समर्पण

"सुखाचा प्रत्येक क्षण...
ज्यांच्या कोमल स्पर्शाने उन्मिलित होतो व
दु:खाचा प्रत्येक क्षण ...
ज्यांच्या प्रेमळ शब्दाने सुसह्य होतो
त्या माझ्या
परमप्रिय आई-वडिल व
स्फुर्तिस्थान असणारे
थोरले बंधू संजिवकुमार यांना
समर्पित"...

...रणजित

RELATIVE ECONOMICS OF CROPPING SEQUENCES UNDER IRRIGATED CONDITION IN WAI TAHSIL OF SATARA DISTRICT

By

YAMGAR RANJIT NARAYAN
(Reg No 98136)

A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI-413 722

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ECONOMICS

DEPARTMENT OF AGRICULTURE ECONOMICS

POST GRADUATE INSTITUTE,
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST. AHMEDNAGAR (M.S.) INDIA

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DEPARTMENT OF AGRICULTURAL ECONOMICS

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RAHURI - 413 722, DIST. AHMEDNAGAR (M.S.) INDIA
2001**

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part there of

has not been submitted by me or other

person to any other University

or Institution for a Degree

or Diploma

Place MPKV, Rahuri **(YAMGAR R.N.)**

Dated / /2001

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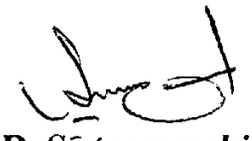
Maharashtra, (India)

CERTIFICATE

This is to certify that the thesis entitled, "**RELATIVE ECONOMICS OF CROPPING SEQUENCES UNDER IRRIGATED CONDITION IN WAI TAHSIL OF SATARA DISTRICT**", submitted to the faculty of Agriculture, **MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI, DIST. AHMEDNAGAR, MAHARASHTRA STATE**, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ECONOMICS**, embodies the results of a *bona fide* research work carried out by ***Shri. YAMGAR RANJIT NARAYAN***, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma

The assistance and help received during the course of this investigation has been duly acknowledged



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Date / /2001 Research Guide

Dr. S.S. Kadam,
Associate Dean,
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CERTIFICATE

This is to certify that the thesis entitled, **"RELATIVE ECONOMICS OF CROPPING SEQUENCES UNDER IRRIGATED CONDITION IN WAI TAHSIL OF SATARA DISTRICT"**, submitted to the **MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI, DIST. AHMEDNAGAR, MAHARASHTRA STATE**, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ECONOMICCS** embodies the results of a *bona fide* research work carried out by ***Shri. RANJIT NARAYAN YAMGAR***, under the guidance and supervision of **Dr. S.D. SURYAWANSHI**, Head, Interfaculty Department of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist Ahmednagar, Maharashtra State and that no part of the thesis has been submitted for any other degree or diploma

(S.S. Kadam)

Place MPKV, Rahuri
Date / /2001

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Place MPKV, Rahuri
Dated X /2001

(Yamgar R N)

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ABBREVIATIONS

et al		and other (s)
d		days
etc		et cetera (and so on)
Fig.		figure
ha		hectare (s)
i e	.	id est (that is)
kg		kilogram (s)
Viz		namely
qtls		quintal (s)
Rs		rupees
Sr. No.	.	serial number
t	.	tonnes
/		per
%	.	per cent

ABSTRACT

RELATIVE ECONOMICS OF CROPPING SEQUENCES UNDER IRRIGATED CONDITION IN WAI TAHSIL OF SATARA DISTRICT.

By

RANJIT NARAYAN YAMGAR

A candidate for the degree of

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Department	:	**Agricultrual Economics**

An attempt was made to investigate into the economics of different cropping sequences and to estimate resource productivities as well as optimum level of resource use under different cropping sequences The data for the year 1998-99, was obtained by survey method from a sample of 150 cultivators adopting the cropping sequences, viz, sugarcane (suru), sorghum-gram, tomato-wheat, chilli-wheat-groundnut and paddy-pea-groundnut, from five irrigated villages of Wai tahsil It was observed that, the net returns from paddy-pea-groundnut, were the highest followed by tomato-wheat, chilli-wheat-groundnut, Sorghum-gram and sugarcane (suru) cropping sequences The combinations of relatively high valued crop enterprises in the cropping sequences,

Viz, tomato-wheat, chilli-wheat-groundnut and paddy-pea-groundnut indicated not only to increase the net returns but also to increase the resource employment on farms

The Cobb-Douglas production function was fitted to the per hectare data of selected cropping sequences for studying the functional relationship between the gross receipts as a dependent variable and the selected six independent variables viz, human labour in man equivalent days (X_1), manure in q (X_2), nitrogen in kg (X_3), phophorus in kg (X_4), irrigation in Rs (X_5) and fixed capital in Rs (X_6). The regression co-efficients of human labour and phosphorus use for tomato-wheat sequence and farm yard manure for sugarcane (suru), chilli-wheat-groundnut and paddy-pea-groundnut were found to be negative. Similarly, the effect of fixed capital on gross receipts in all cropping sequences excepting chilli-wheat-groundnut, was non-significant. The co-efficients of remaining inputs were significant indicating further scope for intensifying the use of these inputs. The existing resources in paddy-pea-groundnut cropping sequence have been used more closely to the optimum level as compared to that in the other cropping sequences. It can, therefore, be concluded that paddy-pea-groundnut cropping sequence is superior both in terms of maximization of returns and optimal use of existing resources.

INTRODUCTION

1. INTRODUCTION

1.1 General

Indian economy is primarily based on agriculture. The total land available with India is 308 m ha, out of which 143 m ha (46.43 per cent) is cultivable. The total foodgrain production was 50 mt in 1950-51 and the population was around 37 crores. There was shortage of grains to feed the people and required importing of grains during early period. During the post-independence period, India has made rapid stride in foodgrain production which elevated to 203 mt in 1998-99. This has changed the image of begging bowl and reach to a stage of exporting foodgrains despite of population raised to 100 crores.

The potential generated by the recent technological break-through in Indian agriculture has been a matter of considerable attention. The discovery and adoption to Indian conditions of relatively photo-intensive, short duration new plant types, highly responsive to the inputs like fertilizers, irrigation and plant protection have provided the needed impetus for the transformation of a traditional to a highly modernized agriculture. All these changes associated with the transformation process call for readjustments in the farm business organization. A study of the nature of resource use efficiency and selection of crop enterprise sequence in different

seasons in a year in this changed setting is of considerable importance.

The present study attempts to examine the most economical cropping sequence and how the resource use should be readjusted for achieving new equilibrium under the existing available technology. It is claimed that the new high intensity of cropping technology in agriculture offers significant opportunities for higher production, income and employment on the farms.

In the past, for want of short duration varieties, cropping intensity could not be made the focal point of agricultural strategy. During recent years, this barrier has been overcome. The significant achievement of agricultural research has made available the high yielding short duration crop varieties. Consequent upon the development in techniques of intercropping, relay cropping and multiple cropping is now possible to have a fairly flexible and highly remunerative cropping sequences.

1.2 The problem

The scientific determination of efficient cropping sequences is the dire need of the day to give real practical meaning to the concept of "Intensive Agricultural Development" for increasing agricultural production. The problem of cropping sequence can be considered in a wider perspective of combination of activities leading to

diversification or specialization in agriculture. The problem of cropping sequence is important both from the view point of the individual farmer as well as the nation as a whole. In the case of individual farmer, it is the question of the combination of crops to be grown on the limited area in a period of one year with the given quantities of labour, capital and management. From the national point of view, it is the problem of evolving a crop pattern, in accordance with the 'plan priorities'. Thus,the problem of cropping sequence is concerned with two important issues at the micro and macro levels. At the micro level the maximization of farm profits in a given year with the available resources and at the macro level the most efficient utilization of the nation's productive resources form the important objectives of appropriate crop sequences in Intensive Agriculture.

In the present study, cropping sequences selected by farmers were important in farm economy of the sample farmers. An endeavour to find out optimum use resources towards the most profitable cropping sequence would become a guideline to prescribe the direction in which the shift of resources as well as cropping sequences should take place in the selected area. Such shift of area to the highly profitable cropping sequence and the use of optimum levels of resources, would not only strengthen the economic position of the cultivators but will also have a considerable impact on the State's economy.

The problem before the farmer is thus, the selection of crop enterprises to be grown in different seasons which will fit in the cropping system to form an appropriate cropping sequence in farm business. Now technological progress in different aspects has given many farmers a greater freedom of choice among rotations viz , monocropping, double cropping, triple cropping or perhaps four crops during a year. There is a gradual shift from subsistence farming to commercialized farming in which only those crops are grown which have the highest comparative advantages. In this technological context, farmers are trying multiple system of cropping.

Availability of new technology does not per se ensure to adopt multiple cropping sequences by farmers. There are various factors responsible for it. Some of the factors are resources constraints, managerial ability, risk bearing capacity, presence of infrastructure like credit facilities, availability of irrigation, marketing facilities and prices. This study tries to examine the possibilities in a normative sense of adoption of different cropping sequences in the context of the existing resource structure and also the possibilities of increasing farm income and employment of farmers. In view of this, the job of production economist is to provide new knowledge to cultivators on continual basis such that resource use efficiency can be increased and profits are maximized. This situation induced the author to study the economics of

different cropping sequences and resource use productivity in the Wai tahsil of Satara district.

1.3 Cropping Sequence Concept

A cropping system is the kind and sequence of crops grown on a given area of soil over a period of time. It may be a regular rotation of different crops in which the crops follow definite order of appearance on the land or it may consist of only one crop grown year after year on the same plot i.e. mono culture. Thus, it is the system which includes different crops but lacks definite order or planned order in which crops follow one after another over a period of time. Cropping sequence is thus, one year crop rotation or it may be one year cropping system in which one (mono cropping), two (double cropping), three (triple cropping) or more crops are grown on the same plot in succession within a period of one year.

1.4 Objectives

The present investigation entitled, "Relative economics of cropping sequences under irrigated condition in Wai Tahsil of Satara district" has been undertaken with the following specific objectives.

1. To study the costs and returns of different cropping sequences.
2. To find out the most profitable cropping sequence.

3. To estimate the resource productivities in different cropping sequences
4. To study the resource use efficiency in different cropping sequences.

1.5 Hypotheses

Following hypotheses have been formulated and will be tested empirically for achieving the above objectives.

1. Higher profits are associated with high intensity of cropping sequence.
2. Combinations of relatively high valued crops in the cropping sequence would result in higher net returns to farmers.
3. Multiple cropping sequence offers significant scope to increase the resource employment on farms.

1.6 Scope and Utility

The present investigation has been carried out in a specific area,

however, the results of this study have a greater scope. Though, the study is restricted to the selected cropping sequences in a selected area, the conclusions of the study with suitable modifications would be applicable to many other similar areas.

The suggestions made on the basis of present study would directly indicate the extent of increase in net income

which may, in turn, facilitate the cultivators to rationalize the investment on the production of crops to be followed in particular cropping sequence under irrigated farming, which offers them a sizable income.

In addition, it is also an attempt to illustrate the use of production function analysis in competing crop enterprises. As suggested by Ludving Auer, "Since reliable estimates of resource productivity in agriculture could be of great value, such studies dealing with these problems could prove very useful".

It is, however, true that the present study is restricted to particular cropping sequences actually followed by the majority of the farmers and it is based on the information obtained from a limited sample of particular cropping sequences, drawn from the Wai tahsil of Satara district. The results may therefore be applicable to other multiple cropping sequences which are followed in the areas where similar agronomical and economical conditions prevail.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Agricultural production can be increased with the year round operation at a high efficiency. The new short duration varieties and recent developments in the field of crop and soil management have made intensive cropping which are highly profitable. In view of this, an attempt is made to investigate into the economics of different cropping sequences. A number of studies had been undertaken by research workers. These past records facilitate the researcher in planning his research project and for making correct decisions in the right direction. It is in this context, the work done in the past is reviewed under the following broad headings.

2.1 Comparative Economics of Different Crops

While calculating the cost of cultivation, the approach has not been uniform. Different workers have used different concepts in estimating the cost of cultivation. However, in the year 1958, the cost concepts were standardized at the seminar on "Agricultural Price Policy" organized by the F.A.O./ECAFE in New Delhi. These cost concepts are cost A, cost B and cost C which have been used by many of the research workers.

Singh R.D. and Singh L.D. (1960) compared the cost of cultivation of different crops with that of sugarcane. They found that the cost of cultivation per acre of wheat was

Rs. 208, sugarcane Rs. 796 (more than 3.75 time that of wheat), potatoes Rs. 890 (more than 4.28 time that of wheat). The per acre profit from wheat was Rs. 145, from sugarcane it was Rs. 198/- and from potatoes Rs. 471.

Vyas and Kalla (1974) have studied "Economics of commercial crops in Borunda Tube-well Command Area". They pointed out that, the cost per hectare was higher for chillies and hybrid bajra (seed) ; and was lower for cumin and rapseed as compared to wheat. But value of output per hectare was higher for hybrid bajra (seed) ; chillies and cumin; it was lower for rapseed as compared to wheat judged from different cost concepts.

Singh and Bal (1974) in their study found out that sugarcane was most profitable crop followed by cotton and groundnut.

Waghamare and Dhongade (1983) analysed the input-output data of important crops studied under cost of cultivation scheme operated in the Maharashtra state for the crops paddy, bajra, jowar, cotton, wheat and sugarcane. It was observed that over a period of time, the share of hired labour input in the cultivation of jowar and sugarcane crops showed an increase, comparing the changes in factor shares for jowar and sugarcane over a period of time.

Thakur and Khan (1994) conducted the experiment during 1990-91 and 1991-92 at Harda. Pooled data of both the years showed that rainy season pigeonpea gave significantly

higher yield equivalent (3780 kg/ha) and highest net return (Rs. 7520 /ha) than soybean (2475 kg/ha, Rs. 3600/ha) and cotton (3075 kg/ha, Rs. 2500/ha). Though cotton gave higher yield equivalent than soybean, it proved to be lesser economic than soybean due to high cost of cultivation. Total production potential under crop sequence of pigeonpea was highest than crop sequence of soybean or cotton.

2.2 Economics of Different Cropping Sequences :

An attempt was made by Jha (1963) to study the "Economics of crop pattern of Irrigated Farms in North Bihar". He concluded that the sugarcane was the most profitable crop but it occupied the land for full one year. Thus, from the point of view of farm enterprise, the best choice for farmer is to combine paddy with pulses or vegetables.

Patil and Hiregoudar (1963) found that raising a paddy after vegetable crops or paddy after garlic gave higher returns as compared to raising a paddy after potato or paddy after beans. They concluded that, it is possible to maximize the return through introducing a pattern of double cropping like groundnut and irrigated ragi which enable farmers to put their land under more intensive use, increase the productivity of labour and employ labour for a greater part of the year.

Singh B. *et al.* (1974) pointed out that sugarcane was more profitable as compared to paddy-wheat rotation on the

medium and large farms but paddy-wheat rotation is profitable on small farms.

Singh and Kunwar (1974) have studied comparative economics of American and deshi cotton, cotton and sugarcane, maize-wheat, cotton-wheat sequences, in Bulandshahar district of U.P. They observed that the net income per hectare from sugarcane was three and half-times higher than cotton. It was mainly due to the fact that sugarcane is highly responsive to irrigation and fertilizers. The quantum of production as well as economic productivity of land per hectare in cotton-wheat crop sequences was lower than maize –wheat crop sequence.

Lal and Ray (1976) indicated that the net profit per hectare per year increased significantly with an increase in the cropping intensities.

Mori and Patil (1976) found that, the crop sequence pearlmillet-wheat-maize (fodder) was the best which produced 5025 kg of foodgrains/ha and 15539 kg of green fodder/ha and gave the net profit of Rs. 6409/ha which was maximum. While, the sequences, groundnut-wheat-greengram and pearlmillet-wheat-greengram were poor in performance.

Hukkeri *et al.* (1978) in their survey, observed that the three crops sequence rice-rice-rice produced maximum food grains i.e. 16.8 tonnes/ha at Manglore. The other three crop sequences produced about 10 tonnes food grains/ha, were rice-wheat-cowpea, rice-rice-groundnut, sorghum-wheat-maize

and sorghum-wheat-greengram. Similarly, two crop sequences, also found to produce near about 10 tonnes food grains/ha, were rice-ragi, rice-maize, maize-wheat and rice-wheat.

Bansode (1979) obtained the data for the year 1977-78, for five cropping sequences, viz., sugarcane (suru), bajra-wheat, onion-wheat, bajra-wheat-onion and groundnut-wheat-onion from Niphad tahsil of Nashik district, concluded that groundnut-wheat-onion cropping sequence is superior both in terms of maximization of returns and optimal use of existing resources.

Thakur and Sharma (1988) in a two year field experiment at Dholi (Bihar), maize-wheat-prosomillet pattern recorded the maximum total seed yield (80.862 q/ha) and seed production efficiency (22.15 kg/ha/day) in 1982-83. Although total cost of cultivation was more in maize-pea (green pod)-wheat-greengram pattern than in the others, gross returns/ha, net returns/ha, economic efficiency (Monetary returns Rs./ha/day) were also maximum in this cropping pattern.

Singh and Yadav (1989) evaluated seven rice-based cropping systems for Gomti river flood plain in 1983-84. Rice yield equivalents of rice-wheat and rice-mustard crops were highest, with rice-barley next. Rice-chickpea produced least. Rice-mustard gave net profit of $ 223.28ha, followed by rice-wheat with $ 216.72/ha.

Prakash *et al.* (1989) studied three rainfed spring rice-based and one June-seeded rice-based cropping patterns (200% cropping intensity) and compared with traditional pattern (150% cropping intensity) in 1981-83 at Hawalbagh experimental farms. Highest rice yield was with spring rice (170 d duration) following fodder legume. June-seeded rice (110 d duration) yielded almost as well and the succeeding wheat crop yielded 2.8 t/ha. Net returns were almost twice as high in the improved crop sequences as in the traditional cropping system. Highest average annual net return was with June-seeded rice-wheat. All intensive cropping sequences had higher benefit : cost ratios than the traditional two year sequence.

Prasad and Kerketta (1992) conducted the field trials during 1983-84 and 1984-85 at Ranchi to evaluate the biologically productive and economically viable cropping sequences. Seven cropping sequences, viz. rice–fallow-fallow, rice-wheat-greengram, rice-berseem-greengram, deenanath grass-wheat-greengram, groundnut-oat-maize + cowpea and deenanath grass-berseem-maize + cowpea, with the recommended doses of nutrients. The crop sequence, with 300% cropping intensity gave higher net returns than the other sequences. It appeared that even inclusion of one forage component in a year round cropping sequence is more remunerative than a complete food crop sequence.

Madhumita-Devi *et al.* (1993) conducted field trials in 1989-90 at Jorhat, Assam and the following cropping sequences were assessed i.e. rice-rice- fallow, rice-wheat-fallow, rice-rice-wheat. The highest rice equivalent yields and net returns were obtained from the sequence rice-rice-wheat.

Jadhao and Joshi (1993) carried out 3-year (1988-91) experiment having 7 rice-based cropping sequences, viz. rice-fallow-rice, rice-fallow-groundnut, rice-frenchbean-groundnut, rice-wheat-greengram, rice-gram-sunflower, rice-sunflower-cowpea and rice-groundnut-greengram, showed that the rice-frenchbean-groundnut recorded the maximum grain productivity, gross returns, rice-grain equivalent, net returns (Rs. 29,464/ha) and land utilization efficiency, followed by rice-fallow-groundnut (Rs. 24,932/ha). Rice-wheat-greengram sequence also showed more grain productivity, gross and net returns than rice-fallow-rice, a traditional sequence.

Padhi, (1993) conducted field experiment during 1987-90 to find out the most suitable rice-based cropping sequence in north-eastern ghat zone of Orissa under irrigated condition. Amongst different rice based cropping sequences, rice-potato-cowpea recorded the highest yield on rice-equivalent basis with maximum production efficiency. This sequence also achieved the highest energy output with maximum energy input : output ratio. Rice-gardenpea-cowpea sequence secured the highest net return and cost : benefit ratio and was on par with rice-potato-cowpea system. Inclusion of cowpea

as summer crop in rice-wheat-cowpea and rice-mustard-cowpea sequences not only enhanced the production of rainy and winter crops of both the sequences but also increased the total production on rice-equivalent basis, net return and energy output over rice-wheat-okra and rice-mustard-okra system. However, rice-cabbage-okra was found superior to rice-cabbage-cowpea due to poor performance of cowpea as compared to okra after cabbage.

Umrani *et al.* (1993) conducted an experiment during 1981-1986 to study the stability and economics of the multiple crop sequences under assured water supply. The sequences included cereals, pulses, oilseeds, and forage crops. Sorghum-wheat-groundnut was the most stable sequence, giving the maximum net returns. Inclusion of *summer* groundnut in the sequence increased the net returns. Short duration pulses and ratooning of sorghum were highly unstable over a period of time. Sorghum-gram-pearlmillet was also productive and stable crop sequence.

Sidhu *et al.* (1994) carried out a field experiment at Ludhiana during 1987-88 to 1990-91 to evaluate the production potential of 10 winter maize (*zea mays* L.) based cropping systems. Winter maize gave higher grain yield of 4994 kg/ha and 4712 kg/ha when raised after groundnut and pigeonpea respectively but gave low yield (4023 kg/ha) after rice. Winter maize after potato gave significantly higher grain yield (4380 kg/ha) than when it followed toria. For fodder-

potato system gave the highest winter maize equivalent yield (29.67 tonnes/ha), gross income (Rs. 65,263/ha), net income (Rs. 27,340/ha) and productivity efficiency (102.3 kg/ha/day). Winter maize-greengram or sunflower system gave low winter maize-equivalent yield (5.7 and 6.9 tonnes/ha) and grass income (Rs. 12,506 and 15180/ha) and resulted in a loss of Rs. 2225 and Rs. 2283/ha respectively. Land-use efficiency was highest (93.9%) in winter maize-pigeonpea followed by winter maize-groundnut and was lowest in wheat maize. Cropping system having legume or potato as one of the components increased the organic carbon and available P and K status of the soil.

Bhatnagar and Chaplot (1995) conducted the study at Banswara during 1992-93, consisted of six crop sequences, viz : maize-wheat-greengram, maize-gram-greengram, maize-indianmustard-greengram, blackgram-maize-greengram, soybean-wheat-greengram and upland cotton-wheat-greengram. All the crops were raised as per the recommended packages of practices. Soybean-maize-greengram gave the highest total production (9.5 tonnes/ha) followed by maize-wheat-greengram (9.2 tonnes/ha). Thus the sequence involving maize as a winter crop gave higher production than that involving wheat. On the basis of wheat-equivalent yield, soybean-maize-greengram sequence showed the maximum production potential (11.7 tonnes/ha) in 308 days, giving the highest production efficiency (38.1 kg/ha/day).

Gaikwad *et al.* (1995) conducted a field experiment with legume-sorghum cropping sequence during 1990-91, 1991-92 and 1993-94 at Solapur to study its performance. The grain yield of sorghum increased by 42% and 105% when preceded by (fodder) cowpea compared with blackgram and soybean respectively. Higher sustainable yield index (0.55) and sustainable-value index (90.46) were obtained from cowpea (fodder) -sorghum sequence. The next best sequence was found black gram-sorghum, with sustainable-value index of 0.44. The available N content of soil increased and also maintained in the cowpea (fodder) -sorghum sequence.

Parihar *et al.* (1995) conducted a field experiment from 1989-90 to 1993-94 and revealed that among the different cropping sequences, rice-wheat recorded the highest yield on rice-equivalent basis with maximum production efficiency. This sequence also secured the highest net return and benefit: cost ratio.

Patil *et al.* (1995) studied the comparative production potential, economies and fertility status of soil as influenced by wheat based cropping systems, under different fertility levels and addition of organic manures during 1988-89 to 1991-92. The gross as well as net monetary returns of pigeonpea-wheat sequence with recommended dose of fertilizer to both the crops were found remunerative and beneficial than other sequences tried. This crop sequence recorded more land use efficiency and production efficiency over the others.

Fertility status of the soil was also improved by adoption of pigeonpea-wheat sequence, but reduced by cereal-cereal sequence.

Pawar and Jadhav (1995) conducted the field trial during crop season of 1988-89 and 1989-90 at Pune with three crop sequences, viz: groundnut-sorghum, greengram-sorghum and soybean-sorghum. The legumes provided additional N to sorghum through fixation and mineralization of their biomass. The N and P balance was positive under groundnut-sorghum sequence, but negative under greengram-sorghum, soybean-sorghum and fallow-sorghum sequences. A positive balance of N and P under groundnut-sorghum sequence can be attributed to the addition of large quantity of crop residue such as roots, stubbles, leaves, nodules and rhizobia rich in nitrogen by groundnut as compared with the other legumes.

Singh *et al.* (1995) conducted a field experiment during 1983-90 at Ranchi to study the stability in production potential of four crop sequences. The cropping systems were maize-wheat, rice-wheat, soybean-wheat. Among the rainy season crops the production of legumes was more stable in different years than of cereals, wheat grown after groundnut or soybean recorded higher (15.6%) stable yield than after maize or rice. Groundnut-wheat system was more efficient in terms of wheat-equivalent yield (6373 kg/ha), net returns (Rs. 16410/ha), benefit : cost ratio (1.87) and monetary productivity (Rs. 68.38/ha/day).

Joshi and Shukla (1997) conducted experiments in Himachal Pradesh in 1991-93 and observed that economic returns were highest for the multiple cropping sequences i.e. tomato-pea and tomato-cabbage-frenchbeans.

Krishna and Anand Reddy (1997) conducted three year (1989-92) experiment at Rudrur with six rice (*Oryza sativa* L.) based crop sequences, viz ; rice-safflower, Indian mustard, bengalgram, maize, wheat and sunflower showed that rice-sunflower gave significantly higher production efficiency (36.4 kg/ha/day), higher net returns (Rs. 26,160/ha) and benefit : cost ratio (3.18). This was followed by rice-bengal gram with rice equivalent yield (7.97 tonnes/ha), net returns (Rs. 23,865/ha) and benefit cost ratio (2.98); whereas that of rice with safflower or maize was 65.71%. The value of sustainable yield index revealed that rice-sunflower system was more stable (89%) followed by rice-bengal gram (82 8%).

Patil and Sale (1997) conducted a study from 1986-87 to 1993-94 on estimation of costs and returns and B : C ratio in different cropping sequences and suggested most appropriate cropping sequence in order to increase profitability in MPKV region. It was observed that amongst different cropping sequences-*kharif* sorghum-*rabi* cabbage-*summer* cowpea gave maximum gross monetary returns/ha followed by cotton-wheat, sorghum-chickpea-green chilli.

Patil (1997) conducted an experiment with four annual cropping sequences (paddy-lathyrus, paddy-wheat, paddy-

gram and paddy-linseed) as double cropping along with paddy-fallow as monoculture. Paddy-gram sequence showed the highest benefit/cost ratio (1.53) than paddy-lathyrus (1.49), paddy-linseed (1.36) and paddy-wheat (1.31), respectively. Whereas sole paddy gave a maximum net return of Rs. 1.73/rupee spent over double cropping.

Pratibha G. *et al.* (1997) carried out a field experiment at Hyderabad during 1990-91 and 1991-92 to develop and test suitable rice (*Oryza sativa*)-based cropping system. Groundnut-blackgram, sunflower and castor were used as the test crops with different tillage practices. The net returns of different crops were in the order of groundnut > sunflower > blackgram > castor. However, rice-blackgram sequence registered higher production efficiency and rice-castor gave higher land-utilization efficiency. Rice-groundnut sequence proved more sustainable and profitable, especially for Telangana region of Andhra Pradesh.

Srinivas A. and Srinivas Raju M. (1997) carried out the investigation to find out a better suitable and profitable cropping system with multiple crops to optimize the land use under light irrigation conditions. A three year field study was carried out during 1993-94 to 1995-96 at Karimnagar. There were seven cropping systems, viz: pigeonpea-maize, pigeonpea-groundnut, pigeonpea-sunflower, pigeonpea-sesame, pigeonpea-indian mustard, pigeonpea-greengram and pigeopea-pigeonpea. The yields of winter crops were converted

to pigeonpea equivalent yields. The pigeonpea grain yield equivalent of different pigonpea based cropping systems indicated that pigeonpea-groundnut followed by pigeonpea-maize were superior to all other crop sequences. The highest net returns was from pigonpea-groundnut. The lowest equivalent yield and net returns was observed in pigeonpea-sesame sequence. The lowest benefit : cost ratio was observed in pigeonpea-sunflower because of lower cost of cultivation. The production efficiency was higher in pigeonpea-groundnut (14.1 kg/ha/day). Thus,under Sri Ram Sagar project command area short duration pigeonpea followed by groundnut was found most suitable followed by pigeonpea-maize.

Nandurkar *et al.* (1998), in order to find out suitable and economically viable cropping sequence, eight cropping sequences were studied during 1991-92, 1992-93 and 1993-94, at Amgaon Bhandare district, of Maharashtra. The gross monetary return, net return, and cost : benefit ratios were highest for the soyabean-chickpea-groundnut sequence. The other most remunerative cropping sequences were rice-fallow-groundnut and rice-sunflower-groundnut.

Kalia *et al.* (1999) conducted a field experiment in 1989-90 to 1992-93 at Malan, Himachal Pradesh, India, comparisons were made of rice followed by potatoes, wheat, Brassica napus, linseed or gram (*Cicer arietinum*). Rice yield did not differ much between the different cropping sequences,

but the rice-potato sequence gave the greatest overall yield and the highest net returns, followed by rice-wheat and rice-gram.

Tripathi *et al.* (1999) carried out a field study for three years at the experimental farm, Karnal to compare the productivity and economics of six important wheat based cropping sequences. Among the crop sequences tried, the most remunerative crop sequence observed was pusa Basmati followed by wheat (*rabi*). Maize-wheat rotation gave the lowest average returns and the least profit. In basmati rice-wheat sequence, on an average about 85% net returns was contributed by basmati rice and only 15% by wheat. Among the crops, the most remunerative was basmati rice followed by berseem, soybean and last profitable was maize.

2.3 Production-Function Studies :

The studies pertaining to input-output relationship or production function have gained much importance in recent years mainly because they provide a sound basis for developing economic aspects of agricultural production on a pattern which would guide cultivators to operate at least cost and highest profit combination.

Various works on resource productivities related to different crops and cropping sequences are mentioned below in brief. It may be pointed out here that the author could not find important studies with special reference to resource

productivities of different cropping sequences and hence this work will be rather pioneer in this field

Acharya T.K.T. (1965) estimated resource productivity and resource allocation of sugarcane grown under irrigation and dry land conditions in Queensland by production-function analysis. He concluded that wet farms gave higher marginal returns than dry ones. Marginal returns for machinery and labour productivity was found to be low while it was higher for fertilizers and land.

The analysis of data from Ahmednagar and Nasik districts of M.S. done by Jha S. (1967) indicated that the elasticities in respect of human labour and working capital were higher in bigger sized farms as compared to the smaller ones. Singh R.V. (1968) had fitted most common forms of Cobb-Douglas, Quadratic and Square-function for studying the productivity of farm resources. He observed that, in almost all these equations, the co-efficients were non-significant or negative signs attached to them. The Cobb-Douglas type of equation which was retained for the final analysis took the following from.

$$Y = 22.01163\ X_1^{0.461}\ X_2^{0.088}\ X_3^{0.516}$$

$$R^2 = 0.8298$$

Where,

Y = main product per acre

X_1 = human labour in days per acre

X_2 = manure and fertilizers in rupees per acre

X_3 = irrigation number per acre

Waghmare and Shingare (1968) fitted a production function for paddy crop. They stated that, individual inputs showed diminishing returns but the sum of elasticities showed increasing returns. Marginal returns to land and bullock labour were above the marginal cost.

Tambad and Hiregoudar (1969) had studied optimum utilization of resources in sugarcane. The function took place in following form :

$$Y = -0.5937\ X_1^{0.17}\ X_2^{0.74}\ X_3^{0.27}$$

Where,

X_1, X_2 and X_3 were, human and bullock labour in rupees, land in guanthas, manure and fertilizers in rupees. At first, seed was additional variable but regression coefficient of seed showed non-significant relation to output and therefore, they dropped this variable. From this it was concluded that the seed rate in sugarcane was not a significant variable.

Ram and Gupta (1978) fitted a Cobb-Douglas production function to examine resource productivity and efficiency of

resources on adopter and non-adopter paddy farms, by using following variables :-

Y	=	Value of output (Rs.)
X_1	=	area under paddy (ha)
X_2	=	human labour days
X_3	=	bullock labour days
X_4	=	value of manure and fertilizers (Rs)

They observed that the co-efficients of land and manure and fertilizer were highly significant and that of human and bullock labour were significant, indicating that yield can be increased by using more of these resources. The marginal value products of all inputs are quite high on adopter farms rather than on non-adopter farms, indicating that there is a scope for increasing profitability on adopter farms.

Kennedy *et al.* (1990) studied the cost and returns, resource use efficiency and production constraints of growing three pulse crops blackgram, red gram and bengal gram (chickpea) in Guntur district, A.P. Returns to scale and resource use efficiency were measured by using Cobb-Douglas production function. The calculated elasticities of land, labour, plant protection were positive indicating that increase in these variables would increase gross returns.

2.4 Employment Potentiality :

Bains (1967) pointed out that, instead of conventional practice of growing one crop a year, if two crops were grown, the employment patential could be increased by two fold If three crops were grown, the employment potential could be increased three folds and so on. He also stated that the adoption of new technology and multiple cropping sequences can offer gainful employment opportunity to a much larger labour force of the country.

Soltani (1974), while estimating the total labour employment in man-equivalent days on farm, converted all woman days and child days by assigning a ratio of 2 child days = 1.25 woman days = 1 man day.

Balishter (1983) estimated relative factor shares in bullock operated farms. The Cobb-Douglas production function was fitted to estimate the factor shares from the data collected from Agra district of U.P. for the year 1981-82. The factors included were farm size, irrigated area, fertilizer, human and bulock labour. The results showed that among different factors, the highest contribution to the farm income was made by farm size. However, the contribution of farm size to farm income was higher in case of bullock operated farms as compared to the tractor operated farms. Thus with the increase in farm tractorization, the relative share of land decreased. Although the share of human labour was negative on both the farms, the negative share was more in case of

bullock operated farms as compared to tractor operated farms. Thus, tractorization decreased the share of human labour in farm income. The share of irrigated area in farm income ranked second after firm size for the bullock operated farms. The share of fertilizer was higher for tractor operated farms. The share of bullock labour was positive but not significant in case of tractor operated farms, while it was negative in case of bullock operated farms.

Borah (1983) examined the factor shares in traditional farming in Assam and concluded that human labour constituted two-third of the total variable cost, whereas the percentage share of manure and fertilizer input was found to be less than one per cent. Depreciation accounted for about half of the total fixed cost. The marginal value products of different resources worked out to be much less than that of the respective cost of factors used. The ratio of output to input tended to decline according to farm size, indicating thereby diseconomics of scale in traditional farming.

The level of technology and its impact on labour employment were studied by Sidhu and Grewal (1990) on the basis of data of the comprehensive scheme in Punjab for the year 1980-81. The proportion of hired labour to the total labour use was greater than that of family labour in case of tractor operated farms. The farm size was found to have negative relationship with labour use. The intensity of cropping as well as the use levels of manures and fertilizers,

MATERIAL AND METHODS

3. METHODOLOGY

3.1 Basic Approach of the Study

In order to feed the ever increasing population in our country, we have to resort to intensive cropping. The choice of crop enterprises and recent technological advancement in agriculture have made different cropping sequences economically feasible. Hence, it is necessary to work out suitable crop combinations for a particular agro-climatic complex. The basic objectives which formulated with above view, are to investigate into the economic aspects of the major cropping sequences adopted by the farmers in an irrigated area of Satara district of Maharashtra. An attempt is made in this study to estimate the per hectare cost of production and income of the selected cropping sequences by using standard cost concepts. In order to arrive at scientific and meaningful conclusions from the present investigation, it was necessary to have an appropriate plan of investigation i.e. sample design, source of data, method of analysis, etc., which is presented in this chapter.

3.2 Selection of the Sample

a) Area

As mentioned earlier, the present study is confined to the irrigated area of Wai tahsil of Satara district. The tahsil Wai is gifted by the nature for availability of irrigation water of river

Krishna which originated at Mahabaleshwar of Sahyadri ranges on the Western ghats of the district. The two canals viz; Dhom right and Dhom left canals provide enough irrigation water to the Wai tahsil. In view of this, Wai tahsil was selected for present investigation.

b) Cropping Sequences

Cropping sequences, instead of individual crop, are considered as the real activities in the present study. One of the reasons is that, the cropping sequences restricted the duration of cropping to one year only. Secondly, the yield of crop is affected, inter-alia by the type of crop rotation followed over a period. There is an interaction between different crops grown in different combinations in a cropping sequence which affects the yield of successive crop considerably. Therefore, each rotation of crops during the particular year has been defined as a separate cropping sequence.

The most common cropping sequences followed in Wai tahsil were selected for the present study.

The cropping sequences were –

I) One crop sequence (Monocropping) sugarcane (suru)

II) Two crops sequence (Double cropping)

a) Sorghum in *kharif* followed by gram in *rabi*

b) Tomato in *kharif* followed by wheat in *rabi.*

III) Three crops sequence (Triple Cropping)

a) Chilli in *kharif* followed by wheat in *rabi* followed by groundnut in *summer.*

b) Paddy in *kharif* followed by pea in *rabi* followed by groundnut in *summer.*

c) Selection of Sample Villages and Cultivators

The design adopted for the investigation was the two stage sampling with villages as the primary unit and cultivators as the secondary unit. Five villages viz. Ozarde, Bhuinj, Panchwad, Surur and Shendurjane from Wai tahsil were selected on the basis of cropping sequences followed by cultivators and availability of irrigation facilities throughout the year.

In the second stage, the list of cultivators, who had adopted the selected cropping sequences during 1998-99 was obtained from the village records. In all 30 sample farmers were selected for each sequence, thus for five sequences in all 150 sample farmers were selected.

3.3 Collection of Data

Considering the limited time at the disposal of the researcher, the survey method was adopted for collection of data. The data related to agricultural year 1998-99 were collected with the help of schedules specially designed for the purpose. Detailed information about the cropping pattern,

capital investment, investment on livestock, physical quantities of resources used and their costs, yields and returns in respect of individual crops raised in the selected cropping sequences was collected personally from the sample cultivators. The schedules used for collection of data in the present investigation are given in Appendix

3.4 Analysis of Data

a) Cost of Cultivation and Receipts Structure

For arriving at the statement of cost of cultivation, the standard cost concepts viz; Cost A, Cost B and Cost C were used. These cost concepts and their definitions were standardized at the seminar on "Agricultural Price Policies" organized by F.A.O./ECAFE at New Delhi in March-April, 1958. The details of various cost concepts as used in the analysis are given below :

i) Cost A

It is the paid out cost consisting of value of hired human labour, hired and owned bullock labour, manures and fertilizers, seeds / seedlings/sets, irrigation, plant protection measures, marketing, hired machinery charges and / or owned machinery expenditure, land revenue, educational cesses and other taxes, depreciation and repairs on implements and machinery and interest on working capital.

The per unit values of the inputs under cost A were as follows :

Hired humar labour		
Male	-	Rs. 50/day
Female	-	Rs. 30/day
Bullock labour	-	Rs. 100/days
Manures	-	Rs. 1000/20 q
Fertilizers		
N	-	Rs. 9.80/kg
P	-	Rs. 18.75/kg
Irrigation	-	Rs. 150/irrigation/ha

Seed (s) / sets		
Sorghum	-	Rs. 19/kg
Wheat	-	Rs. 12/kg
Gram	-	RS. 22/kg
Groundnut	-	Rs. 30/kg
Chilli	-	Rs. 56/100 g
Pea	-	Rs. 48/kg
Tomato	-	Rs. 16/g
Paddy	-	Rs. 30/kg
Sugarcane	-	Rs. 500/tonne

ii) Cost B

It is the Cost A plus inputed rental value of owned land and inputed interest on fixed capital.

iii) Cost C

It is the Cost B plus inputed value of family human labour. Interest on working capital and interest on fixed capital, were charged at the rate of 13 per cent for half of the life period of crops and 11 per cent respectively. Depreciation of fixed assets was calculated at 20 per cent for wooden implements and minor tools, 15 per cent for bullock carts and 10 per cent for iron implements and machinery. The depreciation, repairs and interest on fixed assets were apportioned to the crop on the basis of gross cropped area. Rental value of owned land was calculated on the basis of one fourth of the value of gross produce obtained from a particular cropping sequences minus land revenue.

iv) Returns

To have a meaningful comparison and to arrive at meaningful conclusions, it is necessary to calculate net income derived from different cropping sequences. The returns over Cost A, Cost B and Cost C were calculated separately. The values of output per unit were also calculated.

b) Estimation of Resource Productivities

A scientific study of input-output relationship in agriculture provides a sound basis for developing the production plan and deciding the economic level of inputs used in agricultural production. Various types of functions

could be fitted to agricultural production data, each subject to its assumptions and limitations. On account of its general acceptance for agricultural production data, the Cobb-Douglas type of function which is linear in logarithms and multiple linear regression function have been fitted, to the per hectare data of each cropping sequence in the present study.

The specific form of Cobb-Douglas type of Production Function used is :

$$Y = ax_1^{b1}\ X_2^{b2}\ X_3^{b3}\ X_4^{b4}\ X_5^{b5}\ X_6^{b6} e^{u}$$

and the specific form of linear function used is –

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + u$$

Where, Y is dependent variable, X_i's are independent variables, b_i's, regression coefficients (which are also production elasticities of the corresponding inputs in Cobb-Douglas production Function) and 'a' is the constant.

The variables included in the production function study are given as below –

Y	=	Gross receipts in Rs./ha
X_1	=	Total human labour (hired and family) in man equivalent days/ha
X_2	=	Farm yard manure in q /ha
X_3	=	Nitrogen in Kg/ha
X_4	=	Phosphorus in kg/ha
X_5	=	Irrigation charges in Rs/ha

X_6 = Total fixed capital in Rs/ha

u = error term

The values of regression coefficients in respect of different cropping sequences were compared with each other along with their tests of significance.

Further, only Cobb-Douglas type of production function was used for estimating the marginal productivities and optimum use levels of individual resources. The marginal value products of individual resource input have been worked out at the geometric mean level of the respective input, holding all other inputs constant at their geometric mean levels. An attempt is also made to estimate the optimum levels of resource use under the unlimited and limited capital situations on the basis of their marginal value products, marginal costs and production elasticities of corresponding resources.

At all the levels, the economics of cropping sequences (Costs and returns structure) and resource use efficiency (production function and optimum level of resource use) for selected cropping sequences were compared with each other, in order to arrive at meaningful conclusions from the present investigation.

RESOURCEPRODUCTIVITIES OF SELECTED CROPPINGSEQUENCE ECONOMICS OF CROPPINGSEQUCENCES

4. ECONOMICS OF THE SELECTED CROPPING SEQUENCES

The success of any enterprise in agriculture can be judged on the basis of economic benefits obtained from it. In the present age of competition the farmer in irrigated area is interested to adopt the newly developed technology. It has become necessary for him to look upon agriculture as the commercial pursuit. This can be achieved, when farmer chooses such crop and livestock enterprises which will give him the highest returns.

In view of this, an attempt has been made to analyse the cost and returns from the selected cropping sequences in detail, so as to assess the economics of selected cropping sequences.

4.1 Cost of production of the selected cropping sequences

In modern agriculture, much emphasis is given to *intensive cultivation* which needs more capital. It is a general assumption that when one applies more and more capital, the profits are increased. In this context, it could be interesting to analyse the amount of capital spent on each resource input in each of the selected cropping sequences. Table 4.1 depicts the information relating to the itemwise per hectare cost of production of the selected cropping sequences.

The per hectare total cost of production i.e. cost C worked out to Rs.55799.80 for sugarcane (suru), Rs.34358.39 for sorghum-gram, Rs.75166.26 for tomato-wheat, Rs.71522.21 for chilli-wheat-groundnut and Rs.87432.48 for paddy-pea-groundnut cropping sequences, respectively. This clearly shows that, the paddy-pea-groundnut cropping sequence was highly capital intensive followed by tomato-wheat, chilli-wheat-groundnut, sugarcane (suru) and sorghum-gram cropping sequences.

Looking to the itemwise costs of selected cropping sequences, it has been observed that the costs on the inputs like seeds, manures, fertilizers and irrigation were relatively high in case of paddy-pea-groundnut followed by sugarcane (suru), tomato-wheat, chilli-wheat-groundnut and sorghum-gram, cropping sequences. The costs of human labour and bullock labour were maximum in case of paddy-pea-groundnut followed by chilli-wheat-groundnut, sugarcane (suru), tomato-wheat and sorghum-gram cropping sequences. The cost of marketing in case of sugarcane (suru) was totally absent because of disposal by sugar factories, while it was found to be highest in tomato-wheat cropping sequences.

The share of cost A in the total cost worked out to 63.92 per cent, 53.63 per cent, 54.48 per cent, 54.18 per cent and 51.19 per cent for sugarcane (suru), sorghum-gram, tomato-wheat, chilli-wheat-groundnut and paddy-pea-groundnut cropping sequences, respectively. In case of sugarcane (suru),

the share of cost A in the total cost was relatively high as compared to other cropping sequences. It clearly showed that the sugarcane (suru) was highly paidout capital intensive as compared to that of other cropping sequences. The percentage share of human labour and bullock labour in the total cost was 20.88 per cent, 19.25 per cent, 13.60 per cent, 23.81 per cent and 20.40 per cent for sugarcane (suru), sorghum-gram, tomato-wheat, chilli-wheat-groundnut and paddy-pea-groundnut cropping sequences respectively. Similarly, the share of other resources viz; seeds, manures, fertilizers and irrigation together was 31.66 per cent, 15.55 per cent, 20.04 per cent, 19.21 per cent, and 22.80 per cent for sugarcane (suru), sorghum-gram, tomato-wheat, chilli-wheat-groundnut, and paddy-pea-groundnut cropping sequences respectively. It clearly showed that, the share of human labour and bullock labour in the total cost was highest in chilli-wheat-groundnut cropping sequence while it was the lowest in tomato-wheat sequence. Contrary to this, the share of other resources viz; seeds, manures, fertilizers and irrigation was the highest in sugarcane (suru) while it was the lowest in sorghum-gram cropping sequence.

The items such as rental value of owned land, manures and fertilizers, irrigation, interest on fixed and working capital, human and bullock labour were the major items of cost in all the cropping sequences.

Table 4.1 : Per hectare itemwise cost of production of the selected cropping sequences.

(Cost in Rupees)

Sr No		Sugarcane (suru)		Sorghum-Gram		Tomato-Wheat		Chilli-Wheat-Groundnut		Paddy-Pea-Groundnut	
		Cost	% age	Cost	% age	Cost	% age	Cost	% age	Cost	% age
1	2	3	4	5	6	7	8	9	10	11	12
1	Hired Human Labour										
	Male	3150 00	5 65	396 50	1 16	1205.00	1 60	2211 00	3.09	1462 00	1 67
	Female	2250 00	4 03	697 50	2 03	2376 90	3 16	885 30	1 24	1743 00	1 99
2	Bullock Labour (Hired & Owned)	3000 00	5 38	3109 00	9 05	3937 00	5 24	7386 00	10 33	7614 00	8 71
3	Hired machinery charges and /or owned machinery expenditure	1500 00	2 69	179 95	0 52	220 51	0 29	220 51	0 31	-	-
4	Seeds/Seedlings/ Sets	5000 00	8 96	1718 32	5 00	4323 08	5 75	4171 78	5 83	10542 30	12 06
5	Manures	6000 00	10 75	1445 00	4 21	6000 00	7 98	3010 50	4 21	3735 50	4 27
6	Fertilizers	2915 75	5 23	1280 69	3 73	2193 62	2 92	2509 95	3 51	2058 15	2 35
7	Plant protection	-	-	111 47	0 32	305 00	0 41	340 00	0 47	460 45	0 53

Table 4.1 : Contd...

1	2	3	4	5	6	7	8	9	10	11	12
8	Irrigation	3750 00	6.72	900 00	2 62	2550 00	3.39	4050 00	5 66	3600 00	4 12
9	Repairs, etc.	2250 00	4 03	82 07	0 24	45 60	0 06	136 80	0 19	91 05	0 10
10	Land Revenue	200 00	0 36	42.57	0 12	48 65	0 07	70 95	0 10	75 50	0 09
11	Marketing	-	-	6948 00	20 22	14580 00	19 40	11040 00	15 44	10290 00	11 77
12	Interest on working capital	3902 05	6 99	1099 22	3 20	2459 30	3 27	2344 08	3 28	2708 67	3 10
13	Depreciation	1748 00	3.13	415 71	1 21	705 35	0 94	370 09	0 52	371 76	0 43
	* Cost A	35665 80	63 92	18426 00	53 63	40950.01	54 48	38746 96	54.18	44752 38	51.19
14	Rental value of land	16050 00	28 76	12782 43	37 20	30326 35	40 35	24866 55	34 77	34299 50	39 23
15	Interest on fixed capital	834 00	1.50	740 56	2 16	1187 30	1 58	1360 30	1 90	1360 00	1 55
	* Cost B	52549 80	94 18	31948 99	92 99	72463 66	96 41	64973 81	90 85	80411 88	91 97
16	Owned Human Labour										
	Male	3250 00	5 82	1805 50	5 25	1718 00	2 29	4620 00	6 46	4134 00	4 73
	Female	-	-	603 90	1 76	984 60	1 30	1928 40	2 69	2886 60	3 30
	* Cost C	55799 80	100 00	34358 39	100 00	75166 26	100 00	71522 21	100 00	87432 48	100 00

4.2 Returns from the selected cropping sequences and value per unit

The per hectare gross returns obtained from the selected cropping sequences are presented in Table 4.2.

The per hectare gross returns obtained were Rs.68200 in sugarcane (suru), Rs.51300 in sorghum-gram, Rs.106500 in tomato-wheat, Rs.99000 in chilli-wheat-groundnut and Rs.137500 in paddy-pea-groundnut cropping sequences, respectively. The per hectare returns worked out at cost A were Rs.32534.20, Rs.32874.00, Rs.65549.99, Rs.60253.04 and Rs.92747.62; whereas it was Rs.15650.20, Rs.19351.01, Rs.34036.34, Rs.34026.19 and Rs.57088.12 at Cost B. The net returns at cost C worked out to Rs.12400.20, Rs.16941.61, Rs.31333.74, Rs.27477.79 and Rs.50067.52 from sugarcane (suru), sorghum-gram, tomato-wheat, chilli-wheat-groundnut and paddy-pea-groundnut cropping sequences, respectively. The values of output per unit calculated were as below :

Sorghum -	Rs. 600/q	Wheat -	Rs. 900/q
Gram -	Rs. 1600/q	Groundnut-	Rs. 1500/q
Chilli (green)-	Rs. 500/q	Pea -	Rs. 2000/q
Tomato -	Rs. 500/tonne	Paddy -	Rs. 2000/q
Sugarcane-	Rs. 650/tonne		

Table 4.2 : Per hectare returns from selected cropping sequences

(Rupees)

Sr No	Particulars	Cropping sequences				
		Sugarcane (suru)	Sorghum-gram	Tomato-wheat	Chilli-wheat-groundnut	Paddy-pea-groundnut
1	Value of main produce	65000 00	49800 00	106500 00	99000 00	137500 00
2	Value of By produce	3200 00	1500 00	-	-	-
3	Gross returns	68200 00	51300 00	106500 00	99000 00	137500 00
4	Returns at cost A	32534 20	32874 00	65549 99	60253 04	92747 62
5	Returns at cost B	15650 20	19351 01	34036 34	34026 19	57088 12
6	Net returns at cost C	12400 20	16941 61	31333 74	27477 79	50067 52

4.3 Comparative Economics of the Selected Cropping Sequences

The analysis attempted so far gives an idea with regard to relative profitability of individual cropping sequences on the basis of magnitude of costs that farmers have incurred for production and returns obtained by them from cultivating these cropping sequences. From the comparison of actual net returns realized by the farmers, one can easily know as how profitable is the production of these cropping sequences and which cropping sequence gives the highest profit. The per hectare cost A, cost B, and Cost C as well as gross returns, returns at different costs and output input ratio are presented in Table 4.3.

Table 4.3 : Comparative economics of selected cropping sequences

Sr No	Particulars	Monocropping	Two crops sequences		Three crops sequences	
		Sugarcane (suru)	Sorghum-Gram	Tomato-Wheat	Chilli-Wheat-Groundnut	Paddy-Pea-Groundnut
	Cost (Rs.)					
1	Cost A	35665 80	18426 00	40950 01	38746 96	44752 38
2	Cost B	52549 80	31948 99	72463 66	64973 81	80411 88
3	Cost C	55799 80	34358 39	75166 26	71973 81	87432 48
	Returns (Rs.)					
1	Gross returns	68200 00	51300 00	106500 00	99000 00	137500 00
2	Returns at cost A	32534 20	32874 00	65549 99	60253 04	92747 62
3	Returns at cost B	15650 20	19351 01	34036 34	34026 19	57088 12
4	Returns at cost C	12400 20	16941 61	31333 74	27026 19	50067 52
	Output-input ratio					
1	At cost A	1 91	2 78	2 60	2 56	3 07
2	At cost B	1 30	1 61	1 47	1 52	1 71
3	At cost C	1 22	1 49	1 42	1 38	1 57

It can be observed from the table, that the total cost i.e. Cost C was the highest in Paddy-pea-groundnut cropping sequence followed by tomato-wheat, chilli-wheat-groundnut, sugarcane (suru) and sorghum-gram cropping sequences. While returns at all the levels i.e. at Cost A, Cost B, and Cost C, were found to be the highest in paddy-pea-groundnut cropping sequence followed by tomato-wheat, chilli-wheat-groundnut, sorghum-gram and sugarcane (suru) cropping sequences.

The output-input ratios, as seen from Table 4.3 at Cost C were 1.22, 1.38, 1.42, 1.49, and 1.57 for sugarcane (suru), chilli-wheat-groundnut, tomato-wheat, sorghum-gram and paddy-pea-groundnut cropping sequences, respectively which indicated the returns from one rupee invested in each enterprise. The per rupee return from paddy-pea-groundnut cropping sequence is more than that of other cropping sequences, indicating thereby further scope for adopting paddy-pea-groundnut cropping sequence.

4.4 Costs and returns from the selected cropping sequences over and above the monocropping of sugarcane (suru)

Choice of cropping sequence plays an important role in the business of agriculture. The decision as to the selection of a cropping sequence depends, among other things, on the relative costs and profits of several possible cropping

sequences and increasing component of cropping intensities in comparison with the standard monocropping crop sequence. The basic monocropping crop sequence in the present study is the sugarcane (suru).

Such comparison is helpful in providing information on operationally feasible alternatives in cropping sequences to maximize the efficiencies of production resources. The data in this respect are presented in Table 4.4 and depicted in Fig. 1.

Table 4.4 : Comparative costs and returns from selected cropping sequences over sugarcane (suru)

(Rupees)

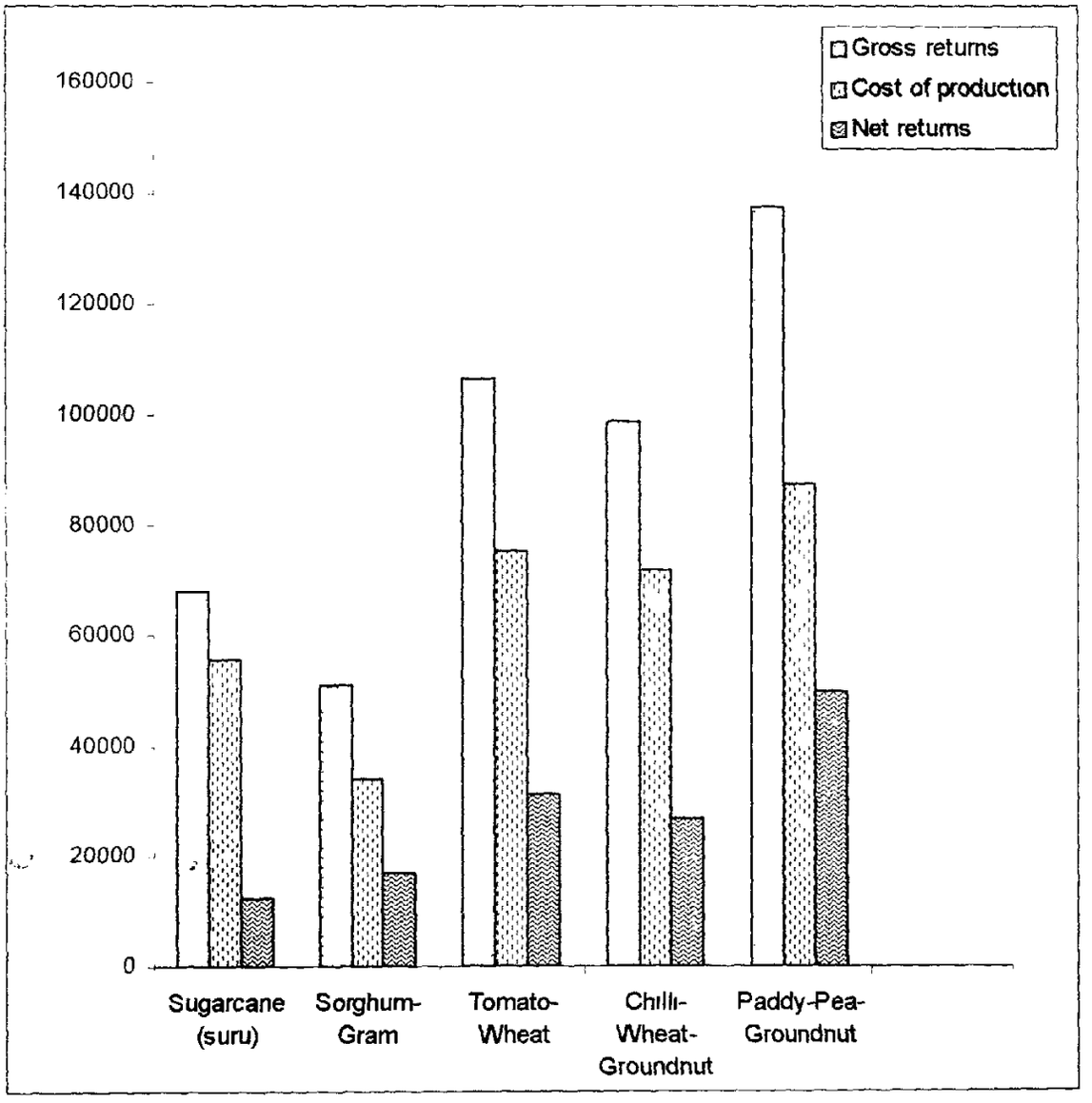
Sr No	Particulars	Two crops sequences		Three crops sequences	
		Sorghum-gram	Tomato-wheat	Chilli-wheat-groundnut	Paddy-pea-groundnut
A	Change in cost over sugarcane (suru)	- 21441 41	+19366 46	+16174 01	+31632 68
B	Change in returns over sugarcane (suru)				
	i. At gross returns	-16900 00	+38300 00	+30800 00	+69300 00
	ii At cost A	+ 339 80	+33015 79	+27718 84	+60213 42
	iii At cost B	+ 3700 81	+18386 14	+18375 99	+41437 92
	iv At cost C	+ 4541 41	+18933 54	+14625 99	+37667 32

It has been noted from the Table 4.4 that by spending Rs.21441.41 less towards sorghum-gram cropping sequence as compared to sugarcane (suru), one will get more net income of Rs. 4541.41. But, by spending Rs.19366.46 and Rs.16174.01 more in case of tomato-wheat and chilli-wheat-groundnut, one can get additional profit of Rs.18933.54 and

Rs.14625.99 respectively over sugarcane (suru). By spending Rs.31632.68 more in case of paddy-pea-groundnut cropping sequence one can get additional profit to the extent of Rs.37667.32 over sugarcane (suru).

It can be concluded from the above that the most profitable cropping sequence is paddy-pea-groundnut, which gives the maximum net returns to the farmers, followed by tomato-wheat, chilli-wheat-groundnut and sorghum-gram cropping sequences. All the above cropping sequences are economically superior over the sugarcane (suru).

Fig No 1 Per hectare costs and returns from selected cropping sequences



RESOURCEPRODUCTIVITIES OF SELECTED CROPPINGSEQUENCE

5. RESOURCE PRODUCTIVITIES OF SELECTED CROPPING SEQUENCES

The production function analysis technique has been extensively used in agricultural economics research to estimate resource productivities. This approach plays an important role in the application of economic theory in solving farm business problems. It recognizes the basic functional relationship that is related to decision making. It also offers a powerful tool in resource reallocations under different economic, social and cultural conditions in the farm planning and reallocation of farm resources.

The main purpose of this chapter is to study the output-input relationship. This relationship determines the extent to which the important factors, considered as independent variables, explain the variability in the output. Besides this, assuming that all other independent variables are held constant at their mean levels, the specific contribution of marginal unit of a particular independent variable to the dependent variable will be an important information. The comparison of marginal value product of a particular resource with its marginal cost, indicates whether existing resource use pattern is greater than or less than the optimum level, based on which one can either increase or decrease the use of the given resources for profit maximization.

5.1 Selection of functional form

Functional relationship between resource inputs and output can be expressed by different forms of production functions. But from the literature on production function, it is observed that the linear and Cobb-Douglas functional forms are most widely used. This is because they are easy to estimate and relationship is adequately depicted by these forms. These types of production functions were tried, however, log-linear production function was observed to be more superior and therefore results of the Cobb-Douglas production function has been used for determining the marginal productivities and optimum use of different resources under limited and unlimited capital situation.

5.2 Variables and their specification

As described in the chapter of methodology, the following variables were specified for estimating production functions for the individual cropping sequences.

Y = Gross returns in rupees per hectare

X_1 = Total human labour in man equivalent days per hectare

X_2 = Farm yard manure in quintals per hectare

X_3 = Nitrogen in kilograms per hectare

X_4 = Phosphorus in kilograms per hectare

X_5 = Irrigation charges in rupees per hectare

X_6 = Total fixed capital in rupees per hectare

In addition to the above variables, bullock labour was also tried as an additional independent variable in the beginning. However, it's regression coefficient turned out to be negative and non-significant in almost all the cropping sequences and therefore, the same was dropped out from the final analysis. Thus, only six independent variables were considered for functional analysis.

5.3 Estimated production function

The Cobb-Douglas type of production functions estimated for the individual cropping sequences are as under,

I) Sugarcane (suru)

$$Y = 1\ 7980\ X_1^{1\ 1714}\ X_2^{-0\ 1743}\ X_3^{0\ 0867}\ X_4^{0\ 3838}\ X_5^{1\ 4394}\ X_6^{0\ 0184}$$

II) Sorghum-gram

$$Y = 2\ 5249\ X_1^{0\ 2528}\ X_2^{0\ 3321}\ X_3^{0\ 1995}\ X_4^{0\ 1735}\ X_5^{0\ 1804}\ X_6^{0\ 0147}$$

III) Tomato-wheat

$$Y = 2.0942\ X_1^{-0\ 2298}\ X_2^{0\ 2190}\ X_3^{0\ 1845}\ X_4^{-0\ 0064}\ X_5^{0\ 7829}\ X_6^{-0\ 0038}$$

IV) Chilli-wheat-groundnut

$$Y = 0.7498\ X_1^{0\ 6599}\ X_2^{-0\ 0027}\ X_3^{0\ 0542}\ X_4^{0\ 1193}\ X_5^{0\ 4109}\ X_6^{0\ 2149}$$

V) Paddy-pea-groundnut

$$Y = 3.1451\ X_1^{0\ 0999}\ X_2^{-0\ 0268}\ X_3^{0\ 6355}\ X_4^{0\ 0103}\ X_5^{0\ 1437}\ X_6^{0\ 0168}$$

VI) Overall

$$Y = 2\ 0600\ X_1^{-0\ 3272}\ X_2^{0\ 5181}\ X_3^{-0\ 2535}\ X_4^{0\ 2201}\ X_5^{0\ 3872}\ X_6^{0\ 3863}$$

The estimated regression coefficients of inputs alongwith their respective standard errors and the coefficients of multiple determination are presented in Table 5.1.

5.4 Coefficients of multiple determination (R^2), regression coefficients and their tests of significance

It can be observed from the results presented in Table 5.1 that of the total variation in the dependent variable (i.e. gross value) as much as 84.89 per cent in case of sugarcane (suru), 80.34 per cent in case of sorghum-gram, 87.14 per cent in case of tomato-wheat, 86.82 per cent in case of chilli-wheat-groundnut and 91.68 per cent in case of paddy-pea-groundnut sequence, was explained by the six independent variables included in the production function.

Table 5.1 further reveals that the regression coefficient of human labour with respect to Tomato-wheat cropping sequence, farm yard manure with respect to sugarcane (suru), chilli-wheat-groundnut and paddy-pea-groundnut cropping sequences and that for phosphorus with respect to tomato-wheat cropping sequence were negative and non-significant.

This indicates that one per cent increase in employment of human labour at its geometric mean will decrease the gross returns of tomato-wheat cropping sequence by 0.2298 per cent at their geometric mean. Similarly, one per cent increase in application of farm yard manure at its geometric mean will decrease the gross returns of sugacane (suru), chilli-wheat-

groundnut and paddy-pea-groundnut cropping sequences by 0.1743, 0.0027 and 0.0268 per cent at their geometric mean respectively. Also in case of tomato-wheat cropping sequence one per cent increase in application of phosphorus at its geometric mean will decrease the gross returns by 0.0064 per cent at its geometric mean level.

These results show that the use of human labour, farm yard manure and phosphorus was in excess in above cropping sequences resulting thereby into reduction in the yields. The regression coefficients and test of significance of the remaining inputs like human labour in sugarcane (suru), farm yard manure in sorghum-gram, tomato-wheat sequence, nitrogen in paddy-pea-groundnut, phosphorus in sugarcane (suru), irrigation in case of all cropping sequences and total fixed capital in chilli-wheat-groundnut cropping sequence, were highly significant. The regression coefficients of all other remaining inputs used in different cropping sequences were non-significant.

The sum of production elasticities for all the cropping sequences, except tomato-wheat and paddy-pea-groundnut cropping sequences were more than one indicating increasing returns to scale.

Table 5.1: Comparative structure of resource productivities (Cobb-Douglas production function)

Sr No	Cropping sequence	Constant	Regression coefficients						Σ b_i	Coeff of multiple determination (R^2)	No of samples
			b_1	b_2	b_3	b_4	b_5	b_6			
1	Sugarcane (suru)	1 7980	1 1714* (0 6559)	-0 1743NS (0 1666)	0 0867 NS (0 1322)	0 3838 ** (0 1642)	1 4394*** (0 2716)	0 0184NS (0 1902)	2 9254	0 8489	30
2	Sorghum-Gram	2 5249	0 2528 NS (0 3864)	0 3321*** (0 1182)	0 1995NS (0 3366)	0 1735NS (0 1887)	0 1804** (0 0815)	0 0147NS (0 0404)	1 1530	0 8034	30
3	Tomato-Wheat	2 0942	-0 2298NS (0 7385)	0 2190* (0 1059)	0 1845NS (0 2888)	-0 0064NS (0 0468)	0 7829*** (0 1066)	0 0038NS (0 0622)	0 9464	0 8714	30
4	Chilli-Wheat-Groundnut	0 7498	0 6599NS (0 5189)	-0 0027NS (0 0766)	0 0542NS (0 2415)	0 1193NS (0 1266)	0 4109* (0 2203)	0 2149 ** (0 0953)	1 4565	0 8682	30
5	Paddy-Pea-Groundnut	3 1451	0 0999 NS (0 2574)	-0 0268 NS (0 0606)	0 6355 ** (0 2435)	0 0103 NS (0 0440)	0 1437 * (0 0752)	0 0168 NS (0 0125)	0 8794	0 9168	30
6	Overall	2 0600	-0 3272 NS (0 1706)	0 5181 *** (0 0909)	-0 2535 NS (0 0722)	0 2201 *** (0 0804)	0 3872 *** (0 1342)	0 3863 *** (0 0714)	0 9310	0 7392	150

Figures in parentheses are standard errors

* Significant at 10% ** Significant at 5%,

*** Significant at 1%, N.S. Not significant

5.5 Marginal value productivities of individual resources

As stated earlier, comparison of marginal value productivities of resources with their acquisition costs provides a tool for estimating the optimum use of different factors of production to maximize the profits. Based on such comparison the farmers can decide as to whether they should increase or decrease the use of that particular resource in the production. In view of this, marginal value products were worked out from the values of elasticities of production corresponding to different resources and presented in Table 5.2.

Given the power function

$$Y = aX^b$$

$$\frac{dy}{dx} = bax^{b-1}$$

$$= \frac{bax^b}{x}$$

$$= \frac{by}{x}$$

Where the values of y and x are considered to be at their geometric mean.

Table 5.2 : Marginal value productivities for the selected cropping sequences

Sr No	Variable	Sugarcane (suru)			Sorghum-Gram			Tomato-Wheat		
		G M	M.V P.	M C	G M	M.V P	M C	G M	M V P	M C
1	X_1	202 68	367.37	40 00	87 39	147 73	40 00	170.41	-141 50	40 00
2	X_2	58 89	-188.13	50 00	28 70	590 96	50 00	68 60	334 98	50 00
3	X_3	212.09	25 98	9 80	49 94	204 02	9 80	151 34	127 92	9 80
4	X_4	38 56	632 67	18 75	42 06	206 67	18 75	36 58	-18 36	18 75
5	X_5	3690 86	24 79	1 00	884 37	10 42	1 00	2505 23	32 79	1 00
6	X_6	7410 82	0 16	1 00	6491 10	0 12	1 00	10625 88	0 038	1 00
		G M of output = 63563 675			G M of output = 51070 25			G M of output = 104929 11		

Sr No	Variable	Chilli-Wheat-Groundnut			Paddy-Pea-Groundnut			Overall		
		G M	M V P	M C	G M	M V P	M C	G M	M V P	M C
1	X_1	230 22	281 24	40.00	266 07	51 46	40 00	179 22	-156 18	40 00
2	X_2	57 98	-4 57	50 00	73 93	-49 69	50 00	54 86	807 88	50 00
3	X_3	135 62	39.21	9 80	77 73	1120 61	9 80	111 06	-195 26	9 80
4	X_4	62 09	188 52	18 75	68 05	20 75	18 75	47.84	393 56	18 75
5	X_5	4024 89	10 02	1 00	3554 43	5 54	1 00	2591 12	12 78	1 00
6	X_6	12093 44	1.74	1 00	12090 88	0 19	1 00	9434 35	3 50	1 00
		G M of output = 98115 59			G M of output = 137064.82			G M of output = 85543 50		

$$\text{MVP of } X_i = b_i \cdot \frac{\text{G.M.of Y}}{\text{G.M.of X}} \quad ; \; i = 1\text{-}6$$

Where, G.M. = Geometric mean.

bi = Production elasticity of i^{th} input

The marginal value productivities of human labour for tomato-wheat cropping sequence, farm yard manure for sugarcane (suru), chilli-wheat-groundnut and paddy-pea-groundnut cropping sequences and phosphorus for tomato-wheat cropping sequence turned out to be negative as regression coefficients of these inputs were negative. Similarly, marginal value productivities of fixed capital for all cropping sequences except chilli-wheat-groundnut sequence was less than marginal cost of the respective input. It indicated that the use of this input should be reduced so as to maximize the profit.

The marginal value productivities of remaining inputs were, however, much higher than their respective acquisition costs. This indicated that there is a scope for increasing profitability of these sequences through increasing use of these resources.

5.6 Optimum level of resource use

From the comparison of MVPs of different resources with their acquisition costs, it is observed that there exists a scope for increasing profitability of different cropping sequences by

increasing or decreasing the use of these resources. However, such comparison cannot give exact idea about the optimum level of each resource. An attempt is therefore, made to estimate optimum level of use of different resources under unlimited and limited capital situation.

5.6.1 Optimum level of resource use under unlimited capital situation

The optimum level of resource use under unlimited capital situation has been worked out as ;

$$X_1 = \frac{bi\ y}{Px_1}, \quad i = 1\text{-}6$$

Where,

X_1 = Optimum level of i^{th} input.

bi = Production elasticity corresponding to i^{th} resource input.

Y = Geometric mean level of gross returns of corresponding cropping sequences.

Pxi = Price per unit of i^{th} input.

Table 5.3 : Estimated optimum level of resource use under unlimited capital situation

Sr. No	Cropping sequence	Resources					
		Human labour (man equivalent days/ha)	Manures (qtls/ha)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Irrigation (Rs/ha)	Total fixed capital (Rs/ha)
1	Sugarcane (suru)	1861.46 (203 00)	-221 58 (60.00)	562.34 (220 00)	1301.11 (40.52)	91493 55 (3750 00)	1169.57 (7578 49)
2.	Sorghum-Gram	322.76 (87.42)	339.21 (28.90)	1039 64 (50.00)	472.57 (42.17)	9213.07 (900.00)	750 73 (6732.36)
3	Tomato-Wheat	-602.82 (170.71)	459.59 (69.23)	1975.45 (151 67)	-35 82 (37.72)	82149.00 (2550 00)	398.73 (10793 63)
4.	Chilli-Wheat-Groundnut	1618.66 (230.41)	-5.30 (59 44)	542.64 (136.06)	624 28 (62.75)	40315.70 (4050 00)	21085 04 (12366.36)
5.	Paddy-Pea-Groundnut	342.32 (266.24)	-73 47 (74.71)	8888 23 (78 00)	75.29 (69.00)	19696 22 (3600.00)	2302 69 (12363.63)
6	Overall	-699.75 (191.56)	886 40 (58.46)	-2212 78 (127 15)	1004.17 (50 43)	33122 44 (2970 00)	33045.45 (9966.89)

Figures in parentheses indicate existing level of resource use.

Table 5.3 presents the estimated optimum levels of resource use for the selected cropping sequences under unlimited capital situation. From the comparison of optimum and existing levels of use of resources, it is observed that there is a great scope for increasing the use of all resources except human labour in tomato-wheat cropping sequence, farm yard manure in sugarcane (suru), chilli-wheat-groundnut and paddy-pea-groundnut cropping sequences, phosphorus in tomato-wheat cropping sequence and total fixed capital in all cropping sequences except chilli-wheat-groundnut cropping sequence. Among the various resources, the estimated optimum use levels of irrigation are much higher than its existing use levels. This indicates that there prevails tremendous scope for increasing returns from different cropping sequences through increased use of irrigation and other different resources. However, in the country like India, where the farmer is generally having limited capital, the use of resources at their optimum level is restricted. Thus, optimum level of resource under unlimited capital situation is not the real guiding instrument for farmers in their decision to use the available resources. It is, therefore, necessary to estimate the optimum level of resource use under existing capital situation.

Fig No 2 Per hectare existing use of human labour and irrigation in respect of selected cropping sequences

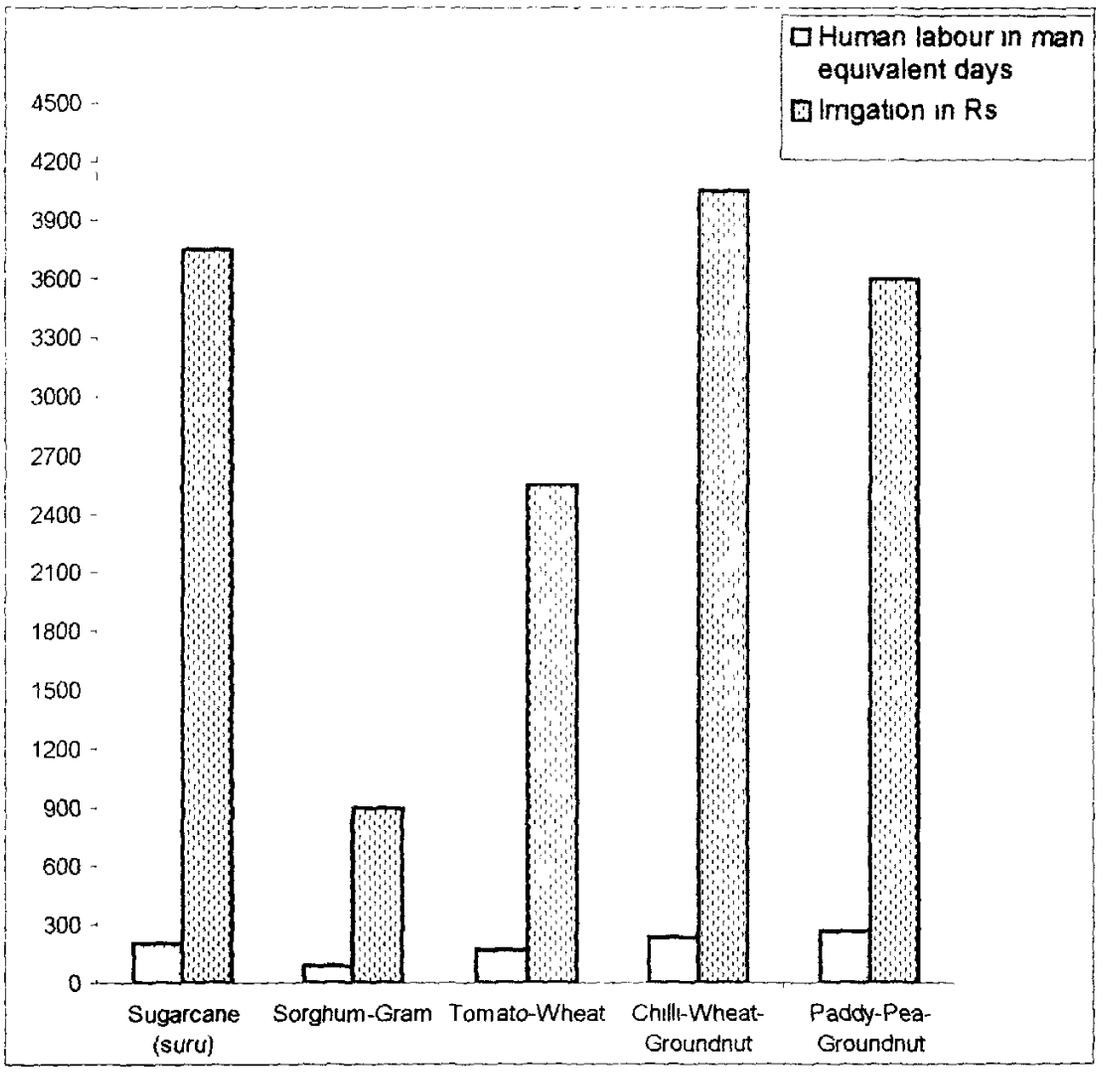
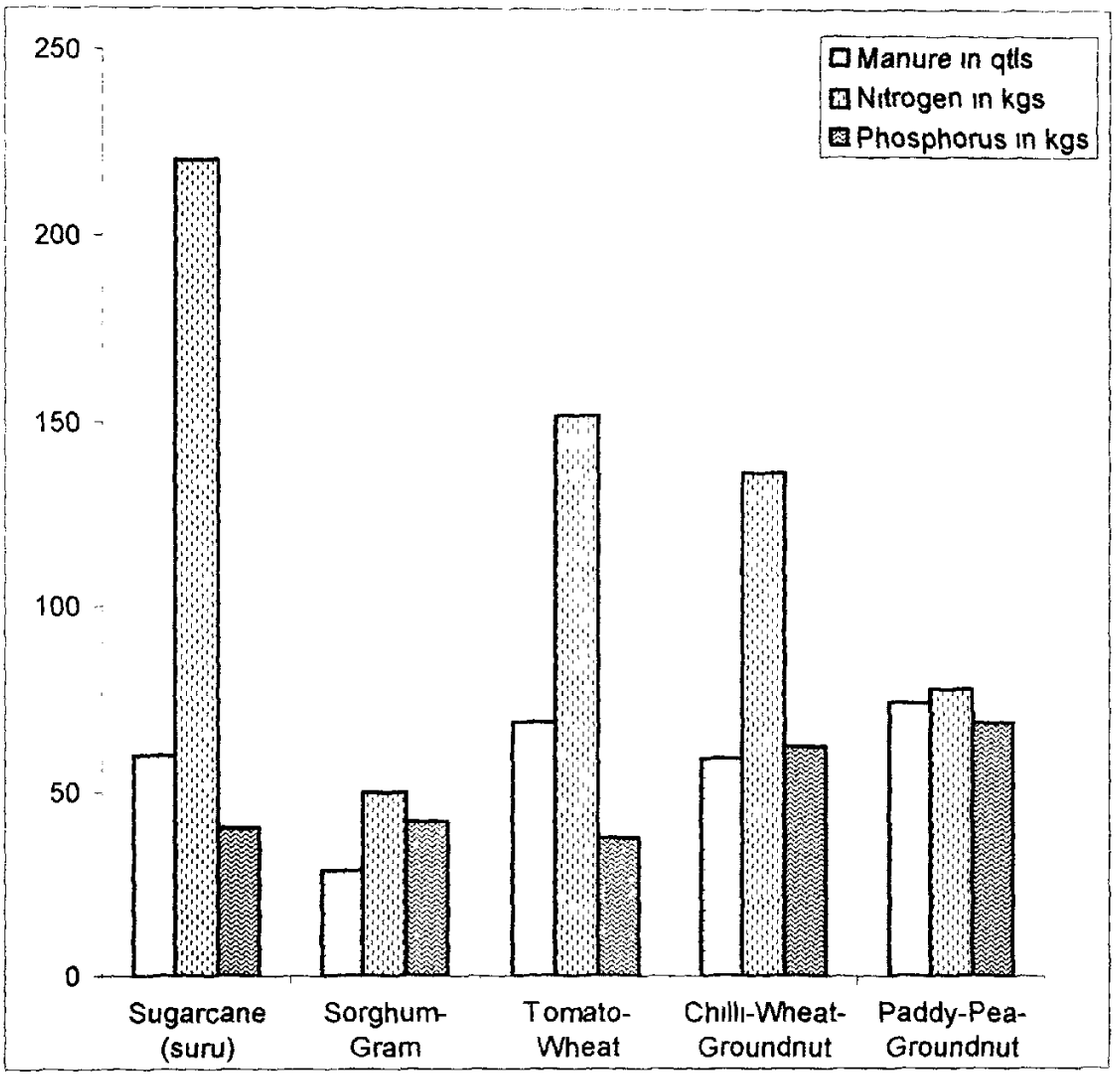


Fig No 3 Per hectare existing use of Manure, Nitrogen and Phosphorus in respect of selected cropping sequences



5.6.2 Optimum level of resource use under limited capital situation

The estimates of optimum level of resource use under limited capital situation are more relevant in present analysis as these estimates give clear picture most closely to the farm reality. As the funds invested in fixed capital assets are not readily available for reallocation, only the working capital available with the farmer is considered for estimating optimum levels through reallocation. Similarly, in case of irrigation resource, eventhough its MVP is relatively very high in comparison with its cost, its use cannot be increased to the optimum level due to limitations on its supply. The irrigation supplied by canal is controlled by external factors and Government policy. While irrigation supplied by well is controlled by natural factors and fixed resources available with the farmer. Though, the productivity of irrigation is high, it is not possible to increase the use through expenses on irrigation during short run period. Therefore, out of the six variables included in the production function, only four variables viz; human labour, manure, nitrogen and phosphorus have been considered for estimating total available capital to be used for reallocating the same for profit maximization. The optimum levels of use of these variables under limited capital situation are obtained by using production elasticities of respective inputs as under :

$$X_I = \frac{b_i C}{S\ Px_i}, \quad i = 1\text{-}4$$

Where,

X_i = Optimum level of i^{th} input

b_i = Production elasticities of i^{th} input

C = Existing total expenditure incurred on all selected inputs

S = Sum of elasticities.

Table 5.4 : Estimated optimum level of resource use under limited capital Situation

Sr No	Name of cropping sequence	Resource use			
		Human labour (man equivalent days)	Manures (qtls/ha)	Nitrogen (kg/ha)	Phosphors (kg/ha)
1	Sugarcane (suru)	140 51 (203 00)	*	42 45 (220 00)	98 21 (40 52)
2	Sorghum-gram	34 11 (87 42)	35 85 (28 90)	109 86 (50 00)	49 94 (42 17)
3	Tomato-wheat	*	57 77 (69 23)	248 33 (151 67)	*
4	Chilli-wheat-groundnut	165 81 (230 41)	*	55 81 (136 06)	64 21 (62 75)
5	Paddy-pea-groundnut	46 71 (266 24)	*	1212 89 (78 00)	10 27 (69 00)
6	Overall	*	142 20 (58 46)	*	161 10 (50 43)

Figures in parentheses indicate existing level of resource use

* Regression coefficients were negative and thus optimum level of these resources are not estimated.

The results presented in Table 5.4 indicate that, there is a need to divert the excessive expenses incurred on human labour in favour of the remaining inputs in case of all the cropping sequences.

Excessive expenses incurred on human labour and phosphorus need to be diverted towards nitrogen in case of the paddy-pea-groundnut cropping sequence. It is observed that manure, nitrogen and phosphorus are highly effective to sorghum-gram cropping sequence, indicating thereby a need for diverting the excess amount incurred on human labour towards above inputs. In case of tomato-wheat cropping sequence, there is a need to divert the excess amount incurred on manures towards nitrogen. And for the cropping sequences like sugarcane (suru) and chilli-wheat-groundnut excessive expenses on human labour and nitrogen should be diverted towards phosphorus as these cropping sequences are more responsive to phosphorus.

It may, therefore, be concluded that there exists a scope for increasing profitability of individual cropping sequences through reallocation of available capital.

In the previous chapter, analysis based on costs and returns from different cropping sequences, indicated that cropping sequences viz; paddy-pea-groundnut gave maximum returns. Optimal use of existing resources analysis based on production function also indicated that existing resources in paddy-pea-groundnut cropping sequences, have been used

more closely to the optimal level as compared to the other cropping sequences. Thus it can therefore be concluded that paddy-pea-groundnut cropping sequence is superior both in terms of maximization of returns and optimal use of existing resources.

SUMMARY AND CONCLUSION

6. SUMMARY AND CONCLUSIONS

6.1 Summary

India today presents most rapidly changing agricultural scene in the world. Some positive changes prominently noted in Indian agriculture during the mid sixties were the introduction of high yielding short duration crop varieties. This phenomenal change in agriculture is known by the name 'green revolution'. Traditional methods of cultivation were replaced by new methods with modern input use. The high yielding short duration varieties and hybrids have generated a series of dynamic changes in different aspects of crop production. Technological progress in irrigation, fertilizers, tillages and plant protection measures has given many farmers greater freedom of choice among rotations as well as crop combinations. This ultimately resulted into intensive use of land by adoption of multiple cropping system for increasing agricultural production per unit of land. This environment gave an impetus to the farmers to adopt several high land intensity cropping sequences. Subsistence farming in which farmer grew as many crops as he needed for his consumption is being replaced by commercialized farming in which only those crops are grown which have the highest comparative advantage. In this technological context, farmers are trying multiple system of cropping.

The cropping system involving two, three or perhaps four crops in a year is an appropriate means, not only to increase the income of the farmers but also to increase the productivity per unit of land. It need not be difficult in a country like India to adopt multiple cropping sequence, where the inputs like irrigation, fertilizers, short duration high yielding varieties and new production technology are made available. The main intention of the present study was to study the economics of the different cropping sequences and to estimate resource productivities and optimum use of resource allocation under different crop sequence situations followed by the farmers. The findings and conclusions from this study will be useful for reorganization of farm business to the most profitable level.

The present study was carried out in the irrigated tract of Wai tahsil of Satara district. Five cropping sequences followed by the farmers, viz; sugarcane (suru), sorghum-gram, tomato-wheat, chilli-wheat-groundnut and paddy-pea-groundnut were selected for present investigation. The basic data, for the year 1998-99; were obtained by survey method from a sample of 150 cultivators adopting the above cropping sequences, from five villages of Wai tahsil.

The data so obtained were compiled systematically and analysed. The average cost on the basis of cost concepts viz: Cost A, Cost B and Cost C, for the selected cropping sequences, were worked out. The returns at Cost A, Cost B and Cost C levels, output - input ratios at different costs, and

comparative costs and returns from the selected cropping sequences were worked out with a view to study the economics of these cropping sequences in the irrigated area.

Further, the Cobb-Douglas type of production function was fitted to the per hectare data of selected cropping sequences for studying the functional relationship between the gross returns as a dependent variable and selected six independent variables viz; human labour in man equivalent days (X_1), manure in q (X_2), nitrogen in kg (X_3), phosphorus in kg (X_4), Irrigation in Rs. (X_5) and fixed capital in Rs. (X_6). With the values of production elasticities of individual inputs which obtained from the results of Cobb-Douglas production function, the marginal value productivities and optimum levels of resources under unlimited as well as limited capital situations for individual resource inputs were worked out, with a view to estimating the resource productivities for selected cropping sequences. The brief summary of results and findings of the present investigation are explained as under :

1. The cost A i.e. working capital required for paddy-pea-groundnut was Rs.44752.38 per hectare, which was more as compared to other cropping sequences. The per hectare cost A was Rs. 18420 00 in case of sorghum-gram, Rs.35665.80 in case of sugarcane (suru), Rs. 38746.96 in case of chilli-wheat-

groundnut and Rs.40950.01 in case of tomato-wheat cropping sequences. This showed that paddy-pea-groundnut was highly capital intensive followed by tomato-wheat, chilli-wheat-groundnut, sugarcane (suru) and sorghum-gram cropping sequences.

It was due to the fact that the resource requirements viz; irrigation, seed, manure, fertilizer and marketing were huge as the intensity of cropping is increased which is observed in case of paddy-pea-groundnut.

2. Though the per hectare paid out capital was higher in case of paddy-pea-groundnut cropping sequence, the per hectare net returns obtained were also high than other cropping sequences which were Rs.50067.52 from paddy-pea-groundnut, Rs.31333.74 from tomato-wheat, Rs.27477.79 from chilli-wheat-groundnut, Rs.16941.61 from sorghum-gram and Rs.12400.20 from Sugarcane (suru) cropping sequences. It clearly shows that all the above cropping sequences were highly competitive with sugarcane (suru).
3. It was observed from the production function analysis that the employment of bullock labour showed negative relation with output. It was due to the fact that the progressive and prosperous

farmers use machine power instead of bullock labour for different farm operations.

4 The use of more human labour with respect to tomato-wheat cropping sequence, farm yard manure for sugarcane (suru), chilli-wheat-groundnut cropping sequences and use of phosphorus for Tomato-wheat cropping sequence were excessive than their requirements and thus, their coefficients were found negative. Similarly, the effect of fixed capital on gross returns in all the cropping sequences except chilli-wheat-groundnut sequence, were non-significant.

5. Marginal productivities of human labour, nitrogen and irrigation were more in all the cropping sequences which indicated further scope for intensifying these inputs in the selected cropping sequences.

6.2 Conclusions

1. Considering the cost C, the paddy-pea-groundnut cropping sequence was highly resource intensive followed by tomato-wheat, chilli-wheat-groundnut, sugarcane (suru) and sorghum-gram cropping sequence.
2. The results indicated that paddy-pea-groundnut, widely adopted cropping sequence, gave the highest

net returns followed by tomato-wheat, chilli-wheat-groundnut, sorghum-gram and sugarcane (suru) cropping sequences.

3. Per hectare labour (human and bullock) requirement was very high in case of triple cropping viz; paddy-pea-groundnut and chilli-wheat-groundnut followed by sugarcane (suru), tomato-wheat and sorghum-gram cropping sequences. It indicates that employment potential is higher in multiple cropping sequences as compared to mono-cropping.

6.3 Recommendations

1. A shift from mono-cropping crop viz; sugarcane (suru) to double cropping, viz; sorghum-gram and tomato-wheat or triple cropping viz; chilli-wheat-groundnut or paddy-pea-groundnut for maximization of farm receipts is recommended. It will offer significant scope, not only to increase the net returns but also to increase the resource employment on farms.
2. In order to increase economic efficiency of farm business, reallocation of existing limited resources is essential for getting maximum possible returns from their use.

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7. LITERATURE CITED

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APPENDIX

:: APPENDIX ::

- SCHEDULE -

"Relative economics of cropping sequences under irrigated conditions in Wai Tahsil of Satara District'

1) Village : _____ , **Tahsil :** Wai, **Dist.** Satara

Name of the landholder : Shri. _____

2) Information about farmers' family :

Sr No.	Name	Age (Year)	Relation with head	Education	Occupation
1.					
2.					
3.					
4					
5					

3) Land Utilization :

Sr No.	Survey or Gat No.	Total holding (ha)	Land under cultivation		Land Revenue (Rs.)	Present Value of Land (Rs.)
			Unirrigated (ha)	Irrigated (ha)		
1						
2.						
3.						
4.						
5.						

4) Livestock :

Sr. No.	Kind	Home breed	Purchased	Purchased Price (Rs.)	Present Value (Rs.)
1. 2.	Bullocks				
1. 2.	Cow				
1. 2	Buffalo				
1. 2.	Calves				
1 2.	Goats				
1. 2	Sheeps				
1 2	Others				

5) Inventory of Buildings and Wells :

Sr. No.	Kind	Number	Year of establishment	Present value (Rs)
1. 2. 3. 4. 5				

6) Inventory of Implements and Machinaries :

Sr. No.	Name	Number	Year of pur-chase	Value		Established life (Rs)
				Purchased (Rs.)	Present (Rs)	
	A) Implements					
1. 2. 3. 4. 5. 6. 7.	Iron plough Wooden plough Harrow Seed drill Hoes Bullockcart Others					
	B) Machinaries					
1. 2. 3. 4. 5. 6.	Tractor Oil Engine Electric motor Thresher Spray pump Others					

7) Cropping pattern :

Survey No	Plot No	Land under cultivation	Kharif Season				Rabi Season				Summer Season				Annual/ Perennial Crop, Irrigated area
			Crop	Area	Unirrigated	Irrigated	Crop	Area	Unirrigated	Irrigated	Crop	Area	Unirrigated	Irrigated	
1															
2															
3															
4															
5															

8) Wage rates of cultivation : (8 hrs) or seasonwise wage rates

Sr. No	Cultivation practices	Man (Rs)	Woman (Rs)	Bullock pair (Rs)	Tractor/ha (Rs)	Other Machinary/ha/hr (Rs)
1						
2						
3						
4						
5						

9) Labour requirement for cultivation :

Name of cultivator :

1. Name of the Crop:
2. Variety :
3. Irrigation (Well/canal):
4. Area under the crop :
5. Land Revenue (Rs.) :
6. Value of land (Rs.) .
7. Sowing/planting month :
8. Kind of land :
9. Mixed crops :
10. Season :

If yes, Variety :

Proportion of mixed crop :

Sr No	Operation	Family			Hired			Wages of Hired (Rs)			Material used		
		M	F	B	M	F	B	M	F	B	Mat-erial	Qty	Value (Rs)
1	Ploughing ½												
2	Harrowing ½												
3	Stubble collection												
4	Clod crushing												
5	Application of F Y M												
6	Preparing ridges and furrows												
7	Preparation of seed beds												
8	Sowing/planting												
9	Fertilizer/Seed treatments												
10	Hoeing ½												
11	Inter culturing ½												
12	Earthing up ½												
13.	Irrigation (Nos)												
14	Application of Fertilizers · NPK/or Name of fertilizers 1st Dose 2nd Dose 3rd Dose												
15	Plant protection												
16	Watching (No of days)												
17	Harvesting												
18	Threshing and Transport												
19	Others												

10) Material used :

A) Oil engine :

1. Irrigation days :
2. Total charges (with oils), if hired (Rs.) :
3. If owned, oil charges only (Rs.) :

B) Electric Motor :

1. Irrigation days :
2. Total hours :
3. Per unit charges of electric motor (Rs.) :
4. Total charges of irrigation (Rs.) :
5. Area irrigated by the electric motor :

C) Tractor :

1. If hired, charges of tractor (Rs.) :
2. If owned, oil charges of tractor (Rs.) :

D) Spray pump charges, If hired (Rs.) :

E) Irrigation Charges :

1. If canal irrigated (Rs.) :
2. If well irrigated :
   i. Value of Well (Rs.) :
   ii. Estimated life (Years) :
   iii. Electric motor (H.P.) :

F) Charges of threshing, if hired (Rs.) :

G) Other :

i. Education cesses :

ii. Employment guarantee cesses :

11) Output :

Product	Quantity	Rate/Unit (Rs.)	Total Value (Rs.)
A) Main Produce B) By produce			

* Total value of output (Rs.)

1. For home consumption :-

2. For Sale :-

3. Marketing cost (Rs.) :-

12) Miscellaneous :

1. Why you have taken these cropping sequences ?
   Reasons :
   a)

   b)

2. Which cropping sequences are profitable ? How ?

   a)

   b)

3. What are the difficulties in adopting such profitable cropping sequences on large scale ?

   a)

   b)

VITA

7. VITA

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MASTER OF SCIENCE (AGRICULTURE)

In

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