigold intercrpping system. However, the maximum number of tubers (3.93 tubers plant^{-1}) was recorded in sole Sweet potato (T1) and the minimum number of tubers (2.40 tubers plnat^{-1}) was obtained in Sweet potato + Marigold African type 1:2 row ratio (T5).
4. The highest fresh weight of Sweet potato tubers (500 g plant^{-1}) was recorded in Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9), which was significantly superior over others and significantly lowest fresh weight of Sweet potato tubers (180g plant^{-1}) was noted in Sweet potato + Marigold African type 1:2 row ratio (T5).
5. The maximum total tuber yield (23.12 t ha^{-1}) of sweet potato was obtained in Sweet potato + Marigold French type 1:1 row ratio (T6), but it was at par to sole crop sweet potato (T1) (22.38 t ha^{-1}) and the minimum total tuber yield (10.43 t ha^{-1}) was obtained in Sweet potato + Marigold African type 1:2 row ratio (T5). Similar trend was noted in case of total tuber yield plot^{-1}.
6. The maximum weevil damaged tubers yield (10.29 t ha^{-1}) and percentage of weevil damaged tubers (45.96%) of sweet potato was recorded in sole crop Sweet potato (T1) which was significantly higher than others, but it was at par to Sweet potato + Marigold French type 1:1 row ratio (T6) (9.92 t ha^{-1}) with 42.88% weevil damaged tubers. The minimum weevil damaged tuber yield (3.65 t ha^{-1}) was noted

in treatment Sweet potato + Marigold African type 1:2 row ratio (T5), but the minimum percentage (24.09%) of weevil damaged tubers was noted in Sweet potato + Marigold African type 1:1 row ratio (T4).

7. The highest marketable tuber yield (14.88 t ha^{-1}) of sweet potato was obtained in Sweet potato + Marigold African type 1:1 row ratio (T4), which was significantly superior over others, but it was at par to Sweet potato + Marigold gold French type 1:1 row ratio (T6) (13.21 t ha^{-1}) and Sweet potato + Marigold French type 1:2 row ratio (T7) (13.19 t ha^{-1}). The lowest marketable tuber yield (6.77 t ha^{-1}) was noted in Sweet potato + Marigold African type 1:2 row ratio (T5). In sole crop Sweet potato (T1) the marketable tuber yield (12.09 t ha^{-1}) was recorded.
8. The significantly higher flower yield (92.21 q ha^{-1}) of Marigold was obtained in sole Marigold African type (T2). Among inter crop treatments maximum flower yield (75.46 q ha^{-1}) was noted in Sweet potato + Marigold African type 1:2 row ratio (T5). The minimum flower yield (15.90 q ha^{-1}) was noted in Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9).
9. The land equivalent ratio (LER) under Sweet potato + Marigold intercropped system ranged from (1.02 to 1.61). The maximum LER (1.61) was recorded in Sweet potato + Marigold French type 1:2 row ratio (T7) followed by 1.55 in Sweet potato + Marigold African type 1:1 row ratio (T6). The minimum LER (1.02) was noted in Sweet potato + Marigold African type alternate plantation on ridge 20 cm spacing (T8).
10. Intercropping of Sweet potato + Marigold gave higher sweet potato equivalent yield over sole crop treatments. The highest sweet potato equivalent yield was recorded under Sweet potato + Marigold African type 1:1 row ratio (T4) (20122kg ha^{-1}) followed by Sweet potato + Marigold French type 1:2 row ratio (T7) (17967

kg ha^{-1}). The minimum sweet potato equivalent yield (6464 kg ha^{-1}) was recorded in sole Marigold French type (T3).

11. The gross return under Sweet potato + Marigold intercropped system ranged between (Rs. 64,640 ha^{-1}) to (Rs. 2, 01,2,20 ha^{-1}). The highest gross return (Rs. 2, 01,2,20 ha^{-1}) was recorded in Sweet potato + Marigold African type 1:1 row ratio (T4), followed by Rs 1, 79,670 ha^{-1} in treatment Sweet potato + Marigold French type 1:2 row ratio (T7) and Rs. 1, 65,400 ha^{-1} in treatment Sweet potato + Marigold French type 1:1 row ratio (T6). The least gross return (Rs. 64,640 ha^{-1}) was recorded in sole crop Marigold French type (T3).
12. The highest net return (Rs.1, 38, 213/- ha^{-1}) was obtained in Sweet potato + Marigold African type 1:1 row ratio (T4), followed by Rs.103048 & Rs.102393 ha^{-1} recorded under treatments Sweet potato + Marigold French type 1:2 row ratio (T7) and Sweet potato +Marigold French type 1:1 row ratio (T6), respectively. The lowest net return (Rs. 13831 ha^{-1}) was noted in sole crop Marigold French type (T3). In sole crop sweet potato (T1), net return of Rs. 73377 ha^{-1} was recorded.
13. The maximum B: C ratio (2.2) was obtained in Sweet potato + Marigold African type 1:1 row ratio (T4), followed by 1.72 in treatment Sweet potato + Marigold African type alternate planting on ridge 20 cm (T8) and 1.67 in treatment Sweet potato + Marigold French type alternate planting on ridge 20 cm spacing (T9). The minimum B: C ratio (0.27) was noted in sole Marigold French type (T3). In sole sweet potato (T1), the B: C ratio of (1.54) was noted.

Conclusion

It can be inferred from one year experimentation on intercropping of Sweet potato + Marigold (French & African types) intercropping conducted in Inceptisols of Chhattisgarh plains, that intercropping of Sweet potato + Marigold African type 1:1 row ratio (T4) registered significantly highest marketable tuber yield of Sweet potato (14.88 t ha^{-1}) with maximum net profit (Rs.138213 ha^{-1}), B:C ratio (2.20), Sweet potato equivalent yield (20122 kg ha^{-1}) and minimum % of weevil damaged tubers (24.09%).

The next better option of intercropping was Sweet potato + Marigold French type 1:1 row ratio (T6) and Sweet potato + Marigold French type 1:2 row ratio (T7).

Suggestions for Future Research work

On the basis of experience gained and results obtained after completion of the present investigation, following suggestions are given to conduct further research.

1. The present investigation can be carried out in other seasons on different soil types, and location in the State to see the effect of varying location and weather condition for different varieties of Sweet potato.
2. The investigation can be carried out with plantation of Marigold (inter crop) 15 days ahead and 15 days later planting of Sweet potato, instead of simultaneous planting.
3. The investigation can be carried out with combination of organic manure fertilizers.
4. The Sweet potato can be intercropped with other beneficial crops, like Yam bean and other medicinal crops.
5. The experiment may be repeated to confirm the results.

Abstract

"STUDIES ON INTERCROPPING OF MARIGOLD IN SWEET POTATO (*Ipomoea batatas* (L). Lam) UNDER AGRO-CLIMATIC CONDITIONS OF CHHATTISGARH PLAINS"

By

Bhimavarapu Sreenivasulu

ABSTRACT

An investigation on "**Studies on intercropping of marigold in sweet potato (*Ipomoea batatas* (L). Lam) under agro-climatic conditions of Chhattisgarh plains**" conducted during rabi season of 2011-12 in the experimental field of AICRP on Tuber Crops at Horticultural Research cum Instructional Farm, Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was laid out in randomized block design with three replications and eleven treatment combinations. The aim of the experiment was to find out the effect of Marigold intercropping on growth; yield and marketable tuber yield of Sweet potato, find out suitable intercropping combination of Sweet potato + Marigold and work out the economics of intercropping of Marigold in Sweet potato.The experiment was carried out with 100% of RDF and simultaneous planting of Sweet potato + Marigold on ridge and furrow method. The Sweet potato was harvested at 120 DAP and the observations were taken in Sweet potato at the time of harvesting. Marigold flower picking was done from 48 DAP to 117 DAP in 7 pickings (within 10 days interval).

On the basis at findings of the present experiments, it may be inferred, that Sweet potato + Marigold African type 1:1 row ratio (T4) was significantly superior to others in the production of maximum marketable tuber yield (14.88 t ha^{-1}), higher production of sweet potato equivalent yield (20122 kg ha^{-1}), more net profit (Rs.138213/- ha^{-1}) almost two fold higher than the sole crop sweet potato (T1), maximum B: C ratio (2.20) and recorded minimum % of weevil damaged tubers (24.09%) ,while in sole crop Sweet potato (T1) recorded maximum % of weevil damaged tubers (45.96%), production of marketable tuber yield (12.09 t ha^{-1}) with net profit (Rs.73377/- ha^{-1}) and B: C ratio (1.54).

So the best suitable intercropping combination for 'Chhattisgarh' plain zone is Sweet potato + Marigold African type 1:1 row ratio (T4). The next better option of intercropping combinations were Sweet potato + Marigold French type 1:1 row ratio (T6) and Sweet potato + Marigold French type 1:2 row ratio (T7), registered13.21 & 13.19 t ha^{-1} of marketable tuber yield, 16540 & 17967 kg $ha^{-1}$of sweet potato equivalent yield, Rs. 102393 & Rs.103048 ha^{-1} net profit and 1.63 & 1.35 B:C ratio respectively.

30.6.12

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References

REFERENCES

Agrawal, N.S., Kar,D.S and Mohanty, A. 2010. Intercropping trial in Cauliflower cv. Snowball-16. K.V.K Jajpur, Orissa. *Indian Journal of Horticulture* 67(4): 314-316.

Aiyer, A.Y.A. 1949. Mixed cropping in India. *Indian Journal of Agricultural Sciences* 19: 454.

Al-dalain,S.A.2009. Effect of intercropping of maize with potato on potato growth and on the productivity and land equivalent ratio of potato and maize. *Agricultural Journal* 4(3): 164-170.

Andrews, D. J. 1970. Intercropping with sorghum. *Sorghum in Seventies Edition, Oxford and Indian Book House*, New Delhi, pp. 548-556.

Andrews, D.J. and Kassam, A.H. 1976. Importance of multiple cropping in increasing world food supplies (In) Multiple cropping. *American Society of Agronomy* 27: 1-10.

Anonymous.2010. Management of sweet potato weevil through barrier crops (yam bean and marigold). *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 184-185.

Arya,R., Awasthi, O.P., Singh, J., Singh, I.S. and Manmohan, J.R. 2011. Performance of component crops in Tree-crop Farming System under Arid Region. *Indian Journal of Horticulture* 68(1): 6-11.

Ayyangar, G. N. R. and Ayyer, A. K. Y. N. 1942. Mixed cropping – A review. *Madras Agricultural Journal* 3(2): 3-13.

Ayyer, A. K.Y.N. 1963. Principles of Crop Husbandry in India. *Bangalore Press* 4: 250-257.

Bediako,A.E., Quaye,A. A.A. and Mohammed,A.2010. Control of Diamondback Moth (*Plutella xylostella*) on Cabbage (*Brassica oleracea var capitata*) using Intercropping with Non-Host Crops. *American Journal of Food Technology* 5(4): 269-274.

Bhagwat,N.R. 2011. Management of sweet potato weevil through barrier crops (yam bean and marigold). *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 183.

Black,C.A. 1965. Method of soil Analysis, part-II, Agronomy monograph, no-9. *American society of Agronomy*, Madison,Wicconsin pp.148.

Bourke, R. M. 1985. Sweet potato (*Ipomoea batatas L*) production and research in Papua New Guinea. *Papua New Guinea Journal of Agriculture, Forestry and Fisheries* 33: 89–108.

Cai, H., Li, S., Ryall, K., You, M. and Lin, S. 2011. Effects of intercropping of garlic or lettuce with Chinese cabbage on the development of larvae and pupae of diamondback moth (*Plutella xylostella*). *African Journal of Agricultural Research* 6(15): 3609-3615.

Carandang, J.J.A. and Curayag, L.J. 1994. Influence of legume intercrops on the production of sweet potato (*Ipomoea batatas* (L.) Lam). *CMU Journal of Science* 7(1): 79-80.

Cerruti, H.R.R., Koon,H.W., Antoon, P. and Robert, M.S.2010.Using marigold (*Tagetes* spp.) as a cover crop to protect crops from plant-parasitic nematodes, *Applied Soil Ecology* 46(3): 307 – 320.

Chattopadhyay,N., Hore,J.K., Bandyopadhyay,A. and Ghosh,D.2006. Response of varying levels of NPK fertilization on Elephant Foot Yam grown as intercrop in Arecanut Plantation. *Agricultural Science Digest* 26(1): 23-26.

Chujoy, E. and Ona, I.1990 .Shade tolerance in sweet potato varieties under intercrop with maize. *The International Potato Center*, Southeast Asia and the Pacific Regional Office, 1099 Manila Phiippines pp.80-90.

Cruz, F.C. and Cadiz, T.G. 1977. Annual productivity of crops grown as monoculture and as intercrops. *The Philippine Journal of Crop Science* 2(2): 126-132.

Cuijpers,W.J.M., Janmaat and Van der Wurff, L.A.W.G.2009. Innovative intercropping system to improve soil health in organic greenhouse cultivation. *International Conference on Organic Greenhouse Horticulture, ISHS Acta Horticulture* 915.

Deveraj,A. and Kalaiselvam,I. 2011. Effect of root exudates of *Tagetes sp* on egg hatching behavior of *Melodogyne incognita*. *International Research Journal of Pharmacy* 2(10): 93-96.

Dhruv,K. and Lal S.S.2004. Evaluation of potato based cropping systems in Bihar plains. *Potato Journal* 31 (1 and 2): 49-53.

Donald, C.M. 1963. Competition among crop and pasture plants. *Advances in Agronomy* 10(3): 435-473.

Dua,V.K., Lal,S.S. and Govindakrishnan,P.M.2005. Production potential and competition indices in potato (*Solanum tuberosum*) + french bean (*Phaseolus vulgaris*) intercropping system in Shimla hills. *The Indian Journal of Agricultural Sciences* 75(6): 26-37.

Elameen, A., Siri, F., Larsen, A., Rognli, O. A., Sundheim, L. and Msolla,S. 2008 . Analysis of genetic diversity in a sweet potato (*Ipomoea batatas* L.). Germplasm collection from Tanzania as revealed by AFLP. *Genetic Resources and Crop Evolution* 55: 397–408.

Evangelio, L.A. and Rosario, E.L. 1981. Effect of different cropping systems of the growth and yield of sweet corn and sweet potato in southern Philippines. *Annals of Tropical Research* 3(4): 47-51.

Food and Agricultural Organisation (FAO) .2009 . FAO Statistics. In: http://apps.fao.org.

Fresco, L.O.1990 . Intercropping of sweet potato and legumes. *AVRDC Progress Report* , pp. 240-243.

Gajanana,T.M., Krishna Moorthy,P., Anupama,H.L., Raghunatha,R. and Prasanna Kumar, G.T. 2006. Integrated pest and disease management in tomato: An Economic Analysis. *Agricultural Economics Research Review* 19(2): Down load, Re PEc:Ags:aerrae: 57763.

Ganajaxi, Halikatti,S.I., Hiremath,S.M. and Chittapur, B.M. 2010. Intercropping of maize and french bean- A Review. *Agricultural Reviews* 31(4): 286-291.

Gawade,M.H., Patil,J.D. and Kakade,D.S.2004 . Studies on effect of intercrops on yield and monetary returns of cabbage. *Agricultural Science Digest* 24(1): 69-70.

Gomez, K.A. and Gomez, A.A., 1984. Statistical procedures in Agricultural Research, *2nd Edition Paper Back*, pp.680

Go´mez-Rodr´guez . 2003. Allelopathy and microclimatic modification of intercropping with marigold on tomato early blight disease development. *Mexico Field Crops Research* 83 (3): 27–34.

Gopinatha,K.V., Nanje Gowda,D. and Nagesh,M .2002. Management of root-knot nematode, *Meloidogyne incognita* on tomato using bio-agent *Verticillium chlamydosporium*, neem cake, marigold and carbofuran. *Indian Journal of Nematology* 32(2): 179-181.

Hazra, P., Chattopadhyay, A., Karmakar, K. and Dutta, S. 2011. Sweet potato, In: Modern Technology in Vegetable Production. *New India Publishing Agency*, New Delhi, India, pp. 358–370.

Hiebsch, C.K. and McCollum, R.E. 1987. Area time equivalence ratio. A method for evaluating the productivity of intercrops. *Agronomy Journal* 79:15-22

Hormchan,P., Wongpiyasatid,A. and Prajimpun,W.2009. Influence of trap crop on yield and cotton leafhopper population and its Oviposition Preference on leaves of different cotton varieties/lines. *Kasetsart Journal of Natural Science* 43: 662 – 668.

Hussain,B., Bilal,S. and Hussain, D.M.2010. Economics of marigold as trap crop against tomato fruit borer in Kashmir Valley. *Trends in Biosciences* 3(1): 30-40.

Ijoyah,M.O and Jimba, J. 2011. Effects of planting methods, planting dates and inter cropping systems on Sweet potato-Okra. Okra yields in Makurdi, Nigeria. *Agricultural Science Research Journals* 1(8): 184-190.

Jackson, W.L. 1967. Soil chemical analysis. *Prentice Hall of India, Pvt Ltd, New Delhi,* pp.183-192.

Jimenez, M.I.G. and Poveda, K. 2009. Synergistic effects of repellents and attractants in Potato Tuber Moth Control. *Basic and Applied Ecology* 10(8): 763-769.

John,S.A. and 'Mini, C. 2005. Development of Okra Based Cropping System. *Indian Journal of Horticulture* 62(1): 49-51.

Joomjantha, S. and Wanapat, M. 2008. Effect of intercropping on biomass yield and chemical composition of cassava. *Livestock Research for Rural Development* 20(7): 73-74.

Kamunya,S.M., Wachira,F.N., Langat,J., Otieno,W. and Sudoi,V.2008. Integrated management of root knot nematode (*Meloidogyne spp.*) in tea (*Camellia*

sinensis) in Kenya. *International Journal of Pest Management* 54(2): 129-136.

Kaul,A., Gupta, A., Shingh, D. And Gupta, S. P. 1996. Intercropping of vegetables in mulberry. *Journal of Sericulture* 4 (2): 48-51.

Kim, H., Thy, N.T., Binh, N.T., Zaag, P.V and Chujoy, E.1992. Studies on intercropping sweet potato with maize. *The International Potato Center*; Southeast Asia and the Pacific Regional Office; 1099 Manila,Philippines, pp.154-164.

Kishore,M.R. and Lal, O.P. 2002.Effect of intercropping on the incidence of diamondback moth,(*Plutella xylostella* L.) on cabbage. *Journal of Entomological Research* 26(2): 141-144.

Korada, R. R., Naskar, S. K., Palaniswami, M. S. and Ray, R. C. 2010. Management of sweet potato weevil *[Cylas formicarius* (Fab.)]: An overview. *Journal of Root Crops* 36: 14–26.

Kumar, N.,UmaShankar, Krishnappa, K., Reddy B.M.R., Ravichandra, N.G.and Karu na, K.2005. Intercropping for the management of root-knot nematode, *Meloidogyne incognita* in vegetable-based cropping systems. *Indian Journal of Nematology* 36(1): 46-49.

Kumar, N.N.S., Angiras, S.S. and Rana,S.S .2011. Intercropping of soybean with maize in control of *Digitaria sanguinalis. Himachal Journal of Agricultural Research* 37 (1): 1-9.

Kumar,R., Sharma,Y.L., Punam, G.D., Sharma and Atul.2011.Intercropping of baby corn with wild marigold (*Tagetes minuta*) under organic conditions in mid-hills of HP. *Himachal Journal of Agricultural Research* 37 (1): 91-94.

Kumar,U.S,N., Krishnappa,K., Reddy,B.M.R., Ravichandra,N.G. and Karuna,K. 2005. Intercropping for the management of root-knot nematode, *Meloidogyne incognita* in vegetable-based cropping systems. *Indian Journal of Nematology* 35(1): 32-36.

Kuruppuarachchi, D.S.P .1996. Intercroping potato with sweet potato in warm coastal lowlands of Sri Lanka. *Selected Research Papers* 1.

La Mondia,J.A .2006. Management of Lesion Nematodes and potato early drying with rotation crops. *The society of Nematologists* 38 (4): 442-448.

Lebot, V. 2009. Tropical root and tuber crops: Cassava, sweet potato, yams, and aroids. *Oxfordshire: CABI.* pp.91-274.

Lorica, M.V and Cabangbang, M.V.D.F. 1997. Integrating sweet potato with multipurpose tree species (MPTS), *Philippine Council for Agriculture, Forestry and Natural Resources Research and Development* (PCARRD), pp. 91.

Mandal,S.K. 1993. Potato and maize as intercrops with mulberry. *Indian Silk* 32 (6): 15-16.

Martin, F. W. 1985. Breeding sweet potatoes for the tropics: vision, plans, methodology and progress. *Acta Hort (ISHS)*, 153: 303–312.

Mehta,R.S., Meena,S.S. and Anwer,M.M.2010. Performance of coriander (*coriandrum sativum*) based intercropping systems. *Indian Journal of Agronomy* 55(4): 47-52.

Nath, R., Chattopadhyay, A., Kundu, C. K., Majumder, A., Islam Sk, J., Gunri, S. 2007. Production potential of sweet potato in the Red and Laterite ecosystem of West Bengal. *Journal of Root Crops* 33: 97–103.

National Hotrticulture Boarrd(NHB 2010), in:http://apps.nhb.org.

Nedunchezhiyan, M.2005. Production and energy-use efficiency of greater yam (*Dioscorea alata)*-based intercropping system as influenced by intercrops and planting patterns. *Indian Journal of Agronomy* 52 (3): 216- 219.

Nedunchezhiyan,M., Byju,G. and Naskar,S.K.2007. Sweet Potato (*Ipomoea batatas* L.) as an intercrop in a Coconut Plantation: Growth, yield and quality. *Journal of Root Crops* 33(1): 26-29.

Nedunchezhiyan,M., Byju,G., Naskar,S.K, and Mukherjee,A. 2010. Effect of mulching and graded doses of fertilizer on yield and nutrient uptake of Greater Yam + Maize intercropping system. *Indian Journal of Horticulture* 67(4): 283-287.

Nedunchezhiyan,M., Rajasekhara Rao,K., Laxminarayana,K. and Satapathy,B.S. 2010. Effect of strip cropping involving sweet potato (*Ipomoea batatas* L.) on soil moisture conservation, Weevil Infestation and crop productivity. *Journal of Root Crops* 6(1): 53-58.

Nedunchezhiyan, M. 2011. Evaluation of sweet potato (*Ipomoea batatas* L*)* based strip inter cropping systems for yield, competition indices and nutrient uptake. *Indian journal of Agronomy* 56(2): 98-103.

Olesen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A.1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *United States, Department of Agriculture.* Circ.939.

Ossom,E.M. and Rhykerd, R.L. 2008. Implications of associating sweet potato [*Ipomea batats (* L.) Lam.] with different groundnut (*Arachis hypogea* .L) populations on tuber yield, soil and tuber chemical properties. *American-Eurasian Journal of Agriculture & Environmental Science* 3(1): 63-69.

Oswald, A., Alkamper, J. and Midmore, D. J. 1985. The effect of different shade levels on growth and tuber yield of sweet potato. 2 nd . Tuber yield. *Journal of Agronomy and Crop Science* 175: 29–40.

Padmaja, G. and Rajamma, P. 1982. Biochemical changes due to the weevil (*Cylas formicarius* Fab.) feeding on sweet potato. *Journal of Food Science and Technology* 19:162–163.

Patel,H.P. and Patel,B.N. 2001. Management of nematodes in bidi tobacco nursery by inimical plants. *Indian Journal of Nematology* 31(1): 47-51.

Patel,N.B. 2010. Intercropping tuber crops in orchards/plantations. *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 176.

Prakash,V., Kumar,N., Bhattachariyya,R., Kumar,M. and Srivastva,A.K. 2007. Productivity, economics, energetics and soil properties of vegetables-based relay intercropping systems. *Indian Journal of Agronomy* 52(4): 300-304.

Prasad, S.M.2010. Intercropping Tuber crops in orchards/plantations. *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 172-173.

Prasad ,S.M.2011. Intercropping spice crops in elephant foot yam. *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 179-180.

Ram,S. and Singh,S. 2010. Effect of intercropping of spices, cereal and root crops on the incidence of *Helicoverpa armigera* Hub in tomato. *Vegetable Science* 37(2): 164-166.

Rao,M.2010.Intercropping spice crops in elephant foot yam. *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 177.

Rao, M.R. and Willey, R.W. 1980. Preliminary studies of intercropping combination based on pigeonpea or sorghum. *Experimental Agriculture 16: 29*-39.

Raut,N.D. and Paradakar, V.K .2003.Effect of flower plant based intercropping system of yield of sweet corn. A.I.C.R.P On Maize improvement Z.A.R.S, Chandangaon , Chindwara 480002 (M.P),India. *International Conference on sustainable crop production in stress environments; Management and genetic options.*

Ray, R. C. and Ravi, V. 2005. Post harvest spoilage of sweet potato in tropics and control measures. *Critical Reviews in Food Science and Nutrition* 45: 623–644.

Robertws-Nkrumah, L. B., Ferguson, T. U. and Wilson, L. A. 1986. Response of the four sweet potato cultivars to levels of shade 2. Tuberization. *Tropical Agriculture* (Trinidad) 63: 265–270.

Roy,S,S and Hore,J.K.2011. Effect of different bio-organic inputs on growth,yield and economics of turmeric grown as intercrop in Arecanut Plantation. *Indian Journal of Horticulture* 68(3): 375-378.

Sato, K., Uritani, I. and Saito, T. 1981. Characterization of a terpene inducing factor isolated from the larvae of the sweet potato weevil, *Cylas formicarius* Fabricus. *Applied Entomology and Zoology* 16: 103–112.

Satyanarayana (2010). Management of sweet potato weevil through barrier crops (yam bean and marigold). *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 184-185.

Sauti,R.F.N., Matabwa, E.S., Bakali,G.F. and Braunnworth Jr.W.S. 2004.The performance of sweet potato varieties with maize and sorghum intercrops in Malawi. Symposium on Tropical Root Crops in a Developping Economy, ISHS *Acta Horticulturae* 380.

Singh,J. 2010a. Identification of suitable intercrops in taro/arvi. *All India co-ordinated Research Project on Tuber Crops, Annual Report* 2010-11, pp.181.

Singh,J. 2010b. Survey and Surveillance of diseases and pests of tuber crops in Chhattisgarh. *Zonal Research and Extension Advisory Committee* (ZREAC), Meeting for C.G plain zones pp. 17.

Singh, K. and Katyal, S. K., 1966, Effect of mixed cropping of wheat and gram with varying levels of N and P on yield. *Journal of Research*, Punjab Agricultural University 3: 364-367.

Singh, P.P. 2010. Management of sweet potato weevil through intercrops. *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp. 187 to 188.

Singh, P.P. 2011. Intercropping spice crops in elephant foot yam. *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp.177- 178.

Singh,R.K., Kumar,H. and Singh,A.K.2010. Brassica based intercropping systems-A Review. *Agricultural Reviews* 31(4): 253-266.

Singh,R..N. 2010. Intercropping Tuber crops in orchards/plantations. *All India Co-ordinated Research Project on Tuber Crops*, Annual Report 2010-11, pp.175- 176.

Singh,R..N.2011. Intercropping spice crops in elephant foot yam. All India Co-ordinated Research Project on Tuber Crops, Annual Report 2010-11, pp. 177.

Singh, S. and Datta S.K.2006. Intercropping of french marigold (*Tagetes patula* Linn) in gladiolus. *Journal of Ornamental Horticulture* 9(1): 37-39.

Singh,S., Rawal,S. and Singh,M. 2007. Design and development of offset type digger for sugarcane + potato intercropping. *Potato Journal* 3: 3-4.

Srinivasan,N and Devrajan,K.2008. Integrated approach for the management of root-knot nematode, *Meloidogyne incognita* in Medicinal Coleus. *Indian Journal of Nematology* 38(2): 154-158.

Subbaiah, B.Y.and Asija, G,L., 1959. Arapid procedure for the estimation of available nitrogen in soils. *Current science*, 25: 259-260.

Suja,G., Susan.Jhon,K. and Srinivas,T. 2010. Cassava production system involved in legumes, *CP/A/C/221*.

Sundararaju,p. 2005. Effect of Marigold, *Tagetes erecta* Intercropped with Banana against Root-lesion Nematode, *Pratylenchus coffeae*. *Indian Journal of Nematology* 35(2): 123-126.

Sutherland, J. A. 1986. An evaluation of foliar sprays, soil treatment and vine dip for the control of sweet potato weevil *Cylas formicarius* (Fab). *Journal of Plant Protection in the Tropics* 3: 95–103.

Swaminathan, M. S. 1980. Past, present and future trend in tropical agriculture perspectives in world agriculture. *Commonwealth Agricultural Bureau* x, England, pp. 1-43.

Tarafder,J. 2011 . Management of sweet potato weevil through barrier crops (yam bean and marigold). *All India Co-ordinated Research Project on Ruber Crops*, Annual Report 2010-11, pp. 183-184.

Tikadar,A. and Sen,S.K.1991. Ginger and Field Pea as intercrop with mulberry. *Indian Silk* 30(3): 47-48.

Ukom, A. N., Ojimelukwe, P. C. and Okpara, D. A. 2009. Nutrient composition of selected sweet potato [*Ipomea batatas* (L) Lam] varieties as influenced by

different levels of nitrogen fertilizer application. *Pakistan Journal of Nutrition* 8: 1791–1795.

Vaiyapuri,K., Amanullah,M.M., Pazhanivelan., Somasundaram,S.and Sthykyanoonthi,K. 2007a. Nutrient uptake, yield of cotton and soil nutrient status as influenced by intercropping unconventional greenmanures. *Journal of Applied Sciences Research* 3(12): 1676-1683.

Vaiyapuri,K., Amanullah,M.M., Pazhanivelan., Somasundaram,s. and Sthykyanoonthi,K. 2007b. Influence of intercropping unconventional greenmanures on pest incidence and yield of cotton. *Journal of Applied Sciences Research* 3(12): 1710-1716.

Verma,L.S., AgarSwal,S., Narayana,K., Thakur,A.K. and Rao,S.S.2008. Sustainable intercrops for coconut under Bastar region of Chhattisgarh, *S.G. College of Agricultural and Research Station*, Kumhrawand, Jagdalpur (C.G).

Wang,J.C., Wu,Y., Wang,Q., Peng,Y.L., Pan,K.W., Luo,P,and Wu,N.2009. Allelopathic effects of *Jatropha curcas* on marigold (*Tagetes erecta* L.). *Allelopathy Journal* 24(1): 123-130.

Willey, R.W. and Roberts, E.M. 1976. Mixed cropping (In) Solar energy in Agriculture. *Joint International Solar Energy Society Conference (Proceed) quoted by.*

Willey, R.W. 1979. Intercropping – its, importance and research needs. Part-I Competition and yield advantages. *Field Crop Abstract* 32: 1-10.

Willey, R. W., Natarajan, M., Reddy, M. S. and Rao, M. R., 1986, Cropping systems with groundnut, resource use and productivity – *In agrometeorology of groundnuts. Proceedings of an International Symposium*, ICRISAT, Sahelian Centre, Patancheru, Andhra Pradesh, India.pp.21-26.

Woolfe, J. A. 1992. Sweet potato, An Untapped Food Resource. *Cambridge University Press*, UK

Wu, Y. V. and Bagby, M. O. 1987. Recovery of protein-rich by products from sweet potato stillage following alcohol distillation. *Journal of Agricultural and Food Chemistry* 35: 321–325.

Yoku,A., Hill,S.B. and Chiasson, H. 1992. Effects of inter cropping sweet potato on the population density of sweet potato Weevil *Cylas Formicarius* (F.). *Science in New Guinea* 18(3): 123-124.

Appendices

Appendix: I Cost of cultivation (fixed + variable) in different treatment combination of Sp in Rs.

Input factor	Rate (in Rs)	T1, T4, T5, T6, T7, T10 & T11		T8 & T9	
		Input	Total	Input	Total
Land preparation					
a. Ploughing (MB)	2000 / ha	1	2000	1	2000
b. Harrowing	500 /ha	2	1000	2	1000
c. Ridge & furrow formation	500 /ha	1	500	1	500
Labour cost	120 / man day	154	18480	132	15840
Cost of inputs					
a.Vine cutting cost		1	1500	1	750
b. FYM	300 /t	25	7500	25	7500
c. Urea	6 /kg	163	978	81.5	489
d. SSP	5.2 /kg	312.5	1625	156.153	812
e. MOP	12 /kg	125	1500	62.5	750
f. Irrigation	200 / irrigation	12	2400	12	2400
Intrest on working capital	12% intrest /annum		4528		3755
Rental value of land			3600		3600
Depreciation			150		150
Land revenu			15		15
transportation			777		777
Miscellaneous			1000		1900
Grand Total			**47,553**		**42,151**

Appendix: II Cost of cultivation (fixed + variable) in different treatment combination of Marigold in Rs.

		T2, T3		T5, T7		T4, T6, T10, T11		T8,T9	
Input factor	Rate	Input	Total	Input	Total	Input	Total	Input	Total
Land preparation									
a. Ploughing (M-B)	2000/ ha	1	2000						
b. Harrowing	500/ ha	2	1000						
c. Marking	250/ha	1	250						
Labour cost	120/man day	84	10080	70	8400	40	4800	24	2880
Cost of inputs									
a. seedling cost	7.5/100 seed lings	16666	12500	16666	12500	83333	6250	41666	3125
b. FYM	300/t	25	7500						
c. Urea	6/kg	173.91	1043	173.91	1043	87	521	43.5	260
d. SSP	5.2/kg	250	1300	250	1300	125	650	62.5	325
e. MOP	12/kg	66.66	800	66.66	800	33.333	400	16.665	200
Irrigation	200/irr	12	2400						
Intrest on working capital			4665		2885		1515		815
Rental value of land			3600						
Depreciation			150						
Land revenu			15						
Transport			2066		1141		818		571
Miscellaneous			1500		1000		500		500
Grand total			50,809		29,069		15,454		8,676

Appendix: III Treatment wise total cost of cultivation (Sweet potato + Marigold) in Rs.

Tr.No	Treatment	Cost of cultivation for Sp Rs.	Cost of cultivation for Inter crop Rs.	Total cost of cultivation Rs.
T1	Sole crop sweet potato	47553	-	47553
T2	Sole crop marigold (African type)	-	50809	50809
T3	Sole crop marigold (French type)	-	50809	50809
T4	Sweet potato + Marigold (African type) 1:1 Row ratio	47553	15454	63007
T5	Sweet potato + Marigold (African type) 1:2 Row ratio	47553	29069	76622
T6	Sweet potato + Marigold (French type) 1:1 Row ratio	47553	15454	63007
T7	Sweet potato + Marigold (French type) 1:2 Row ratio	47553	29069	76622
T8	Sweet potato + Marigold (African type) alternate planting on ridge(20 cm spacing)	42151	8676	50827
T9	Sweet potato + Marigold (French type) alternate planting on ridge (20 cm spacing)	42151	8676	50827
T10	Sweet potato + Marigold (African type) alternate planting on ridge (10 cm spacing)	47553	15454	63007
T11	Sweet potato +Marigold (French type) alternate planting on ridge (10cm spacing)	47553	15454	63007