

Intercropping of vegetables in banana (*Musa* spp.)

*A Thesis submitted to the
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in Partial fulfillment of the Requirement for the degree of
Master of Sciences in Agriculture
(Vegetable Science)*

By

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CERTIFICATE-I

This is to certify that the thesis entitled “**Intercropping of vegetables in banana (*Musa spp.*)**” submitted in partial fulfillment of the requirements for the award of the degree of **MASTERS OF SCIENCE IN AGRICULTURE (VEGETABLE SCIENCE)** to the Orissa University of Agriculture and Technology is a faithful record of *bona fide* and original research work carried out by **Kishor Chandra Naik** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

It is further certified that the assistance and help received by him from various sources during the course of investigation has been duly acknowledged.

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CERTIFICATE-II

This is to certify that the thesis entitled “**Intercropping of vegetables in banana (*Musa spp.*)**” submitted by **Kishor Chandra Naik** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE IN AGRICULTURE (VEGETABLE SCIENCE)** has been approved by the students’ advisory committee and external examiner.

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ABSTRACT

The present investigation entitled, “**Intercropping of vegetables in banana (Musa Spp.)**” was carried out during 2014-15 at All India coordinated Research Project on Fruits in Horticulture Research Station, OUAT, Bhubaneswar, Odisha.

Among all the desert types of banana crop variety Champa is most popular in Odisha among the people and is commercially cultivated in most of the districts. During commercial cultivation the crop is grown alone and the interspaces remain unutilised during the crop growth period. So, an attempt has been taken in the present study to utilise the interspaces in newly cultivated banana plantation by growing some partial shade loving vegetable and spice crops. There are seven treatment i.e; T1-Banana+Colocasia, T2-Banana+Elephant foot yam, T3-Banana+Arrow root, T4-Banana+Ginger, T5-Banana+Mango Ginger, T6-Banana+Turmeric, T7-Control (No Intercropping).

Sword Suckers of uniform size were planted at a spacing of 2m X 2m and intercrops were planted inside banana maintaining spacing as per crops yield and yield attributing characters and performance of the intercrops were recorded during the course of investigation. From the experiment it was found that banana alone gave an yield of 29.63 t/ha. Where as arrow root intercropped with banana gave the highest yield of 16.4 t/ha and banana 28.88t/ha and followed by elephant foot yam 13.5 t/ha and banana 29.75t/ha but the minimum yield was with ginger where a yield of 6.2 t/ha and banana 28.56 was obtained. Banana & Arrow Root intercropping yielded gross return of Rs.843200/ with a net profit of Rs. 3,98,750/- as compared to gross return of Rs.810900/ and net profit of Rs. 3,66,450/- with banana + turmeric and a gross return of Rs.4,44,450 and net profit of Rs. 1,95,750/- in control. Maximum B:C ratio of 2.38 was obtained in Banana + Arrow Root intercropping as compared to 2.29 with Banana+Turmeric & minimum in control i.e; 1.78.

So, from the above findings it can be concluded that banana cultivation can be commercially followed with Banana + Arrow Root intercropping Profitably without decreasing the returns from banana cultivation alone. However, the intercrops may give different result under varied edaphic and agroclimatic conditions.

ABBREVIATIONS USED

AICRP	- All India Coordinated Research Project
OUAT	- Orissa University OF Agriculture & Technology
NHM	- National Horticulture Mission
Kg	- Kilogram
g	- Gram
SEM	- Standard Error of Mean
CD	- Critical Difference
INM	- Integrated Nutrient Management
MT	- Million Tonnes
t	- Tonne
cm	- Centimetre
m	- Metre
ha	- Hectare
BCR	- Benefit Cost Ratio
%	- Percent
Mm	- Millimetre
°C	- Degree Celcius

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INTRODUCTION

Sustainable agriculture seeks at least principles to use nature as the model for designing agriculture system. Since we are modelling nature understanding of the principles by which nature functions and utilisation of the principles to reduce cost and increase profitability and at the same time sustaining our ecology and land resources are quite important for modern agriculture. There is far more cooperation in nature than competition while growing intercrops.

Intercropping offers farmers the opportunity to engage nature's principle of diversity on their farms. Plant spatial arrangements, planting rates, spacing, crop growth & their growth behaviour act as an insurance against failure of crops under adverse condition gives additional income, reduce soil run off, utilize resources efficiently and maintain the soil fertility and nutrient uptake from different layer of soils depending upon the root growth of different crops. Intercropping in scientific way should be viewed from a theme of competition to one of collaboration with mutually beneficial relation with proper planning to get more return from limited natural resources.

Indian Agriculture past strategies to increase food grain production to produce more in shortest period, however have resulted in massive exploitation of natural resources contributing to unsustainable growth creating a situation to use of land and other resource in a more judicious and planned way to make agriculture income more lucrative and by that to increase the living standard and income of the framers for which planned intercropping in fruit orchard is the right management for proper utilization of soil, water and light for crop production.

Banana which is referred as kalpataru (plant of virtues) and kalpa vriksha produce the wonder berry forming staple food for millions across the globe providing balance diet, a rich source of carbohydrates nearly free of fat having many therapeutic values and a way of livelihood of many farmers in India and Odisha is closely associated with the cultural heritage, culture and considered to be a symbol of prosperity and fertility in Indian mythology. Owing to it' socio economic importance, short duration, demand, palatability, profitability and good return the crop it is commercially grown in India covering an area of 802.6 ('000ha) with a production of

29724.6 ('000 MT) with a productivity of 37.0 MT/ha (Indian Horticulture Database-2014) After implementation of NHM in Odisha there is a growing demand for commercial cultivation of this crop .

In India, Banana is known for its antiquity from Ramayan (2020 BC), Kautilya's Arthasastra (300-400 BC) and it's presence in painting & sculptures of Ajanta & Ellora caves (600 BC). India has been growing bananas from vedic times and mention of dwarf stature bananas and a banana with reddish sap has been quoted in Tamil Literature dating back to 120 BC.

Banana is a perennial herbaceous fruit crop which gives a good return even in poor condition and contributes to livelihood, nutritional and economic security to many farmers of Odisha.

Most of the farmers in Odisha under NHM are cultivating banana in more scientific manner with tissue culture plants under proper INM and water management practices. In Odisha, Champa (AAB) is a popular variety liked by the people for consumption and also cultivated by farmers for it's hardy nature and good rattoning ability. The inter spaces (2mx2m) remain idle for the initial 4-5 months of crop growth and the interspaces can be very well utilized by growing some vegetable crops which do well under partial shade condition. Keeping the above facts in view it was though worth while to utilize interspaces in newly planted banana by growing some vegetable crops like Colocasia (*Colocasia esculenta*), Elephant Foot Yam (*Amorphophallus campanulatus*), Arrowroot (*Maranta arundinaceae*), Ginger (*Zingiber officinale*), Mango ginger (*Curcuma amada*) and Turmeric (*Curcuma longa*). These intercrops are mostly partial shade loving . Following the normal cultural package of practices both for intercrop and banana the experiment was conducted with the following objectives.

- 1) To study the growth of main crop and intercrops.
- 1) To study the yield of banana and intercrops.
- 2) To study the plant stand and performance of intercrops.
- 3) To evaluate the economics of the intercrops along with banana.



REVIEW OF LITERATURE

The present investigation entitled “Intercropping of Vegetables in Banana (*Musa spp.*)” is supported by a brief account of previous research findings in the form of review on the following heads. There are several research work conducted by different scientific workers. This chapter mainly provides good guidelines to carry out research work. So, in this chapter the resources and authors have been fully acknowledged pertaining to the aspects investigated in the present study.

Intercropping system

Nair *et al.* (1974) studied on basic resource of crop production namely soil and solar energy were not being utilized to the maximum extent possible in pure stand crop of coconut. Except during period between 8-20 years of age coconut plantation, interspaces received filtered sunlight varying amount, which might be adequate energy to raise various crops.

A five year field experiment by Swaminathan (1999) conducted at Pudukkottai, Tamil Nadu to get information that will facilitate the scientific development of tree mixtures in an agro forestry system with 2 fruit trees *viz.* mango and cashew and four tropical nitrogen fixing trees. Growth in cashew was enhanced by 25% when inter-planted with *Casuarina* and plant girth (10.8cm) was maximum when inter-planted with *Leucaena*

Venugopal & Sheela (2009) reported that productivity and income was enhanced in banana variety Nendran by modifying the planting pattern and adopting intercropping. Individual bunch weight didn't register any variation with planting pattern. However, maximum yield per hectare was registered in modified system of planting. Combination of modified planting system of cucumber and amaranthus has the highest net profit and BCR.

Ouma (2009) that intercropping is a very beneficial cropping system in East Africa because of its reducing poverty and increasing food security and reducing poverty and increasing soil fertility. It is increasingly becoming important in east

Africa where land scarcity is increasing. Banana is a very important crop in east Africa but due to the fact that small scale farmers also require food security. It should be intercropped with many of the annual crops being grown by farmers to achieve this.

Root and tuber crops as intercrop

Studies on intercropping of 'Basrai' banana by Chhundawat *et al.* (1984) revealed that when banana grown alone or intercropped with *Curcuma longa*, *C.amada* or *Dioscorea alata*, gave average yields of 55195, 54293, 50202 and 49079 kg banana fruits ha⁻¹ and the yields of the 3 intercrops were 5543, 1915 and 1390 kg ha⁻¹, respectively. Only *C. longa* was recommended to be grown as an intercrop with 'Basrai' banana.

Since coconuts occupy 40% of the cultivated land and do not start cropping until 5 to 7 years after planting, returns from the land are low. In trials carried out between 1978 and 1987, coconuts were intercropped with 5 crops with monoculture as the control. The total net incomes (intercrop + coconut) over the years were: coconut alone, Rs. 5,000, coconut with cocoyam (*Dioscorea*), Rs.7,104.00 with Elephant Foot Yam (*Amorphophallus campanulatus*), Rs. 10,704.00 with tapioca (*Manihot esculenta*), Rs.6,570.00 with turmeric (*Curcuam longa*), Rs.6,710.00 and with Ginger (*Zingiber officinale*), Rs.9,950.00 as reported by Singh *et al.* (1988)

Nayar and Suja (1996) conducted a field experiment for three consecutive seasons (1990-93) at Central Tuber Crop Research Institute, Trivandrum, India to study the effect of intercropping of four genotypes of *Dioscorea* (Sree Keerthi, Sree Priya, Sree Dhanya and Sree Latha) with banana cv. 'Nendran'. There was no perceptible deleterious effect on growth and productivity of banana due to intercropping with different genotypes of *dioscorea*. Intercropping banana with SreeKeerthi and SreePriya was very profitable in comparison to farmers practice of sole cropping of banana.

Sharma *et al.* (1996) conducted a trial in a 30 years old coconut stand which were spaced at 7.5×7.5m under rainfed conditions. They reported that among colocasia, ginger, turmeric as intercrops, ginger gave the highest value of crop (Rs.52,000 ha⁻¹), but the low cost of cultivation of colocasia made it most profitable

Jata *et al.* (2009) conducted a study on intercropping of elephant foot yam in orchard crops & they reported that elephant foot yam can be planted between the interspaces of fruit or orchard crops with a recommended spacing of 90cm X 90cm. Depending upon the canopy size of fruit & orchard crops, 5000-9000 plants of elephant foot yam per hectare can be accommodated & elephant foot yam is not competing for light as because this crop is able to tolerate shade.

Girija Devi *et al.* (2011) in their study on performance studies of various crops in coconut based cropping system compared to sole cropping reported that Nendran banana, Elephant Foot Yam, Ginger can be grown as suitable intercrops in coconut garden in different combinations . All these crops produced significantly at par yields with their sole crops in coconut garden and by adjusting the plant population of intercrops remuneration from the coconut garden can be increased sufficiently.

Sit and Roybarman (2012) conducted a study on performance of different turmeric cultivars under coconut plantation for sub Himalayan Teria regions of west Bengal and reported that cultivar like Suguna, Suraniana and Suvarna performed well in coconut plantation in terms of yield and they produced 17.1, 16.0 and 15.9 t fresh turmeric in one hectare of coconut plantation, respectively. More yield of leaf number, leaf length, Number of secondary fingers, Length, width and weight of primary and secondary finger and clump weight.

Krishnakumar *et al.* (2013) in their study on Integrated Nutrient Management for Elephant Foot Yam intercropped in coconut gardens concluded that Elephant Foot Yam (var. Gajendra) can be successfully intercropped in coconut gardens with the application of 50% recommended dose of NPK fertilizers along with biofertilizers (Azospirillum and Phosphobacteria) @ 5kg per hectare and vermicompost @ 1kg per plant.

Swadija *et al.* (2013) in their study on growth and yield of arrowroot intercropped in coconut garden as influenced by organic management indicated that arrowroot can be profitably intercropped in coconut gardens.

Netsere *et al.* (2015) in their investigation on intercropping of *Arabica* coffee with turmeric (*Curcuma longa*) and ginger (*Zingiber officinale*) at Tepi, south west Ethiopia reveal that coffee intercropped with turmeric and ginger was found to be agronomically and economical beneficial in the south west Ethiopia. Therefore, depending upon the suitability of area and priority of farmers coffee intercropped with turmeric and ginger can be practised as an important remedy to increase crop production and economic returns and coffee can be grown with turmeric and ginger without significant yield reduction.

Vegetable as intercrop

Dzalagonija (1964) reported that intercropping of vegetables (cucurbits and legumes), green manure crops and perennial grasses increased citrus productivity as compared to the monocropping.

Singh (1968) suggested that cowpea, cucurbits, spinach, okra, cabbage, beetroot, onion, carrot and cauliflower crop combination of intercrops with mango are beneficial.

During the pre bearing age of papaya, short duration vegetables like cabbage, cauliflower, onion, chillies, radish, tomato etc. could be grown as intercrops which not only kept the soil free from weeds but also added to the income of the growers (Singh and Dahiya,1982).

An experiment conducted by Avilan *et al.* (1983) with Avocado, which was intercropped with cocoyam, papaya and cowpeas. The best result was observed in terms of yield, land and labour utilization efficiency when coco yam was used as intercrop.

Rao and Edmunds (1984) studied the intercropping of banana with cowpea, maize and sweetpotato. They found that all the intercropping treatments significantly reduced the pseudostem girth of banana at 5month after planting and increased the number of days to shooting and harvesting.

In papaya, vegetables like tomato, beans, chillies, etc. could be grown when the plants were young during the first year of planting. Growing of intercrops not only

utilized the vacant space between the plants optimally but also checked the growth of weeds (Subrahmanyam, 1987).

Bhuva *et al.* (1988) studied the effect of intercropping on the main crop of mango and the economics on mango cv. Rajapuri, planted at 6m×6m and interplanted with (a) banana. (b) cassava (c) tomato followed by cluster bean (d) brinjal followed by cowpea. They opined that mango grown with tomato and cluster bean as intercrops gave greatest financial return per hectare with benefit-cost ratio of 1.22.

Radha *et al.* (1991) reported the effect of intercropping in pineapple cv. Kew was grown at a spacing of 30cm×60cm×180cm and intercropped with ginger, turmeric, cowpea, *Colocasia sp.*, and at spacing of 30cm×60cm×90cm as monocrop. It was observed that yield was significantly higher when pineapple was raised as monocrop at higher density, than when intercropped with other crops at lower density.

The effect of different variety of peas as intercrops on growth and yield of ber in semi-arid region was studied by Singh and Nath (1995). They obtained higher fruit yield (16.84 kg tree⁻¹) with intercrops than without intercrops (5.10 kg tree⁻¹). Arkel variety of pea produced maximum yield (52.6 q ha⁻¹) as compared to other variety.

Singh *et al.* (1996) studied the effect of intercrops on growth and economic yield of mango cv. Langra. They used intercrops (i) chilli as annual crop (ii) chilli followed by soybean (iii) okra-gram-okra. It was observed that okra-gram-okra combination gave significantly higher yield than other treatments and net income was obtained considerably higher with the same treatment.

Sharma (1999) studied the effect of intercropping on yield and economic viability of a 6 year old mango orchard (cv. Langra) and reported that intercropping with (1) okra in kharif, gram in rabi and then okra in summer, (2) soybean in kharif and chilli in rabi induced high levels of fruit drop of mango than on mango grown alone, but the intercrop gave additional monetary returns and enhanced the profits.

Pandey *et al.* (2004) tried various intercrops in five year old mango orchard 'Amrapalli' and 'Mallika'. During rainy season of the year 2003, 25.75 q per ha cluster beans, 45.24 q per ha okra and 81.9 q per ha cowpea could be harvested with

additional bio-mass yield of 161, 142.6, 193, 55.83, 84.54 and 337.3 q per ha respectively'

The comparative performance of different kharif vegetables viz. Tomato, French Bean, Cowpea, Brinjal, Okra and green maize with papaya as filler crop was studied by Jain and Raut (2004) in young mango orchard (5-8years) over two monsoon seasons of 2001 and 2002 at farmer's field of village Tihari (M.P). The economics of the intercropping systems- revealed that the gross monetary returns of Rs. 62,760 with net return of Rs. 29, 320 per ha were found the highest when tomato was intercropped in mango orchard with filler crop papaya. The cost benefit analysis of different intercrops resulted with the best cost benefit with tomato (2.60) followed by cowpea(1.90)

The result of an intercropping trial conducted by Swain and Patro (2006) in guava orchard showed that cowpea as intercrop recorded significantly higher plant growth in respect of tree height, girth, canopy area, shoot growth and number of leaves/shoot of guava in the watershed area.

An intercropping experiment in a seven years old bearing mango orchard with filler crop guava revealed that the maximum increase in plant height, girth and canopy area of mango and guava was recorded with cowpea followed by french bean intercropping as compared to plants without intercropping (Swain and Patro, 2007)

Pulses as intercrop

Intercropping of legumes (moong, urd, soybean, groundnut and cowpea) in 'Basrai Dwarf' banana was studied in detail by Baghel *et al.* (1986). They observed that intercrops gave additional seed/pod yield and increased the net return. They concluded that urd (*Vigna mungo*) was the most effective intercrop for 'Basrai Dwarf' banana.

Potentiality of growing cowpea (cv. California Blackeye-5) as an intercrop with one year old grape fruit orchard was studied in South Florida by Stofella *et al.* (1986). It was found that the total yield of fresh marketable pods was 1854 kg ha⁻¹. The result suggested that cowpea could provide a cash crop for growers with newly established citrus (grape fruit) groves.

Rao and Reid (1987) studied plantain based cropping system and reported that the most profitable association was cowpea.

Nybe *et al.* (1991) studied weed management in banana cv. Nendran with cowpea as an intercrop. Chemical methods of weed control were compared with intercropping with cowpeas cv. Kanakamani had hand weeding for the control of weeds in bananas. They concluded that intercropping with cowpea was the most effective and economic method of weed control in bananas.

An intercropping system (cashew orchard with vegetables, pulses and oil seed under rainfed conditions) was studied by Gupta (1999) under long term evaluation at Jagdalpur to determine the most suitable intercrop for obtaining maximum returns per unit area in the Bastar plateau zone. Cowpeas, bush-type-french beans, cluster beans, rice beans, urd beans, moong beans, soya beans and ground nuts were grown in a three year old cashew orchard. Gross and net return per hectare worked out for different models for the year 1993-94 and 1994-95 showed that all the intercrops recorded higher net return than the sole crop of cashew.

Fruit crop as intercrop

Anil Kumar and Pillai (1989) studied the economics of coconut based intercropping system, where mature coconut plantation was intercropped with coconut seedlings, cassava, cowpeas, pineapple or bananas. They found that although intercropping was profitable in all cases, the highest net returns were obtained when interspaces in the coconut plantation were used for raising quality coconut seedlings of the cultivars West Coast Tall and Komadan.

Economics of intercropping-

According to Leela Bhaskaran (1978) growing groundnut as rainfed intercrop in coconut stand registered a net additional income of Rs. 2,772 per ha, he realized through the sale of intercrop produced and savings in expenses effected by skipping certain cultural operations and inputs to the main crop. The cost benefit-ratio worked out to be 1:1.6. The cropping system also generated additional employment for about 20 men and 85 women. Groundnut could thus be considered as a compatible intercrop in coconut stands.

Since coconut occupy 40% of the cultivated land and do not start cropping until 5 to 7 years after planting, returns from the land are low. In trials carried out between 1978 and 1987, coconuts were intercropped with 5 crops, with monoculture as the control. The total net incomes (intercrop + coconut) over the years were: coconut alone, Rs.5,000; coconut with cocoyam (*Dioscorea*), Rs.7,104.00 with elephant foot yam (*Amorphophallus campanulatus*) Rs.10,704.00 with tapioca (*Manihot esculenta*), Rs.6,750.00 with turmeric (*curcuma longa*), Rs.6,710.00 and with ginger (*Zingiber officinale*) Rs.9,995.00 as reported by Singh *et al.* (1988).

The effect of different variety of peas as intercrops on growth and yield of ber in semi-arid region was studied by Singh and Nath (1995). They obtained higher fruit yield (16.84 kg tree⁻¹) with intercrops than without intercrops (5.10 kg tree⁻¹). Arkel variety of pea produced maximum yield (52.6 q ha⁻¹) as compared to other variety.

Sairam *et al.* (1997) estimated variable capital requirement and economics of coconut based cropping system under rainfed and irrigated condition. Various intercrops like elephant foot yam, ginger and turmeric taken under rainfed condition while banana taken under irrigated condition. A gross return of `100500 ha⁻¹ for the coconut and ginger system, whereas for the coconut monoculture it was only Rs.31,500 . Gross return from the banana and coconut system was Rs.69,000 profit from the bananas alone accounting for Rs.13,000. So it is concluded that it is more profitable to adopt coconut based cropping system.

The result of the two years of investigation carried out by Ghosh (2001) indicated that in terms of total returns, guava + groundnut combination proved the best. However, the net profit per hectare was maximum under guava + ridge gourd followed by guava + groundnut combination.

Pulse crops, i.e., pigeon pea and black gram, could be profitably grown as intercrops in fruit orchards during the pre-bearing stage (Mishra and Swain, 2001).

Singh *et al.* (2001) carried out an experiment to study the suitability and profitability aspects of intercrops in young mango orchard cv. Langra. They reported that among the different vegetable intercrop combinations, the bottle gourd-radish combination increased the mango yield followed by okra finger-carrot and chilli-

onion compared to control. The maximum net income of Rs.88, 757.32 ha⁻¹ was obtained from the bottle gourd-radish followed by sponge gourd tomato (Rs.86, 397.62 ha⁻¹) combination.

The comparative performance of different kharif vegetables viz. tomato, french bean, cowpea, brinjal, okra and green maize with papaya as filler crop was studied by Jain and Raut (2004) in young mango orchard (5-8 years old) over two monsoon seasons of 2001 and 2002. The economics of the intercropping systems revealed that the gross monetary returns of Rs.62,760 with net return of Rs.29, 320 ha⁻¹ were found the highest when tomato was intercropped in mango orchard with papaya as filler crop. The cost benefit analysis of different intercrops resulted with best cost-benefit ratio with tomato (2.60) followed by cowpea (1.90).

Lenka *et al.* (2005) studied on feasibility and profitability of intercropping with groundnut, cowpea, turmeric and pineapple in cashew plantation. The results revealed that these were grown successfully as intercrops in 9-10 year old cashew orchard of without affecting the yield of main crop cashew. The net profit ranging from Rs.5,060 ha⁻¹ in cashew + groundnut crop combination to Rs.3,0150 ha⁻¹ in cashew + turmeric crop combination could be obtained. In view of the low investment and better profitability as well as maintaining the soil fertility, cowpea intercropping in cashew orchard recorded highest cost benefit ratio (1:4.84).

Pattanaik *et al.* (2007) studied the economics of intercrops in cashew plantation with vegetable crops and found that the yield of main crop varied from 60.1 to 8.70 q ha⁻¹ under various crop combinations. Highest returns of Rs.19,350 ha⁻¹ was obtained from colocasia and lowest recorded in cowpea. Net highest return of Rs.44,908 ha⁻¹ was obtained when cashew was intercropped with colocasia, followed by brinjal. Minimum net return of Rs.21,350 ha⁻¹ was obtained from the sole crop, cashew var. Vengurla 4.

Yadukumar (2007) evaluated different annuals, biennials and perennials and inter and mixed crops with an objective to utilize interspaces and to check soil erosion during initial stages of cashew. Soil erosion could be checked using cover crop. Sustained additional income can be obtained by growing intercrops.

On farm experiment was conducted at multi location testing site, by Nazrul (2007) for consecutive two years by taking four intercropping combination viz. banana (sole), banana + okra, banana + sweet gourd and banana + bitter gourd were considered as treatment variables. The result showed that the highest Banana equivalent yield advantage (20%) than sole banana recorded from the intercropping combination of Banana + Sweet gourd. This intercropping system also showed the highest benefit cost ratio (2.41) and therefore, it might be more economically viable than sole banana.

Pattnaik *et al.* (2007) studied on economics of intercrops in cashew plantation with vegetables crops and found that yields of main crop varied from 60.1 to 87.0 q per ha under various intercrops. Highest return of Rs 19,350 per ha was obtained from colocasia and lowest recorded in cowpea. Net highest return of Rs 44,908 per ha was obtained when cashew was intercropped with colocasia, followed by brinjal. Minimum net return of Rs 21,350 per ha was obtained from the sole crop, cashew, var. Venglura

Hipparagi and Chinnappa (2008) revealed that soyabean and red gram could be raised successfully in the interspaces of banana garden without affecting the main crop. Soyabean and red gram were proved to be ideal intercrops in banana garden providing net income of Rs.8,148.20 and Rs. 6,160.95 at 50% NPK level.

Ghosh and Hore (2011) in their study on economics of a coconut –based intercropping system as influenced by spacing and seed rhizome size of ginger reported that the maximum net return (Rs. 78,421/-) was realised from closest spacing with smaller seed rhizome in 20 X 15 cm spacing may be recommended for ginger as intercrop in coconut plantation for maximizing the yield.

Asten *et al.* (2011) studied on profitability of intercropped coffee-banana systems in region growing Arabica (Mt. Elgon) and Robusta (south and west) coffee in Uganda. They reported that coffee-banana intercropping is much more beneficial than banana or coffee monocropping.

Singh *et al.* (2012) reported that if mandarin is intercropped with soyabean in kharif and coriander in rabi after harvesting soyabean during October-November, the

main crop mandarin during March-April, there may be income for almost six month as against 1-3 month under either option of sole cropping.

Mahant *et al.* (2012) conducted a field experiment on intercropping studies in banana where he reveals that banana with onion was most profitable system under drip irrigation. Which recorded higher banana equivalent yield, land equivalent ratio and net realization while, benefit cost ratio was maximum under banana with garlic.

Nayak *et al.* (2014) in their study on economics and yield performance of some short duration fruit and medicinal crops under agrisilvicultural system in rainfed uplands of Odisha reported that *Acacia magium* with pineapple based agrisilvicultural system recorded the highest gross return, net return and BCR as compared to other agrisilvicultural systems and sole crops.

Ray *et al.* (2007) studied different vegetables and flowering crops in pre-bearing areca nut garden. They reported that vegetable crops like radish, cabbage, cauliflower and brinjal performed well and resulted in higher net return per rupee invested during winter season and among flowering crops, marigold and chrysanthemum performed well and resulted in higher B:C ratio (2.05 to 2.43) compared to gladiolus.

Drip irrigation

Mohanty *et al.* (2006) studied the intercropping of banana with two crops : turmeric and cowpea. The study indicated that the growth and yield of banana are not affected by the intercrops. The irrigated water use efficiency was highest in unirrigated intercrop treatments, additional incomes from turmeric was about Rs.23,700/- ha⁻¹year⁻¹ which means that investment in drip recovered back within two years by intercrop alone.

In case of banana better plant growth, early flowering, more number of fingers and enhancement in the yield were recorded under drip irrigation with plastic mulch (Paul and Mishra, 2008).

Mahanta *et al.* (2012) was conducted a field experiment on intercropping studies in banana where they revealed that banana with onion was most profitable

system under drip irrigation. Which recorded higher banana equivalent yield, land equivalent ratio and net realization while, benefit cost ratio was maximum under banana with garlic.

Mulching

Singh and Kumar *et al.* (1999) had carried out a field experiment at Central Horticulture Experiment Station Ranchi on banana cv. Dwarf Cavendish mulched with grass cuttings or not mulched. Mulching increases the fruit yield in banana.

Paul *et al.* (2008) studied the effect of drip irrigation with plastic mulch on plant growth, flowering, fingers, and yield of banana. According to them better plant growth, early flowering, more number of fingers and enhancement in yield obtained under drip with plastic mulch. Mulch alone could increase the yield by 7% even in absence of drip.

Dorel *et al.* (2010) studied the effect of no-till banana planting on crop residue mulch. The result indicated that the banana growth was better with crop residue mulch left on soil surface with no tillage treatment.

Solia *et al.* (2010) conducted an experiment in South Gujrat to find out agro techniques for enhancing the productivity of banana. The studies involved drip irrigation, fertigation, mulching and intercropping. The result of the experiment indicated that there is an increase in banana yield due to either black plastic mulch or sugarcane trash mulch @ 5t ha⁻¹ which was more pronounced in narrow spacing (1.5×1.5m) than wider spacing.



MATERIALS AND METHODS

The present investigation entitled “INTERCROPPING OF VEGETABLES IN BANANA (*Musa spp.*)” was carried out at All India Coordinated Research Project on Banana located at the Horticultural Research Station, Orissa University of Agriculture and Technology during the year 2014-2015.

Location of experimental site

The Horticultural Research Station (HRS) of Orissa University of Agriculture and Technology is situated about 7 km away from the university and located at the latitude of 20°15'N and longitude of 85°52'E. It is about 62km away from Bay of Bengal and has an altitude of 25.5 m above mean sea level.

Cropping History of Experimental Site

2012-13	Fallow
2013-14	Fallow
2014-15	Banana+Intercrops

Soil

The composite soil Sample 0-15cm depth was collected from the experimental plot prior to planting and physical and chemical analysis was done which is presented in the table-1

Table-1 Soil characteristics of the experimental field

Sl. No.	Constituents	Standards in % on air dry basis
1	Texture	Sandy clay loam
2	Sand	79.6
3	Silt (%)	8.8
4	Clay (%)	11.8
5	Soil (pH)	5.6
6	Bulk density	1.52
7	Organic Carbon	6.0 g/Kg
8	Available Nitrogen (Kg/ha)	218.2 Kg/ha
9	Available Phosphorous (Kg/ha)	46.2 Kg/ha
10	Available Potassium (Kg/ha)	7.2 Kg/ha

Meteorological observation

Climate

The Experimental site is characterised by warm and moist climate with hot and humid summer and mild winter. The weather data recorded during the period of experiment is presented in table-2

From the weather data it is observed that the maximum and minimum temperature were 33.2⁰c and 21.4⁰c respectively. Average maximum and minimum humidity during cropping period was 90.9 at morning (7.00 am) and 52.03 at afternoon (2.00 pm). The total rainfall received during the cropping season and the numbers of rainy days were 309.7 mm and 95 days, respectively. Average evaporation was 6.6 mm/day during the season.

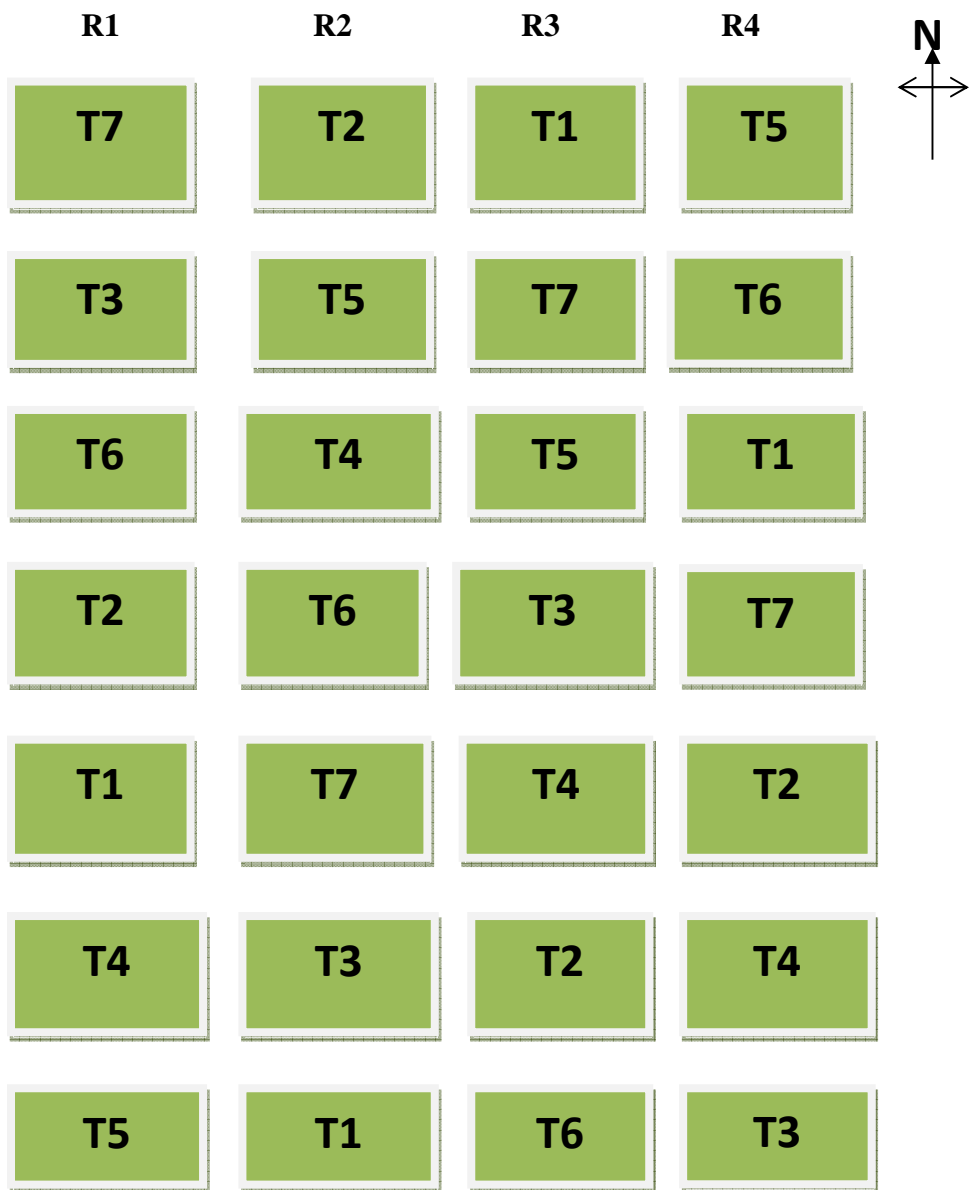
Table-2 Weather data of Bhubaneswar from June 2014 to May 2015

Month	Rainfall (mm) Mean	No. of Rainy Days	Temperature (°C) Mean		RH (%) Mean		Evaporation (mm/day)
			Max	Min	Morning	Evening	
June 2014	14.8	10	36.6	26.3	87	61	6.0
July 2014	18.6	22	31.4	24.7	94	82	2.8
August 2014	13.8	20	33.08	24.76	93.91	78.52	3.2
September 2014	19.1	20	31.61	24.26	95.14	76.67	2.9
October 2014	16.3	10	31.7	22.0	93.3	63.8	3.3
November 2014	0	0	30.9	17.5	89.7	42.7	3.5
December 2014	0	0	27.7	13.9	88	45	3.5
January 2015	10.7	2	27.8	14.2	91	43	3.6
February 2015	18.4	1	32.5	17.0	94	39	4.3
March 2015	8.2	3	35.8	21.5	91	40	5.7
April 2015	9.4	1	39.8	24.4	88	40	7.1
May 2015	33.7	6	39.23	25.72	87.07	48.75	7.44
Total	309.7	95	398.12	256.24	1091.31	624.44	79.44
Mean	25.8	7.9	33.2	21.4	90.9	52.03	6.6

Experimental details

The experiment was laid out with Randomized Block Design with 7 treatments and 4 replications using Fishers random Table. The main crop banana Champa variety was planted at 2mX2m distance.

LAYOUT PLAN OF EXPERIMENT PLOT



Treatments

T1- Banana + Colocasia

T2- Banana+ Elephant foot yam

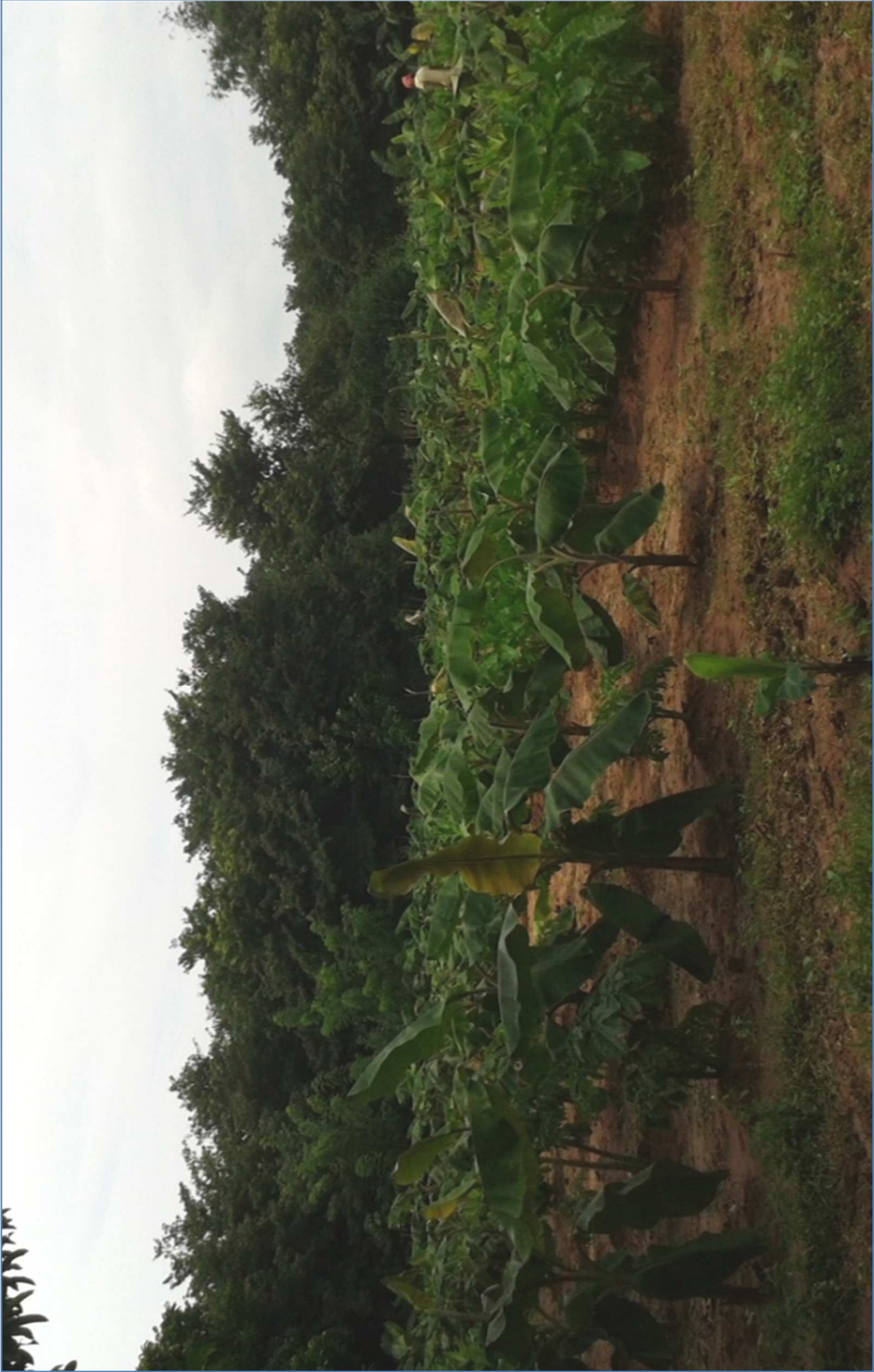
T3- Banana + Arrow root

T4- Banana + Ginger

T5- Banana + Mango ginger

T6- Banana + Turmeric

T7- Control



A general view of the experimental plot

Source of planting material-

1. Banana- AICRP on Banana, OUAT
2. Colocasia- CTCRI, Bhubaneswar
3. Elephant Foot Yam- CTCRI, Bhubaneswar
4. Arrow root- CTCRI, Bhubaneswar
5. Ginger- High Altitude Research Station, Pottangi, OUAT
6. Mango Ginger- High Altitude Research Station, Pottangi, OUAT
7. Turmeric- High Altitude Research Station, Pottangi, OUAT

Spacing of different crops during experiment-

1. Colocasia- 60 cm x 20 cm
2. Elephant Foot Yam- 75 cm x 75 cm
3. Arrow root- 60 cm x 30 cm
4. Ginger- 20 cm x 30 cm
5. Mango ginger- 20 cm x 30 cm
6. Turmeric- 20 cm x 30 cm
7. Banana- 2m x 2m

Fertiliser Dose of intercrops-(Kg/ha)

Intercrops	N	P	K
COLOCASIA	60	50	70
ELEPHANT FOOT YAM	80	60	100
ARROW ROOT	40	30	50
GINGER	125	100	100
MANGO GINGER	60	30	90
TURMERIC	60	30	90
BANANA	200	50	200



T1- Banana + Colocasia



T2- Banana + Elephant Foot Yam



T3- Banana + Arrow root



T4- Banana + Ginger



T5- Banana + Mango ginger



T6- Banana + Turmeric



T7- Control

Cultural management practices followed-

Banana- The land was ploughed, levelled and made weed free and good quality planting materials (suckers) of champa variety of banana were planted at a spacing of 2mX2m in a 45X45X45 cm³ pit well prepared and filled with 10 kg of well rotten compost. Furdon @ 40g was applied in the pit to protect it from nematode. Fertiliser dose of 200:50:200g NPK/plant was applied per banana.

1/3rd of N, 100% P and 1/3rd K was applied at the time of planting. Then 1/3rd N, 1/3rd K was applied each on 3rd, 5th and 7th month after planting. Necessary weed control, water management, desuckering, removal of old leaves etc. were followed as and when necessary during the crop growth period.

Intercrops :-

Elephant Foot Yam :- Var. Gajendra, time of planting 16th June 2014, size of seed material 300g, pit size 1ft x 1ft x 1ft, Spacing :- plant to plant 75 cm x 75 cm, Seed treatment:- 1kg fresh cow dung + 1ltr water + 2g Dithane- M- 45+ 3g Bavistin + 0.5g Streptocycline + monocrotophos 2 ml, Treatment time :- 30 min, Air dried 2 days and then planted, fertilizer dose :- 80:60:100 N:P:K Kg per hectare. total P at planting, 1/3 N & 1/3 K 30 days after planting, 1/3N & 1/3 K 60 days after planting, 1/3 N & 1/3 K 90 days after planting.

Colocasia :- Var. Muktakeshi, fertilizer dose:- 60:50:70 NPK Kg per hectare, total P as basal dose, 1/3 N & 1/3 K at the time of planting, 1/3 N & 1/3 K 30 days after planting, 1/3 N & 1/3 K 60 days after planting, Seed treatment same as Elephant Foot yam, Spacing :- 60 cm x 20 cm

Turmeric :- Var. Surama, Fertilizer dose :- 60:30:90 NPK Kg per hectare, Total P as basal dose, & 1/2 K at the time of planting, 1/2 N & 1/4 K 45 days after planting, 1/2 N & 1/4 K 90 days after planting, Spacing 20 cm x 30 cm, Seed treatment : - 1 ltr water + 3 gm Dithane-M 45+ 1gm Bavistin + 0.1 gm Streptocycline + 2ml chloropyriphos. 1/2 hour seed treatment then air dried and planted

Ginger :- Var. Suprava, Fertilizer dose :- 125:100:100 NPK Kg per hectare, total P as basal dose, & 1/2 K at the time of planting, 1/2 N & 1/4 K 45 days after planting, 1/2 N & 1/4 K 90 days after planting, Spacing 20 cm x 30 cm, Seed treatment : - In 1 ltr water + 3 g

Dithane-M 45+ 1g Bavistin + 0.1 g Streptocycline + 2ml chloropyriphus .1/2 hour seed treatment then air dried and planted.

Mango Ginger :- Var.Amba Fertilizer dose :- 60:30:90 NPK Kg per hectare, Total P as basal dose & 1/2 K at the time of planting ,1/2 N & 1/4 K 45 days after planting, 1/2 N & 1/4 K 90 days after planting ,Spacing 20 cm x 30 cm, Seed treatment : - In 1 ltr water + 3 g Dithane-M 45+ 1g Bavistin + 0.1 g Streptocycline + 2ml chloropyriphos .1/2 hour seed treatment then air dried and planted

Arrowroot :- Var:- khordha local ,Fertilizer dose 40:30:50 NPK Kg per hectare ,Total P as basal, 1/3 N & 1/3 K as basal, 1/3 N & 1/3 K at 30 days after planting, 1/3 N & 1/3 K at 60 days after planting ,Spacing 60 cm x 30 cm

Observations recorded

Growth characters of main crop banana

Five plants were selected from each treatment and observations were taken from these plants. The yield per plot was taken on plot basis. Data recorded was statistically analyzed for all quantitative characters.

Plant height

The height of the banana plant and other intercrops were taken at the time of harvest from base to the top and was expressed in cm.

Pseudostem girth

The girth of the pseudostem was measured with a measuring tape at the maximum circumference which is roughly around 10 cm height above the ground level and averaged to calculate the mean.

Number of leaves per plant

The number of functional leaves produced from planting till the time of shooting was calculated and was analysed.

Average weight of bunch

After harvest of bunch, the bunches were weighted with stalk with a digital balance and was expressed in kg.

Yield of bunch/hectare

The bunch weight of all banana plants were summed up and as per plant population in one hectare it was calculated to get the total yield of banana in tonnes/ha.

Number of suckers per plant

The number of suckers per plant produced in banana in control and also with response to intercrops was calculated and statistically analysed.

Days taken for appearance of spadix

The number of days taken from planting till appearance of spadix in different treatments is calculated and expressed in number of days.

Days taken for emergence of bunch

The days taken from appearance of spadix to emergence of bunch was calculated and expressed in days for different treatment.

The days taken for maturity of bunch

The number of days taken from appearance of bunch to maturity of bunch was calculated under different treatment and statistically analysed.

Number of hands per bunch

The number of hands produced in each bunch due to interaction of different intercrops and banana alone was calculated and the mean was used for analysis.

Number of fingers per bunch

The number of fingers in each hand was calculated from the plants and summed up and the average was taken to calculate the mean value in banana.

Yield related characters in main crop (Banana)

Days taken for shooting

The days taken from planting to emergence of inflorescence was recorded. The date of shooting was recorded when the flower bud tip was visible on the pseudostem. Total number of days taken for shooting was calculated for each treatment.

Bunch weight

After harvesting of bunch from the selected plant, it was weighed by a digital balance and the weight (kg) was recorded.

Number of fingers per bunch

The total number of fingers presented in a bunch was counted and the average number of finger was recorded by taking the number from five selected plants.

Observation on intercrops-

Height of intercrops- The height of intercrops at maturity was measured by a measuring tape at harvest and the mean was used for analysis.

Number of leaves per plant- The number of leaves per plant from sample plants of all intercrops were counted, added and mean was used for analysis.

Yield of intercrops- The yield of individual intercrops from the total plot in between banana was recorded and was converted to yield per hectare and was presented in table.

Yield of biomass of intercrops- The yield of biomass of intercrops at the time of harvest was recorded from sample plant and the mean was used for analysis.

Cost economics calculation- The yield from intercrops and banana was taken into consideration and was added to get the gross return from growing banana and intercrops. The cost of cultivation of intercrop and banana was also taken and added to get the total cost of cultivation of both Banana and intercrops. Total return from Banana + intercrops was calculated and it was deducted from the total cost of cultivation to get the net return.

Statistical analysis

Analysis of variance and test of significance

The analysis of variance for each character was carried out with the mean values of each treatment under each replication. The total variance was positioned in components such as replication, treatment and error. The variance was tested at 5% level of significance. Standard Error of Mean and Critical Difference (0.05) were calculated for comparing the mean values as per Panse and Sukhatame (1954). The

standard errors of mean and critical difference were calculated by using following formulae.

$$SE (m) \pm = \sqrt{\frac{EMS}{r}}$$

Where SE(m) = standard error of mean.

EMS = error mean sum of square

r = Number of replication

CD (0.05) = $\sqrt{2}$ x SE (m) x t value at error d.f. at 5 %

Economics

The economics of main crop, intercrops and the complete cycle of crops was worked out taking into consideration the cost of cultivation, gross return and net return per hectare. The cost of cultivation was calculated on the basis of the prevailing local market rates of inputs while the gross return on the yield and sale price at the farm gate. For working out of economics in case of complete cycle of crops the equivalent banana yield from intercrops and other treatments were determined by taking into account the yield and sale price of intercrops and the sale price of banana and is given by the formula-

Equivalent banana yield (q ha⁻¹)

$$= \frac{\text{Yield of intercrop (q ha}^{-1}\text{)} \times \text{sale price of intercrop (Rs./q)}}{\text{Sale price of banana (Rs./q)}}$$

For appropriate economic assessment of intercropping in monetary terms, the monetary advantage was calculated by the following formula.

$$\text{Return per rupee investment} = \frac{\text{Gross return (Rs)}}{\text{Cost of cultivation (Rs)}}$$

$$\text{Benefit: cost ratio} = \frac{\text{Total net return (banana+ intercrop)}}{\text{Total expenditure (banana+ intercrop)}}$$



RESULTS

During the period of experiment varied plant characters, yield attributing characters and yield data were recorded during the course of investigation are presented in this chapter supported by tables. The mean data obtained were tabulated and were analysed statistically with a view to find out the significant effect of different characters which are presented in the following characters and presented in tabular form and the relevant standard error of mean as well as the critical difference (CD) at 5% level of significance is also focussed.

Plant height (cm)

During the course of investigation the plant height of Champa var. of banana did not show any significant variation due to growing of different intercrops. The plant height was maximum 283.13 cm with Banana + Ginger intercropping followed by 280.13 cm with Banana + Arrow root, 275.25 cm with Banana + Colocasia. 244.13 cm with Banana + Elephant foot Yam and 272.35 cm with Banana + Mango ginger. Control treatment produced the lowest plant height of 266.18 cm during the course of investigation.

Plant girth (cm)

The data presented in table 3 showed no significant variation for plant girth of banana among the treatments. Highest plant girth of 65.50 cm was obtained with Banana + Turmeric intercropping. Banana + Arrow root intercropping produced a plant girth of 62.23 cm followed by 60.68 cm in Banana + Elephant Foot Yam, 58.18 cm with Banana + Mango ginger, 57.23 cm with Banana + Ginger and 56.35 cm with Banana + Colocasia intercropping. In control where banana was only grown it produced the lowest plant circumference of 54.05 cm during the experiment.

Number of leaves per plant

The number of leaves per plant in Champa variety of banana with different intercrop combination data is presented in the table 3. It was found that the number of leaves in banana did not vary significantly due to the effects of intercrops. Banana + Colocasia intercropping produced 10.93 numbers of leaves followed by Banana + Ginger where 10.73 number of leaves were produced. Banana when intercropped with Elephant foot Yam produced 10.38 number of leaves followed by 10.30 with Banana+ Arrow root intercropping. Banana + Mango Ginger produced 9.98 number of leaves and the lowest leaves were recorded with Banana + Turmeric. However, in control 10.50 number of leaves were produced during the trial.

Bunch weight (kg/plant)

The bunch weight of banana is presented in the table 3. It is observed that the intercrops did not influence much in bunch weight and no significant variation was obtained in bunch weight among the treatments. Highest bunch weight of Champa banana was obtained with Banana + Elephant foot Yam, 11.85kg with Banana + mango ginger and Control. However, the lowest bunch weight of 11.43kg was obtained with banana and ginger intercropping which produced a bunch weight of 11.5kg during the trial.

Yield of bunch (t/ha)

The total yield of bunch in t/ha is presented in Table 3. It is observed that the yield of banana per hectare did not vary significantly during the trial. The highest bunch yield of 30.00 t/ha was recorded with Banana + Colocasia intercropping followed by 29.75 t/ha with Banana + Elephant Foot Yam, 29.63 t/ha in Banana + Mango ginger & control. Banana + turmeric produced 29.26 t/ha, Banana and arrow root 28.88 t/ha and the lowest with Banana + Ginger, where a yield of 28.56 t/ha was obtained.

Table-3 Comparative growth and yield characters of banana

Treatment		Plant height (cm)	Plant girth (cm)	No. of leaves / plant	Bunch weight (kg)	Yield of bunch (t/ha)
T1	Banana+ Colocasia	275.25	56.35	10.93	12.00	30.00
T2	Banana + Elephant foot Yam	274.13	60.68	10.38	11.90	29.75
T3	Banana+ Arrowroot	280.13	62.23	10.30	11.55	28.88
T4	Banana + Ginger	283.13	57.23	10.73	11.43	28.56
T5	Banana + Mango Ginger	272.35	58.18	9.98	11.85	29.63
T6	Banana + Turmeric	274.13	65.50	9.88	11.71	29.26
T7	Control	266.18	54.05	10.50	11.85	29.63
	SEM±	5.047	2.755	0.358	0.151	0.377
	CD (0.05)	NS	NS	NS	NS	NS

Biometrical observations of banana based cropping system**Number of suckers/plant**

The number of both sword and water suckers produced due to effect of intercropping is presented in the table 4. The number of suckers produced was highest in banana + arrowroot treatment and control. Banana + Mango ginger intercropping produced 6.20 number of suckers followed by 6.15 in Banana + Colocasia and Banana+ Turmeric. However, 6.13 numbers of suckers were produced with Banana + Elephant Foot Yam and the lowest with Banana + Ginger intercropping.

Days taken for appearance of spadix

Days taken for appearance of spadix in banana during the trial is presented in the table 4. It was observed from the tabulated data that days taken for appearance of spadix in different treatments did not vary significantly. Highest days (267.25) to appearance of spadix was recorded with Banana + Turmeric followed by 264.00 days

with Banana + Mango ginger, 261.75 days with Banana + Ginger, 263.25 days in control, 263.00 days with Banana + Arrow root, 261.50 with Banana + Colocasia and the lowest 255.00 with Banana +Elephant Foot Yam.

Days taken for emergence of the bunch

Days taken for emergence of the bunch is presented in the table 4. From the tabulated data it is found that the character did not vary significantly among the treatments. The highest days (28.50) was taken in Banana + Ginger for emergence of bunch followed by 27.50 with Banana+ Arrowroot , 26.00 in control. 24.25 days with Banana + Turmeric, 24.0 days with Banana + Mango ginger and 23.50 in Banana+ Colocasia and Banana + Elephant Foot Yam treatment during the trial.

Days taken for maturity of the bunch

Days taken for maturity of the bunch is presented in the table (2) . It was found that no significant variation was observed among the treatment for this character, Days taken to maturity of bunch was highest (91.50) in Banana + Elephant Foot Yam intercropping, followed by 91.0 days with Banana + Turmeric, 90.75 days with Banana + Colocasia, 90.00 days with Banana + Ginger, Banana + Mango ginger and Control. Banana intercropped with arrow root produced the lowest value of 89.75 days during the course of investigation.

No. Of hands/bunch

The number of hands per bunch did not vary significantly during the course of investigation & is presented in table 4. Number of hands was highest (10.28) in Banana+ Arrowroot intercropping followed by Banana + Colocasia (10.18), Banana+ Mango ginger (10.05), Banana + Turmeric (9.35), Banana + Ginger (9.33) and the lowest (9.05) in Control.

No. Of fingers per bunch

The number of fingers per bunch in different treatments during the trial is presented in the table 4. Which varied significantly among the treatments. Highest (155.38) number of fingers per bunch was recorded in control followed by 153.80

with Banana + Arrowroot, 149.20 with Banana + Turmeric, 144.8 in Banana + Colocasia, 143.50 with Banana + Mango ginger, 129.35 with Banana + Ginger and 138.25 with Banana + Elephant Foot Yam, and 155.38 in Control respectively.

Table-4 Comparative yield attributing characters of banana

Treatments	No. of suckers of the main plant	Days taken for appearance of spadix	Days taken for emergence of the bunch	Days taken for maturity of the bunch	No. of hands/bunch	No. of fingers/bunch
T1- Banana + Colocasia	6.15	261.50	23.50	90.75	10.18	144.8
T2- Banana + Elephant Foot Yam	6.13	255.00	23.50	91.50	9.10	138.25
T3- Banana + Arrowroot	7.10	263.00	27.50	89.75	10.28	153.80
T4- Banana + Ginger	6.10	261.75	28.50	90.00	9.33	129.35
T5- Banana + Mango ginger	6.20	264.00	24.00	90.00	10.05	143.5
T6- Banana + Turmeric	6.15	267.25	24.25	91.00	9.35	149.20
T7- Control	7.10	263.25	26.00	90.00	9.05	155.38
SEm±	1.98	4.03	7.99	1.89	2.79	2.18
CD 5%	5.8	12.21	23.73	5.79	8.29	6.37

Height of the intercrop at the time of harvesting

The height of the different intercrops at the time of harvesting of the crop is presented in the table 5. It was observed from the tabulated value that the height of the intercrops varied significantly among themselves and it was highest (150.75cm) with Banana + Elephant foot Yam, Followed by 140.75cm with Banana + Arrowroot, 82.00cm with Banana + Colocasia, 80.25cm with Banana + Turmeric, 74.25 cm with Banana + Mango ginger and 60.75 cm with Banana + Ginger intercrop.

Number of leaves of intercrop at the time of harvesting

The number of leaves of different intercrops recorded at the time of harvest varied significantly among the treatments. The highest number of leaves 16.00 was recorded with arrowroot followed by 15.00 with colocasia, 9.75 with ginger, 8.25 with mango ginger, 6.25 with turmeric and lowest 1.50 with elephant foot yam.

Yield of intercrops

The yield of intercrops and banana is presented in the table 5. It was observed that there was significant variation in yield among crops. Yield of 16.40 t/ha with arrowroot, 13.50 t/ha with elephant foot yam, 10.70 t/ha with colocasia, 9.30 t/ha with turmeric, 7.60 t/ha with mango ginger and lowest 6.20 t/ha with ginger during the trial.

Biomass production of the intercrops

The biomass produced by different intercrops during the trial is presented in the table 5. It is revealed from the tabulated data that biomass production varied significantly among the treatments. It was highest 2606.25 g/plant with elephant foot yam, 252.25 g/plant with arrow root, 238.25g/plant with banana+mango ginger, 183.75g/plant with banana+ turmeric, 114.75g/plant with banana+ginger and 103.75g/plant with banana+ colocasia.

Table 5 Morphological characters and yield of intercrops

Treatments	Height of the intercrop at the time of harvesting	No. of leaves of intercrop at the time of harvesting	Yield of the intercrop	Biomass production of the intercrop
T1- Banana + Colocasia	82.00	15.00	10.70	103.75
T2-Banana + Elephant Foot yam	150.75	1.50	13.90	2606.25
T3-Banana+Arrowroot	140.75	16.00	16.40	252.25
T4-Banana+Ginger	60.75	9.75	6.20	114.75
T5=Banana + Mango ginger	74.25	8.25	7.60	238.25
T6-Banana+Turmeric	80.25	6.25	9.30	183.75
T7-Control	0.00	0.00	0.00	0.00
SEM±	26.19	2.51	2.86	155.38
CD 5%	77.78 (S)	7.45(S)	8.50(S)	461.38(S)

Return from the intercrops (Rs)

The return that is obtained from different intercrops is presented in the Table 6. Highest return was obtained from arrowroot (4.1 lakhs) followed by 37.2 lakhs from turmeric, 3.375 lakhs from Elephant foot yam., 2.48 lakhs from ginger, 2.28 lakhs from mango ginger and and 2.14 lakhs from colocasia during the trial.

Yield of banana and return from banana

The yield of banana with different intercrops and control is presented in the table 6. It was found that highest yield of 30.00 t/ha was obtained with colocasia followed by 29.7 t/ha with elephant foot yam, 29.63 t/ha in mango ginger and also in control, 29.56 t/ha with turmeric, 29.26 t/ha arrow root. The return from banana was highest 4.45 lakhs with colocasia, 4.4625 lakhs with elephant foot yam, 4.4445 lakhs with mango ginger and control, 4.389 Lakhs with turmeric, 4.284 lakhs with ginger during the trial.

Return over control (Rs)

The return from both banana and intercrops as compared to control is given in table 6. It was seen as compared to income generate from control a return of 3.9875 lakhs was obtained from arrow root, 3.6645 lakhs from turmeric, 3.393 lakhs from elephant foot yam, 2.298 lakhs from mango ginger, 2.3195 lakhs from ginger and 2.1955 from colocasia during the trial

Table 6 Benefit :cost ratio of banana based intercropping system

Treatment		Intercrop yield (t/ha)	Return from intercrop (Rs.)	Yield of Banana (t/ha)	Return from banana (Rs.)	Total Return (Rs)	Return over control (Rs.)
T ₁	Banana+ Colocasia	10.7	214000	30	450000	664000	219550
T ₂	Banana+ Elephant foot Yam	13.5	337500	29.75	446250	783750	339300
T ₃	Banana+ Arrowroot	16.4	410000	28.88	433200	843200	398750
T ₄	Banana+ Ginger	6.2	248000	28.56	428400	676400	231950
T ₅	Banana+ Mango Ginger	7.6	228000	29.63	444450	672450	228000
T ₆	Banana+ Turmeric	9.3	372000	29.26	438900	810900	366450
T ₇	Control			29.63	444450	444450	0

Cost of cultivation of intercrops

The cost of cultivation of intercrops are presented in table 7. It was observed that more or less around 1.152 lakhs cost of cultivation was recorded with elephant foot yam and 1.05 lakhs was incurred for colocasia, arrowroot, ginger, mango ginger and turmeric during the trial period.

Cost of cultivation of banana

The cost of cultivation of banana is presented in the table 7. It is observed that around 2.487 lakhs was spend for raising a successful crop of banana for one hectare area.

Total cost of cultivation

The total cost of cultivation for both intercrops and banana is presented in table 7. It was observed from the data that highest cost of cultivation was found with Banana + Elephant foot yam (3.639 lakhs) followed by around 3.537 lakhs in colocasia, arrowroot , ginger, mango- ginger and turmeric. But, in control when banana was alone grown the total cost of cultivation was around 2.487 lakhs/ hectare.

Gross return

The gross return from both intercrops and banana is presented in table 7. It was seen from the tabulated data that highest gross return of 8.432 lakhs was obtained from Banana + Arrowroot. Rs.8.109 lakhs from Banana + Turmeric Rs. 7.8375 from Banana + Elephant Foot Yam, Rs. 6.764 lakhs from Banana + Ginger, Rs. 6.7245 lakhs for Banana + Mango ginger, Rs. 6.64 lakhs from Banana + Colocasia and Rs.4.444 lakhs from banana alone.

Net profit

The net profit from both banana with intercrop and banana alone is presented in table 7. It was found that highest net profit of Rs.3.9875 lakhs was obtained from Banana + Arrow root intercropping followed by Rs.3.6645 lakhs with Banana + Turmeric, Rs.3.393 lakhs with Banana + Elephant Foot Yam, Rs.2.3195 lakhs with Banana + Ginger, Rs.2.28 lakhs with Banana + Mango ginger, Rs.2.1955 lakhs with Banana + Colocasia and Rs.1.9575 lakhs with banana alone..

Table 7 Economics of production per hectare for banana plus intercrop

Treatment		Cost of cultivation of intercrop (Rs)	Cost of cultivation of banana (Rs)	Total cost of cultivation (Rs)	Net return (Rs)	Net profit (Rs)	Benefit : Cost ratio
T1	Banana+ Colocasia	105000	248700	353700	664000	219550	1.87
T2	Banana+ Elephant foot Yam	115200	248700	363900	783750	339300	2.15
T3	Banana+ Arrowroot	105000	248700	353700	843200	398750	2.38
T4	Banana+ Ginger	105000	248700	353700	676400	231950	1.91
T5	Banana+ Mango Ginger	105000	248700	353700	672450	228000	1.9
T6	Banana+ Turmeric	105000	248700	353700	810900	366450	2.29
T7	Control		248700	248700	444450	195750	1.78

Benefit:cost ratio

The benefit cost ratio during growing banana with inter crop and banana as sole crop is given in table 7. It was observed that highest benefit: cost ratio of 2.38 was obtained with Banana + Arrowroot, followed by 2.29 with Banana + Turmeric, 2.15 with Banana + Elephant Foot Yam, 1.19 with Banana + Ginger, 1.90 with Banana + Mango ginger, 1.87 with Banana + Colocasia, but the lowest with banana alone i.e;1.78 only



DISCUSSION

The present investigation is intended to evaluate the performance of different intercrops in newly planted banana (Champa) under humid agroclimatic condition of coastal Odisha with an intention to provide some valid output on intercropping of different vegetables and spices during 2014-15. The result of the present study on yield and other parameters of intercrops and banana is discussed in this chapter.

Yield and yield attributing characters of banana-

The height of banana along with girth of pseudostem, number of hands, number of fingers and over all weight of the bunch in banana are more economical characters deciding net return from a plantation. It was seen from the observed data that most of the economical characters of banana did not vary significantly due to growing of intercrops. Banana received the normal light and spacing and normal cultural and management practices with proper water and nutrient management practices. The crop derived its nutrition from the soil which was well spaced from the intercrop for which there was no remarkable effect of intercrops on growth and yield of banana during the present investigation. It was more or less observed that banana performed better when intercrops are grown than alone. Plant height was found to be highest with banana+ginger and lowest with control but, was found to be more in other treatments as compared to control. Plant girth as observed was more in most of the cases as compared to control. Number of leaves/plant, bunch weight and yield of banana in tonnes/ha did not vary significantly indicating that growing of shallow rooted, partially shade loving intercrops on banana did not significantly influence the growth parameters but, over all most of the parameters showed slightly positive influence. Increase in bunch weight and yield per/ha due to growing of intercrops had been already reported by Nazrul 2007 who confirmed that intercropping system in banana showed the highest benefit cost ratio (2.41) and therefore, it might be more economically viable than sole banana. Hipparagi and Chinnappa 2008 supported to the above findings that soyabean and redgram could be raised successfully in the interspaces of banana garden without affecting the main crop. Soyabean and redgram were proved to be ideal intercrops in banana garden providing net income of Rs.8,148.20 and Rs. 6,160.95 at 50% NPK level. Venugopal & Sheela reported that

productivity and income was enhanced in banana variety Nendran by modifying the planting pattern and adopting intercropping. Individual bunch weight didn't register any variation with planting pattern.

Increase in bunch weight and yield per hectare due to growing of inter crops had been already reported by Chhundawat et al. (1984), Nayar and Suja (1996) and Ghosh and Hore, 2011 in coconut.

Vegetative growth parameters of banana-

Number of suckers produced per plant, days taken for appearance of spadix, days taken for emergence of bunch, number of hands/bunch and number of fingers per bunch are important characters in banana over all deciding the health and reproductive characteristics of banana. Number of fingers per bunch was found significant and other characters did not vary much in banana due to the effect of intercrops. Number of suckers per plant, days taken for appearance of spadix, days taken for emergence of bunch, days taken for maturity of bunch and number of hands per bunch which has already been reported by Nayar and Suja 1996 who confirmed that there was no perceptible deleterious effect on growth and productivity of banana due to intercropping with different genotypes of dioscorea. Intercropping banana with Sree Keerthi and Sree Priya was very profitable in comparison to farmers practice of sole cropping of banana.

The present finding is in conformity with the findings of Behera and Dash (2014), Paul et al. (2008), Baghel et al. (1986) and Rao and Reid (1987).

Growth behaviours of intercrops-

Most of the growth characters of intercrops varied significantly for height of intercrops, number of leaves at the time of harvesting, yield of intercrops and biomass production. This type growth behaviour is due to different type of intercrops with different growth habit. Maximum height of intercrops was observed with elephant foot yam and the minimum with ginger, number of leaves was maximum with arrow root and the minimum with elephant foot yam. Yield of intercrops was highest in arrow root 16.40t/ha and the minimum with ginger i.e; 6.20 t/ha and the maximum biomass was produced with elephant foot yam and the lowest with ginger. It was observed that the growth of the intercrops were normal and the banana

plantation did not get affected by the growth behaviour of the intercrops. The present findings is supported by the study of Jata *et al.*, 2009 who reported that 5000-9000 plants of elephant foot yam per hectare can be accommodated between the interspaces of fruit and orchard crops and elephant foot yam is not competing for light as this crop is able to tolerate shade. This study is again supported by Girija Devi *et al* 2011 who reported that Nendran banana, Elephant Foot Yam, Ginger can be grown as suitable intercrops in coconut garden in different combinations . All these crops produced significantly at par yields with their sole crops in coconut garden and by adjusting the plant population of intercrops remuneration from the coconut garden can be increased sufficiently

The present findings is in conformity with the findings of Singh *et al.* (2001) in mango based intercropping, Sairam *et al.* (1997) and Nazrul *et al.* (2007).

Cost and return in banana based cropping system-

The yield of individual intercrops, return from intercrops, yield of banana and return from banana were calculated to get the total return from banana were calculated to get the total return from banana intercropping system. The return over control varied depending on the yield and rate of the economic products of the intercrops. It was observed that even though the yield of colocasia was more as compared to ginger, mango ginger and turmeric but, the return was more from ginger, mango ginger and turmeric as the rate per kg of these products are more than that of colocasia. It was observed that return from banana+arrow root was more followed by turmeric. By considering the return from banana under different treatments. It was found that total return from banana+arrow root was more followed by Banana+Turmeric and the least was with banana alone. The similar trend was also observed for return over control. The present finding give a better economic return as compared to sole crop of banana The present result also confirm with the findings of Singh *et al* 1997 in coconut, Singh *et al* 2001 under mango and Nazrul 2007 with Banana.

Economics of banana and intercrops-

From the experiment due to high rate and cost of planting materials the cost of cultivation of elephant foot yam was more as compared to other intercrops. Cost of cultivation of both intercrops and banana was taken to consideration and the

corresponding gross return and net return was found out during the experiment . It was observed that as compared to control, a banana crop with varied combination of intercrops is giving more return depending on yield and prevailing cost of the produce. As compared to control where around Rs. 2 lakhs was profit per hectare in banana a two fold increase i.e; around Rs. 3.98 lakhs was obtained with banana+arrow root intercropping followed by turmeric. By taking into consideration the B:C ratio in the present experiment it can be concluded that banana+arrow root is the best combination for more economic return as compared to banana+turmeric and banana+elephant foot yam intercropping than others. The present findings in accordance with the report of Jain and Raut (2004) and Behera and Das (2013) However, the result may vary with other varieties of banana and under different agro-ecological and edaphic conditions which is also ascertained from the findings of Lenka *et al.*, 2005 who reported on feasibility and profitability of intercropping with groundnut, cowpea and pineapple in cashew plantation and revealed that these were grown successfully as intercrops without affecting the yield of main crop cashew. On farm experiment was conducted at multi location testing site, by Nazrul 2007 for consecutive two years by taking four intercropping combination viz. banana (sole), banana + okra, banana + sweet gourd and banana + bitter gourd were considered as treatment variables. The result showed that the highest Banana equivalent yield advantage (20%) than sole banana recorded from the intercropping combination of Banana + Sweet gourd. This intercropping system also showed the highest benefit cost ratio (2.41) and therefore, it might be more economically viable than banana alone.



SUMMARY AND CONCLUSION

Indian Agriculture at present largely depends an extensive use of resources to get more return. To make Agriculture Sustainable one should adopt practices that help to maintain ecological equilibrium and encourage natural regenerative process of nutrient enrichment and recycling, check soil erosion and protect natural biodiversity. Fruit crops are generally wide spaced and with a long gestation period. In such situation there is every scope of soil erosion under traditional method of tillage and the inter spaces which can be economically utilised is kept fallow, So, intercrops in fruit orchard not only check soil erosion, properly utilise soil, soil water nutrients and light but also provide some additional income to the growers. Banana is an important commercial fruit crop in Odisha and is widely grown during the present year after implementation of National Horticulture Mission.

So, in the present study on “Intercropping of vegetables in Banana (*Musa spp.*)” an attempt has been taken to evaluate the performance of different intercrops like Colocasia, Elephant Foot Yam, Arrow Root, Ginger, Mango ginger and Turmeric under newly planted banana (Champa) Plantation during 2014-15 under AICRP on banana at Horticulture Research Station, Bhubaneswar. The trial was conducted in RBD with seven treatments and four replication. The temperature, RH, rainfall and sunshine hours were recorded during the period and reported under materials and method. Banana was planted at a spacing of 2m x 2m. The selected good quality suckers were planted in pit at a distance of 45 x 45 x 45 cm³ following other recommended cultural practices. All the intercrops were grown following normal recommended nutrient management practices. Different yield and yield attributing characters of both banana and intercrops were taken during the course of investigation which is summarised below.

- 1) The height of banana plant varied between 266.18cm in control to highest in 283.1cm with banana+ginger intercropping.
- 2) The girth of banana plant ranged between 54.05cm in control to 65.50cm with banana+arrow root intercropping.

- 3) Number of leaves per plant ranged from 9.88 in control to 10.93 with banana+colocasia followed by 10.73 with banana+ginger.
- 4) Bunch weight of banana varied from 11.43kg with banana+ginger and the highest was with banana+colocasia 12.00kg . Bunch weight of 11.85 kg was recorded in control.
- 5) Yield of banana per hectare ranged from 28.56t/ha with banana+arrow root to 30.00 t/ha with banana+colocasia and 29.63 t/ha in control.
- 6) Plant height, plant girth, number of leaves per plant, bunch weight and yield in t/ha did not vary significantly during the observations.
- 7) Number of suckers ranged from 6.10 to 7.10 in banana+intercrop but it was only 7.10 in control.
- 8) Days taken for appearance of spadix varied from 255.00 days in banana+elephant foot yam intercropping to 267.25 with banana+turmeric intercropping.
- 9) Days taken for emergence of the bunch varied from 23.50 with banana+colocasia and banana+elephant foot yam and 28.50 with banana+ginger.
- 10) Number of hands per bunch varied from 9.05 in control to 10.28 with banana+arrow root intercropping control to lowest 129.35 with banana+elephant foot yam.
- 11) Number of fingers per bunch ranged from 155.38 in control to lowest 129.35 with banana+elephant foot yam.
- 12) The height of intercrops 60.75cm in ginger, 74.25cm with mango ginger, 80.25cm with turmeric, 82.00cm with colocasia, 140.75 with arrow root and 150.75cm with elephant foot yam.
- 13) Number of leaves of intercrop varied from 1.50 in elephant foot yam to 16.00 in arrow root

- 14) Yield of intercrop was 13.90 t/ha in elephant foot yam, 10.70 t/ha in colocasia, 9.30 t/ha in turmeric, 7.60 t/ha with mango ginger and 6.20t/ha with ginger.
- 15) Biomass production per plant was 2606.25 g in elephant foot yam, 252.25g in arrow root, 238.25g in mango ginger, 183.75g with turmeric, 114.75g with ginger and 103.75with colocasia.
- 16) Returns from intercrops alone was highest from arrow root Rs.4,10,000.00 followed by Rs. 3,72,000 with turmeric and the lowest was with colocasia Rs.2,14,000.00 .
- 17) Total return from banana+arrow root was Rs.8,43,200 followed by Rs. 8,10,900 in banana +elephant foot yam and the lowest with control Rs.4,44,450.00
- 18) The highest B:C ratio of 2.38 was found with banana+arrow root followed by 2.29 with banana+turmeric and 2.15 with banana+elephant foot yam and lowest with control 1.78 only.

Conclusions-

The present experiment entitled “Intercropping of vegetables in Banana (*Musa spp.*) was carried out under AICRP on banana at Horticulture Research Station, Bhubaneswar during 2014-15 with banana (Champa) variety along with different intercrops like Colocasia, Elephant Foot Yam, Arrow root, Ginger, Mango ginger and Turmeric revealed that highest net return of Rs. 3,98,750.00 (B:C ratio 2.38) can be obtained from banana+arrow root intercropping followed by Rs. 3,66,450.00 (B:C ratio 2.29) with banana +turmeric intercropping and Rs. 3,39,000.00 (B:C ratio 2.15) and the lowest in control Rs. 1,95,750.00 (B:C ratio 1.78) under coastal humid agroclimatic condition of Bhubaneswar.



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