THE EFFECT OF *Leucaena leucocephala* MULCH ON THE GROWTH AND YIELD OF IRRIGATED TOMATO (*Lycopersicon esculentus* Mill.)

A THESIS

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THE MASTER OF SCIENCE DEGREE IN AGROFORESTRY

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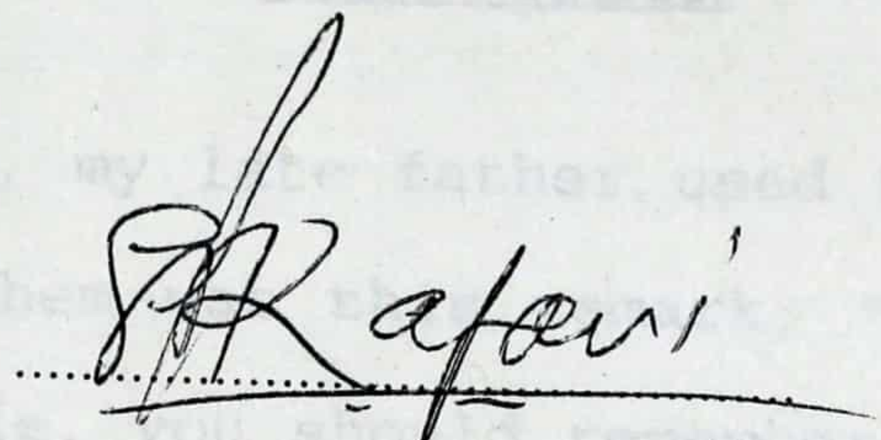
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SEPTEMBER, 1996

CERTIFICATION

Certified that this Thesis is the candidate's own account of his research



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DEDICATION

When I was young, my late father used to share his wisdom with me. Among them was this remark; "Son, for you to be successful in life, you should remember it is not all what the majority believe in, do and/or say that is always right. You would always need to do a lot of observing and listening and take a stand based on your own careful analytical judgement of the situation".

I owe whatever success I have made and continue to make to the ear I gave to the old man's wisdom. This work is dedicated to my late father.

ABSTRACT

The research was conducted at Akumadan vegetable irrigation project in the Ashanti region of Ghana from 12th December, 1994 to 7th April 1995 with the following objectives:

a) To evaluate the effect of *Leucaena leucocephala* mulch on the yield and yield components of irrigated tomato.

b) To assess the fertilizer replacement potential of Leucaena mulch.

c) To determine from the treatments, the most economic alternative for tomato production.

Experimental design used was a split plot with fertilizer as the main plot treatment and leucaena mulch as the sub-plot treatment. There were three blocks with 4 levels of fertilizer (0, 50, 100 and 150 kgN/ha) and three levels of leucaena mulch (0, 5 and 10 tons/ha).

The results show that leucaena mulch has a significant effect on the growth and development, fruit set, fruit weight, reproductive efficiency and fruit quality of tomato. Leucaena mulch also showed significant effect on weed control, soil moisture content and soil bulk density but not on soil chemical properties. Along with these were significant effects shown by fertilizer/mulch combination and by fertilizer alone. In general, leucaena mulch showed

a high fertilizer replacement potential, better exploited at mulch levels of 10 tons/ha fresh mulch. At 10 tons/ha mulch level combined with 50 kgN/ha, yields were as economic as applying fertilizer alone at a high rate of 150 kgN/ha. It was also realised that no extra rewards were gained by increasing fertilizer rates to 100 kgN/ha combined with 10 tons/ha mulch.Using the 1995 production figures, profitability margins turned to be higher with a high supplementation of chemical fertilizer with mulch, with 10 tons/ha mulch combined with 150 KgN/ha giving the highest B/C ratio.

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CHAPTER 1

INTRODUCTION

The role of agroforestry in bringing about sustained and improved yields in various crops has been well established by the International Centre for Research in Agroforestry (ICRAF). However, very scanty information is available on vegetable production in combination with multipurpose trees and shrubs (MPTS) (Palada et al., 1992). In Ghana, tomato is one of the popular vegetables consumed domestically.It is known to give the most economic returns to farmers among the commonly grown vegetables (Table 1.1) and in recent times has proved to have a high potential for foreign exchange earnings to the nation.

Most of the tomato produced in Ghana come from the nations's Irrigation Projects. A good portion of the nation's tomato also comes from the minor season vegetable farmers and from what would be described as "bucket irrigation" being carried out in very small holdings along perenial rivers or near hand-dug wells. Satisfactory yields of tomato requires about 150kg/ha of nitrogen, combined with various levels of potassium and phosphorus under irrigation (Kim, 1991; FAO, 1979).

Table 1.1. Dry Season vegetable production figures (1989).

Vegetable	Average Production Cost/ha (Cedis)	Average Yield/ha (tons)	Total Income/ha (Cedis)	Profit Margin (cedis)
Freshokro (Lady's Finger)	120,500	17	220,000	99,500
Pepper (Long red)	163,384	15	325,000	161,616
Tomato (Roma VF)	188,476	12	390,500	202,024
G. Eggs (Local)	154,246	15.6	294,600	140,354

Source: Bontanga Irrigation Project, Tamale, Ghana.

Vegetable crop production on the nation's irrigation projects have not been without agronomic problems. Most prominent among them is the high cost of fertilizer which has led to a drastic reduction in the application of recommended fertilizer rates to tomato and other vegetables and hence a fall in tomato yield. There is a further effect in lowering the innate nutrient status of the soil which is taxed by the crop for its extra nutrient requirement created by the shortfall in fertilizer application. The resultant effect is the depletion of N, K and Mg from the soil and a build-up of Al^{3+} which results very often in soil acidity (Dalland et al., 1993).

The Akumadan Vegetable Irrigation Project in the Ashanti Region of Ghana contributes immensely to tomato production in Ghana. This is also the area which records the highest number of minor season vegetable farmers and dry season "bucket irrigation" farmers in the southern half of the country. Tomato cultivation in Akumadan is the main occupation of the people in both the dry and wet seasons and is the major source of income to them. However, with the complete removal of government subsidy on fertilizer culminating in the sudden shoot up of fertilizer prices (Table 1.2), tomato cultivation in recent times has been associated with a gradual reduction of fertilizer application rates and a corresponding drop in tomato yields.

The situation is not any better with the "bucket irrigation" farmers or the minor season vegetable farmers. Other problems, the impact of which have not been seriously considered but which no doubt also cause a reduction in tomato yield on the project include problems of unfavourable soil physical, biological and chemical conditions. Coupled with this is the unreliable weather conditions such as poor and erratic rainfall patterns experienced in the area in recent times as a result of severe deforestation. The effect of this is the lowering in the yields of rain-fed crops such as maize, plantain, cassava and yam leading to an increase dependence of the farmers on the Akumadan Irrigation

Table 1.2: Average market prices of two fertilizers in the Brong-Ahafo Region (B/A) of Ghana (in cedis)

Fertilizer Type	1989	1990	1991	1993	1994	1995
*S/A	2,350	3,100	3,100	6,100	9,100	12,500
**153	3,350	4,200	4,200	7,100	10,000	14,000

* Sulphate of Ammonia or Ammonium Sulphate fertilizer

** N.P.K. 15-15-15 compound fertilizer

Note:
1. Fertilizer prices increase as you move from the harbour in the south to the north of the country.
2. Government subsidy on fertilizer was removed completely by 1991.
3. Fertilizer prices are unstable and unpredictable and keep on increasing in line with the increase in the dollar rate against the Ghanaian cedi.

Source: Ministry of Food and Agriculture, Crop Services Department, Techiman, B/A.

Project and on tomato cultivation in particular. The need to seriously look for alternative means of supplementing fertilizer application on the numerous "bucket irrigation" farms on the one hand and irrigation projects on the other, so as to provide a source of sustained rural income generation and spare the forest of further depletion in search of fertile land, gives prominence to agroforestry.

Agroforestry is known to improve soil fertility and soil physical conditions and at the same time provide for better water retention ability of the soil (Omoro and Nair, 1993).

One of the very popular agroforestry practices that could have been adopted in irrigated vegetable cultivation is hedgerow intercropping or alley cropping. However, despite its numerous advantages in improving soil chemical, physical and biological conditions, its use under irrigation would pose a threat to irrigation structures, obstruct mechanical cultivation and impede water flow especially in gravity irrigation systems. Besides, the establishment of hedgerows which forms the basis of the practice of alley cropping is yet to be encouraged on the nation's irrigation projects. In this regard, prunings of MPTS could be carried from outside the project and used as mulch on irrigated crops - a practice known as biomass transfer (Young, 1989a).

It should also be noted that irrigation farming in Ghana is becoming increasingly commercial and tomato farmers would assess the profitability aspects of any technology introduced to them before adoption. This is more so in the Akumadan area where tomato is the major crop cultivated at least 3 times in a year for commercial purposes. Therefore, apart from establishing the most sustained combination levels of fertilizer and biomass prunings, there would be

the need to carry out some economic analysis of the system, no matter how basic, to be able to advise on the most rewarding alternative. The study was therefore conducted with the following objectives:

a) To evaluate the effect of *Leucaena leucocephala* mulch on the yield and yield components of irrigated tomato.

b) To assess the fertilizer-replacement potential of Leucaena mulch.

c) To determine from the treatments the most economic alternative for tomato production.

In other to meet these objectives, the hypothesis that Leucaena mulched irrigated tomato (i) increases crop yield (ii) reduces fertilizer use (iii) gives economic returns to the farmer would be tested.

CHAPTER 2

LITERATURE REVIEW

2.1 The Concept of Agroforestry.

Agroforestry is a collective name for landuse systems in which woody perennials such as trees, shrubs and bamboos are grown in association with herbaceous plants such as crops, pasture and/or livestock in a spatial or temporal arrangement and in which there are both ecological and economic interactions between the tree and non-tree components of the system (Young, 1989). The main components of agroforestry systems are trees, shrubs, crops, pastures and livestock, together with the environmental factors of climate, soils and landforms (Young, 1989). Additionally, its essential nature is that there must be an interaction between the tree and non-tree parts of the system. Agroforestry also covers transfers of biological materials such as incorporation of leaf litter into soil or feeding of such litter as browse to livestock with subsequent return to the soil as manure (Young, 1988). Economic interactions mean that the tree and non-tree components each serve to meet some of the farmer's needs, whether for subsistence such as needs for food, fodder and fuelwood or for cash. Ecological interactions refer to effects such as shading of crops by trees, protection of crops or animals by live fences, effects of

trees on soil moisture and provision of shade for livestock (Young, 1989).

The distinctive features and/or functions of trees in agriculture are the essence of agroforestry. Trees used in agroforestry are referred to as multipurpose trees since they have more than one service and productive function to the landuse systems in which they are grown. The concept of agroforestry is based on multipurpose trees (MPTS). It has been rightly said that all trees are multi- purpose. The same species of tree can be managed for a single purpose such as timber or for multipurpose (and hence in agro-forestry). *Leucaena*, the MPT used in this research, is a non-traditional MPT which is fast catching up in use in Agroforestry throughout Ghana.

2.1.1 *Leucaena leucocephala*

his is the most widely used in modern scientific agro-forestry, particularly but by no means exclusively for hedgerow intercropping. *Leucaena leucocephala* is valued especially for its effects on soil fertility. It was used for shade and soil improvement in tree and coffee plantations in Java as early as 1900 (Young, 1989). Formerly considered a tree mainly for humid tropics, it has recently been found to equal or exceed the performance of most other species in moist and dry subhumid climates and even into the

margin of the semi-arid zone (Young, 1989). It is being promoted in some areas as a substitute for fertilizer, but also, when used in combination with moderate levels of fertilizer, it improves the crop response. Attack by psyllid, *Heteropsylla cubana* is currently serious in some regions and there can be a residual effect on the succeeding crop (Young, 1989).

Leucaena has properties that are relevant to soil fertility improvement (Nair, 1984). These include:

A) high biomass production (10,000 - 25,000 kg DM/ha/yr).

B) high nitrogen fixation (100 - 500 kgN/ha/yr).

C) high level of nitrogen in leaves (2.5 - 4.0%), and thus high rate of return in litter or prunings.

D) substantial content of other nutrients in leaves.

E) high biomass in root system, possibly leading to substantial annual turnover of organic matter and nutrients and a favourable effect on soil physical properties.

2.2 Agroforestry Practices for Soil Fertility Improvement

Several Agroforestry practices have been used in soil fertility improvement. Among them include the taungya system, improved fallow, crops under tree cover, shifting cultivation, hedgerow intercropping and biomass transfer (Nair, 1984).

2.2.1 Shifting Cultivation.

Shifting cultivation is the earliest and still the most widespread practice of agroforestry (Young, 1989). Two main forms can be distinguished: shifting cultivation in forest and shifting cultivation in savannas (Nair, 1984). The important phenomenon in shifting cultivation that is of considerable relevance to the agroforestry approach is the restoration of soil fertility during the fallow period through biological processes associated with revegetating the area. The soil improvement that takes place during the fallow period as well as the possibility for replacing the "traditional" fallow species with other useful plants provide sound guidelines for agroforestry as an approach to improved land management in such areas (Nair, 1984). Shifting cultivation is a sustainable system, provided that the fallow is long enough to restore soil conditions to the same state as in previous cultivation. An early attempt at improving shifting cultivation was the corridor system, in which the fallow is still natural forest regeneration, but

the area cleared for cultivation is a belt along the contour, moving up the slope in successive years to produce contour-aligned belts of forest at different stages of regeneration. Whilst achieving erosion control, this does not in itself change the rest period requirement and thus fails to restore the soil fully of its lost fertility. More radical attempts to improve shifting cultivation take it into the class of improved tree fallow.

2.2.2 Improved Fallow.

This involves the deliberate planting of trees with desirable characteristics for soil improvement during fallow periods. Reasons for using the rotation of crops with planted trees in place of colonization by natural vegetation may be to obtain harvested products from the trees, improve the rate of soil amelioration or both. A question of fundamental importance for agroforestry design is the relative efficiency in soil improvement of a rotational tree fallow and a spatial, concurrent arrangement of trees. Most people observe that rotational tree fallows occupy well over 50% of time in the tree-crop cycle, a ratio that would be economically unacceptable as a ratio of areas in space. The apparent success of hedgerow intercropping, in which the tree cover is generally below 35%, suggest a greater efficiency for spatial systems. Mechanisms leading to greater efficiency of nutrient recycling under spatial systems would

seem to be the cause, but what these are is not known; the answer could lie in the permanence of the tree rooting system. Rather than simply alternate trees with crops, the most valuable systems are likely to be those that combine inter-cropping with rotation such as the taungya system.

2.2.3 Taungya System.

In the taungya practice, food crops are interplanted during the first few years of tree establishment. This does not appear desirable as regards soil fertility. Many forestry trees do not leave the soil in good condition after felling and food crop yields are fairly low (Young, 1989a). Conversely, it is suspected that annual crops may compete for nutrients with the newly planted trees. In Kenya, soil carbon and phosphorus were substantially lower under tree plantations with food crops than in pure forest stand (Young, 1989a). It was assumed that the fall in fertility occurred during the cropping period. The taungya practice appears to be neutral to adverse from a soils view point, becoming seriously undesirable only if substantial erosion is allowed to occur.

2.2.4 Crops Under Tree Cover.

Many kinds of trees are grown on cropland for productive purposes, without having any clear adverse effects on adjacent crops. A small number of species are planted, or

more often, preserved in part for their beneficial effects on soils and crop yields, known by farmers and in some cases demonstrated by scientists. Good examples of such trees include *Acacia albida*, *Acacia senegal*, *Paulownia spp.* and *Prosopis cineraria*. Where such effects occur, it seems logical to augment them by increasing the tree density to something approaching a full canopy, or until light reduction counteracts the improvement in crop growth (Nair, 1984).

2.2.5 Hedgerow Intercropping.

Hedgerow intercropping (alley cropping, barrier hedges) refers to a cropping system where arable crops are grown in the interspaces (or alleys) between rows of planted trees or woody shrubs, which are pruned periodically during the cropping season to prevent shading and to provide green manure and/or mulch to arable crop (Nair, 1984). It is commonly called alley cropping, although this name is less appropriate in that it refers to only one of the two components. Where established on slopes, with the primary objective of erosion control, it may be called barrier hedges, but no clear difference exists between barrier hedges and hedgerow intercropping on slopes (Young, 1989).

Hedgerow intercropping has aroused more current interest among scientists than any other agroforestry system. Well

over half of all diagnosis and design studies have suggested it as an intervention to help solve landuse problems. Among reasons, the potential for maintenance of soil fertility is usually cited.It is also one of the agroforestry practices on which substantial soil research has been done (Young, 1989). The hedgerow intercropping system offers the advantages of incorporating a woody species within an arable farming system without impairing soil productivity and crop yields. By adjusting the interrow spacing of the woody species, mechanized equipment could be used, wherever deemed desirable for various field operations connected with cropping. Moreover, the trees can be cut back and kept pruned during the cropping period and leaves and twigs containing substantial quantities of nutrients applied to the soil both as a mulch and a nutrient source, with the bigger branches being used as stakes or firewood. Large amounts of nitrogen can be fixed by hedgerows. Leucaena for instance fixes between 75-120 kgN/ha in six months (Young, 1989).

The extent to which the potential benefits of the hedgerow intercropping system can be exploited will depend, however, on a number of factors. In addition to the species of crops and trees, and the environment (climate, soil), tree management aspects such as method of planting, species admixture pattern and the pruning regime, are also extremely important

factors. Moreover, the effectiveness of the practice will also depend on the general level of production of the crop (Nair, 1984).

2.2.5.1 Hedgerow Intercropping Research in the Tropics

Alley cropping research results have demonstrated various effects on soil physical, chemical and biological properties. In two separate studies at Ibadan, Nigeria, and cited by Young (1989), soil changes were monitored over time. The first consisted of intercropping Leucaena with a maize-cowpea rotation (one crop of each per year) on a sandy soil under a moist subhumid climate. Soils on plots with prunings applied to the soil were compared with those on plots with hedgerows but with prunings removed. Application of prunings led to higher organic matter, potassium, calcium and magnesium, and substantially improved the available water capacity. Soil organic matter was maintained over six years compared with a decline where prunings were removed. In the second experiment in which various rates of NPK fertilizer was applied and hedgerows were established with *Gliricidia sepium*, *Flemingia congesta* and *Senna siamea*, intercropped with two maize crops over two years, plus a control with no hedgerows, it was realised that organic matter decline in the control plot was reverted by Senna and Gliricidia, even with prunings removed. The obvious suggestion is root residues. Phosphorus improved under Senna and Flemingia, but

none of the hedgerows showed a decline in potassium. Soil physical properties were significantly better under all species than without hedgerows. The authors several times singled out the favourable effects of the abundant and persistent mulch from the Senna.

The results of a study into alley cropping with *Leucaena leucocephala* and *Flamingia congesta* on soil chemical and physical properties in Zambia (Dalland et al., 1993) showed that the beneficial effects of organic matter on soil physical properties is due in part to the action of organic gums in binding soil particles into aggregates, leading to an improvement in soil structure with a balanced distribution of pore sizes. This leads to improved permeability, aeration and easier root penetration. This in turn provides favourable conditions for the development of fine feeder roots and mychorrhizae, increasing the efficiency of nutrient uptake and increased yields. There were also reductions in soil bulk density, increases in the pore volume fraction and infiltration rates and lower penetration resistance in Leucaena treatments. There were higher levels of Mg, K and overall CEC and higher pH values under the hedgerows, particularly Leucaena (Dalland et al. 1993).

The detrimental effects of frequent applications of nitrogenous fertilizer is a decrease in Mg and K and to some

extent Ca content in the soil resulting in Al^{3+} build up in the soil and hence acidification. Young (1989) argued that it is unlikely that alley cropping can raise pH on naturally acid soils but that further acidification may be checked by increasing the concentration of Ca and other bases in leaves brought up from the lower layers and recycled to the surface.

Results of alley cropping *Amaranthus cruentus* L., *Celosia argentea* L., *Hibiscus esculentus* L., and *Lycopersicon esculentus* Mill., with *Leucaena leucocephala* in Nigeria (Palada et al., 1992) indicate that Leucaena can reduce fertilizer requirement for vegetable production. Cost and return analysis using 1988 prices indicated that alley cropping with vegetable crops can be profitable (Palada et al., 1992). Omoro and Nair (1993), and Grewal and Singh (1992) have also reported on the positive effects of agroforestry on soil properties.

In Ibadan, Nigeria, papaya trees were intercropped with vegetables (okra, water melon, sweet potato, bush greens, jews mallow and *Solanum gilo Raddi*). The aim was to select crops suitable for intercropping in the alleys of papaya plants in orchards. Sweet potato and *Solanum gilo* Raddi caused marked reduction in the yield of papaya. Land equivalent ratio (LER) computed for papaya intercropped with

okra, water melon, sweet potato, bush greens, jews mallow and *Solanum gilo* indicated that all the combinations were more advantageous than the monocrop of papaya. Monetary value of the mixture, however, indicated that the inclusion of intercrops of sweet potato or *Solanum gilo* Raddi, is disadvantageous (Aiyelaagbe and Jolaoso, 1992).

In a field experiment conducted for 4 consecutive years on a tropical inceptisol at Apia, Western Samoa to evaluate the effects of alley cropping on soil characteristics, weed population and taro yield, Rosecrance et al., (1992) found that hedge-biomass yields ranged from 5.1 to 16.1 tons/ha/yr dry weight with *Calliandra calothyrsus* and *Gliricidia sepium* performing equally well. They found biomass yields to be in the order 4m > 5m > 6m and were lower by 2 tons/ha at the 6m spacing. Weed population were significantly lower in the 4m alleys compared to 5m, 6m and control (no alleys), with 6m supporting the significantly highest population. Soils from alley plots held significantly more water than soils from controls. Four years of mulch application measurably improved soil water holding capacity and bulk density. However, no improvement was seen in the nitrogen, phosphorus, potassium, calcium, magnesium and organic carbon content in the alley plots compared to the controls. There was no positive effect of alley cropping on taro yield.

In another experiment, Hulugalle and Ndi (1993) studied the effects of no-tillage and alley cropping with *Cassia spectabilis* hedgerows on soil properties and crop yields in the humid forest zone of Central Africa over a period of 2 years in Cameroon. The experimental treatments were no tillage and hand tillage, both of which were either alley cropped with *C.spectabilis* hedgerows or not alley cropped (control). A maize and cassava intercrop was planted in all plots and *C. spectabilis* prunings were cut and mulched on alley plots. No-tillage had no significant effects on soil physical properties except to decrease soil temperature. In comparison to hand tillage, no-tillage increased soil organic matter and total N in both years and soil pH in one of the years. Alley cropping caused significant reductions in dry season temperature, surface seal formation and cassava root growth, and increased exchangeable Ca, effective CEC and water infiltration compared with non-alley cropped controls. Lowest maize cob and cassava tuber yields were observed when no-tillage was combined with alley cropping whereas highest yields occurred with no-tillage alone.

2.2.6 Biomass Transfer.

Biomass transfer, a spatial-zoned practice and the subject of this study refers to the practice of cutting tree foliage from natural forest and carrying it into crop land (Young,

1989a). This practice is very popular in Nepal and doubtless to say it improves yield or farmers would not undertake the enormous labour involved. It is however not yet a popular agroforestry practice and very little literature is available on it. The concept of biomass transfer is probably being seriously considered now as a result of the numerous benefits derived from hedgerow intercropping.

2.3 Trees as Producers of Biomass.

In considering the use of leaf prunings or tree biomass as mulch in crop cultivation, knowledge of biomass production (both quantitative and qualitative) of the MPT involved is of great importance if the MPT has to provide the desired nutrient requirement to the crop as well as be sustained for continuous use. The total biomass of mature tropical forests range between 200 and 400 tons/ha of dry matter per year (Young, 1989a). Only about 40% to 50% of the total biomass is added to the soil, mostly as leaves, small branches and roots. Fortunately, the nutrient accumulation rate in these parts is faster than in the rest of the vegetation (Sanchez, 1976). Yield of leaf prunings of MPTS is even lower. For the humid and subhumid climates, net primary leaf production is of the order of 2-4 tons/ha per year (Young, 1989a). In using leaf prunings as mulch therefore, there is the need to be conscious of the optimum level of biomass prunings that would sustain the productive life of the tree.

Maximum biomass yield is obtained with the first pruning while subsequent prunings could be lower depending on the season, the MPT species involved, the cutting interval and the ecological zone concerned. Cutting height appears not to influence yield as much as cutting interval (Karim et al., 1991). The frequency of pruning alsc affects the yield of biomass. Three prunings per year depending on the MPT and ecological zone is therefore adequate. Biomass production by trees used in agroforestry has also been studied. Yields vary depending on the agroforestry practice, the climatic zone and the management practice employed. In humid climatic conditions, *Leucaena leucocephala* was recorded to give a net primary production (above-ground dry matter) of 20,000 - 30,000 kgDM/ha/yr while it gave 10,000 - 25,000 kgDM/ha/yr under subhumid conditions (Pound and Cairo, 1983, quoted by Young, 1989) in plantation. Leaf production under planta-tion gave 3,000 - 5,000 kgDM/ha/yr (Buck, 1986, quoted by Young, 1989). In hedgerow intercropping under the moist subhumid bimodal regime, net primary production of *Leucaena leucocephala* was 6,770 kgDM/ha/yr (Kang et al., 1985, quoted by Young, 1989) while leaf production was recorded as 2,470 kgDM/ ha/yr.

The potential dry matter production by any vegetation is closely related to the amount of solar radiation intercepted by the foliage (Huxley and Westley, 1989). Any pruning that

removes foliage and decreases light interception will reduce the rate of dry matter production by the trees. However, the decrease in productivity may be less than expected because:

A. the rate of photosynthesis of the remaining foliage may increase due to the increased sink/source ratios, better illumination and increased share of root-originated metabolites and

B. the leaves removed may be the older, more shaded ones, which have lower rates of photosynthesis than younger leaves (Avery et al., 1991).

Research questions on pruning involve how to prune (for example whether to coppice, pollard, or basal prune), how much to remove (what coppicing height, how severely to pollard), and when and how often to prune. These questions need to be answered with reference to the tree product required (green mulch, fodder, fuelwood or timber) and the tradeoff between the productivity of the trees and of the intercrop. It must however be remembered that severe pruning can kill trees if followed by drought and that recovery will depend upon the amount of foliage and storage reserves (of carbohydrates and minerals) left on the trees. Coppicing small trees is often more life threatening than coppicing large trees with thick roots and storage reserves; pollarding is usually less life threatening than coppicing.

The effect of cutting height and cutting intervals on dry matter production of *Leucaena leucocephala* (Lam) De Wit using three year old trees showed that dry matter yield were highest at 75 and 100cm cutting height in a four (25, 50, 75 and 100cm) cutting height trial, especially at the longer, three-monthly cutting intervals. At the one-monthly interval, dry matter yield was significantly reduced probably due to the increased number of recovery phases. Leaf nitrogen yields per tree for trees cut at three-monthly intervals were over twice as high as the total yields obtained from monthly cutting over the same period (Karim et al., 1991).

"Measured rates of net primary biomass production under natural ecosystems serve as a reference point for Agro-forestry. The most representative for rainforest is 20,000 kg/ha/yr (dry matter), ranging from half to over twice this value. Semi deciduous forest,under climates with a short dry season, is only slightly lower than evergreen forest in typical value, but does not attain the very high rates of some evergreen sites. Forest at high altitudes does not necessarily have slower growth, showing a typical value of 22,000 kg/ha/yr" (Young, 1989). Savanna communities according to Young (1989) show wide range of productivity, differing between moist savanna, dominated by broad leaf species and occurring above some 1000 mm/yr rainfall, and

dry savanna, dominated by narrow-leaved species. He further stated that representative values are 10,000 kg/ha/yr for moist savanna and 5,000 for dry savanna, and that communities described as desert scrub or the like range downwards from 2500 kg/ha/yr. In summary, studies of natural ecosystems suggest the following rates of net primary production (above-ground dry matter) that can be expected according to climatic zone (Young, 1989).

- Humid tropics (no dry season) - 20,000 kg/ha/yr or more
- Humid tropics (short dry season) - 20,000 kg/ha/yr
- Subhumid tropics (moist) - 10,000 kg/ha/yr
- Subhumid tropics (dry) - 5,000 kg/ha/yr
- Semi-arid zone - 2,500 kg/ha/yr or less.

According to Young (1989) forests characteristically contain large quantities of "living" biomass (including wood) and therefore, a large inventory of chemical elements. About 20 to 25 percent of the total living biomass of the trees is in roots and there is a constant addition of organic matter to the soil through dead and decaying roots. Under a moist tropical forest, the net annual contribution of dead roots was around 2600 kg/ha-1. In addition to this there could be a significant formation of soil organic matter during active root growth, much of it directly from the root tissue without the intervention of soil microfauna (Nair, 1984).

The major recognised avenue for addition of organic matter (and hence of nutrients) to the soil from the trees standing on it is through litter fall, that is through dead and falling leaves, twigs, branches, fruits and so on. The bulk of the organic matter and nutrients that are so added to the soil are located in the topsoil (Young, 1989a). Potassium, calcium and magnesium on the other hand, are concentrated in the biomass, except in high base status soils (Young, 1989a). That is why forest clearing leads to a considerable lost of the nutrients - those in the biomass being "exported" from the system, and those in the soil being lost by leaching and runoff.

2.4 Mulch Material and Mulching.

While the effects of soil erosion on chemical properties of the soil can be rectified to some extent by external inputs such as fertilizers, those on physical properties such as moisture-holding capacity are not easily replaceable, nor the physical loss of surface soil. Apart from rainfall which initiates the erosion process, other factors such as the presence or lack of vegetative cover or the inherent soil characteristics accelerate the problem. Vegetative materials that are used for erosion control and soil fertility improvement are available from sources such as grass, crops and trees (leaves and prunings), and are commonly applied as mulch (Thurston et al., 1994). Plastic

materials and paper are also used as mulches. Most studies on vegetative mulches have focused on the use of grass or crop residues, and only very few on the use of tree foliage (Omoro and Nair; 1993). Studies on the use of foliage or mulch from trees reported so far have mainly addressed the effects of the mulches on soil fertility and productivity (Omoro and Nair, 1993).

The principles of mulching are very relevant to Agroforestry systems. Loppings from fast-growing and quickly-regenerating woody perennials grown with agricultural crops in either zonal or mixed cropping schemes could be added as mulch on crop production fields. The hedgerow intercropping (alley cropping) system is an excellent illustration of this possibility. In these situations, the most readily available form of mulch is likely to be woody residues. Besides, there will often be difficulties in obtaining enough quantities of grasses and other leafy mulches for which there is an alternative use as cattle feed.

2.4.1 Research on the Effect of Mulch on Crop Production

Mulching with crop residues and other vegetative matter has been a consistently successful practice in shifting cultivation. Several benefits have been attributed to the practice of adding mulch. Lal (1973 and 1975), quoted by Young, 1989) has shown experimentally 46, 55 and 22 percent

yield responses of maize to mulch at IITA, Nigeria over the period 1970 to 1972. Such yield increases represent the net effect of a number of favourable effects ranging from seedling emergence and growth aspects to nutrient relations. Moreover, the presence of organic cover on the soil not only reduces the raindrop impact on the soil, but also improves both the physical conditions and fertility status of the soil. In his M.Sc thesis, Banful (1994) reported that Agboola and Udom (1967) indicated that mulching reduced the competitive effects of weeds to such an extent that yields of maize were doubled. The reduced competitive effects could be due to the lower light intensity in the mulched environment. Morgan (1986), quoted by Thurston et al., (1994) stated that mulching may also encourage weed growth. He suggested that weed growth can only be suppressed if the amount of mulch applied is heavy enough to prevent minimal light from passing through it.

Mulching has proved an effective means of improving the yields of many tropical crops. In Nigeria, Okigbo (1972), quoted by Thuston et. al., 1994) found maize plant population, number of ears and grain yield to be significantly higher in mulched plots than in unmulched plots. Different types of mulches also increased stover and grain yield of maize. Salau et al., (1992), quoted by Thurston et al., (1994) in a study in Nigeria to compare the effects of five

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different mulch treatments (*Pennisetum purpureum*, plastic, *Pennisetum purpureum* on plastic, plastic on *P. purpureum* and wood shavings) on the yield of plantain, reported that mulching significantly enhanced vegetative growth and increased bunch yield of plantain. The increase in bunch yield was about 41% higher in the mulched plots than in the unmulched plots.

Banful (1994) in his M.Sc thesis in Ghana, gave evidence of the improvement of plantain yields by mulch. He added that plantain plants in *Flemingia congesta*-mulched plots performed better than plantains in *Leucaena leucocephala*-mulched plots. This he suggested could be as a result of the lower soil temperatures and higher moisture content recorded in *F. conjesta*-mulched plots than in *L. leucocephala*-mulched plots. Yield, he stated was also highest in *F. congesta*-mulched plots.

In a review on research carried out on the effect of organic mulches, soil amendments (organic materials incorporated into the soil) and cover crops on soil borne plant pathogens and their root diseases, Thurston et al., (1994) stated that the majority of the information available in the literature indicated that maintaining a high level of organic matter on and in the soil is generally associated with reduced incidence and severity of root diseases. Ancient Chinese,

Greek, Roman, Arab and Spanish writers have documented the importance and use of composted organic materials and several types of manures to improve crop production and for the management of plant diseases (Thurston, 1992, quoted by Thurston et al., 1994). They further stated that it appears that the extensive addition to manures and composted organic fertilizers combined with flooding are major factors improving root health by suppressing or eliminating inoculum sources of soil borne plant pathogens as well as through the improvement of soil structure.

Root diseases are generally rare in undisturbed or natural ecosystems such as native forests and prairies, whereas soil borne pathogens and their root diseases are severe and often a limiting production factor in conventional production systems (Cook and Baker, 1982; Cook et al. 1978, quoted by Thurston et. al., 1994). It was suggested that the increase of root diseases in the conventional production systems may be due to the tillage practices used and the destruction of organic materials. Thurston et al., (1994) further stated that several authors have reviewed the literature and listed the numerous examples available where the management of crop residues or the addition of various types of organic amendments (either fresh, dried or composted) had either increased or decreased the populations of plant pathogens and their diseases (e.g. cited by Thurston et al., 1994

include Allarmas et al. 1988; Cook and Baker 1983; Cook et al. 1978; Hoitink and Fahy, 1986; Lewis and Papavizas, 1975; Palti, 1981; Patrick et al. 1964; Rowe-Bulton, 1957; Schippers et al. 1987 and Sumner et al. 1981). Successful suppression of plant-parasitic nematodes, including the destructive root-knot nematodes (*Meloidogyne spp.*) have been documented with the use of cover crops, trap crops, cropping sequences, and the addition of organic amendments (e.g. Muller and Gooch, 1982; Nusbaum and Ferris, 1973; Rodriguez-Kabana et al. 1987; and Rodriguez-Kabana, 1992 cited by Thurston et al., 1994).

In an experiment entitled "Yield, Nodulation and Mycorrhizal establishment in slash/mulch versus Row-cropped beans, Rosemeyer (1994, quoted in the review of Thurston et al., 1994) stated that bean production in the slash/mulch system was significantly higher than that in the row-sown beans with a dibble stick in the first year after fallow and in the second year. The results further showed a definite response of the slash/mulch system to combined N and P fertilizers. It was further shown that the bean yield only responded to P with a plateau reached between 97.5 and 195 kg/ha P. Experimental data also established that for some dry years, mulching can encourage nodulation. In the second year after fallow, four times greater nodulation was found in the slash/mulch system than in the row-cropped system,

perhaps because there was a drought that year. During drought conditions, mulch can maintain soil moisture and reduce temperature, thus encouraging nodulation and nitrogen fixation (Sprent and Minchin, 1983 cited by Thurston et al., 1994).

In contrast to the above-mentioned benefits, Thurston et al., (1994) also cited several examples that exist in the literature documenting the direct or indirect effects of the management of certain mulches and organic matter on the increased severity of root diseases (e.g. Cook and Baker, 1983; Palti, 1981; Sumner et al. 1981; and Thurston, 1992a and 1992b). Increased severity of root diseases on several crops caused by *Pythium spp.*, *Phytophthera spp.*, *Rhizocteria solani* and *Sclerotium rolfsii* have been attributed to specific management of soil organic matter. All these fungi are non-specialized pathogens having a wide host range, good saprophytic ability under certain conditions, and are generally favoured by high moisture conditions. Cook et al. (1978, quoted by Thurston et al., 1994) in a review of literature, indicated that crop residues left in the field affect plant diseases in at least the following categories:

1. For many plant pathogens, residues provide food and a place to live and reproduce.
2. Residues affect the physical environment occupied by the host and the pathogen.

3. As organic soil amendments, residues intensify the microbial activity of the soil and this along with a variety of decomposition products (some phytotoxic or fungitoxic), may affect pathogens, susceptibility of the host, or both.

Again Thurston et al., (1994) in their review quoted Webster and Wilson (1990) as having cautioned that mulching may sometimes result in yield decreases, especially on soils of medium to fine texture in humid areas. This they thought could result from the lack of oxygen and a corresponding accumulation of carbon dioxide in the mulched soil. Banful (1994) reported that mulching encourages superficial rooting in crops resulting in such roots being exposed to drought and damage when the mulch gets completely decomposed and it is not replaced. He added that Inorganic mulches, particularly the black polythene sheets tend to cause an increase in the soil temperature especially if applied in the tropics, resulting in a yield decline in most crops.

2.5 Tomato

It is necessary to also carry out a review on tomato, which is the crop used to establish this effect. This is necessary so as to provide a better understanding of the trends in development arising as a result of the mulch application. It seems likely that modern tomato has a more

complex ancestry, and that after it was domesticated, diversity accumulated in it partly as a result of hybridization with several other Lycopersicon species which grow in the New World tropics. Though its wild ancestors are outbreeding plants, the tomato has become predominantly inbreeding in cultivation (Cobley, 1986). Purseglove (1987) stated that *Lycopersicon* Mill is a small genus of 6 species of usually perennial soft herbs. With the exception of *Lycopersicon esculentum*, which is the cultivated tomato and *L. cheesmanii* which is endemic in the Gatapagos Islands, they grow wild in a narrow coastal strip extending from Ecuador to Northern Chile. The genus is sometimes included in Solanum (q.v.). There are two subgenera: Eulycopersicon with 2 red-fruited edible species - *L. esculentum* and *L. pimpinellifolium* and Eriopersicon with 4 green-fruited species - *L. cheesmanii* Riley, *L. glandulosam* C.H. Muller, *L. hirsutum* Humb. and Bonpl., and *L. peruvianum* Mill. The cultivated tomato *L. esculentum* Mill, is one of the most important vegetables in most regions of the World, ranking second in importance only to potatoes (*Solanum tuberosum*).

Tomatoes show a wide climatic tolerance and can be grown whenever there is more than 3 months of frost-free weather. They are more successful with long sunny periods and light, evenly distributed rainfall and temperatures of 21-25°C (FAO, 1979; Purseglove, 1987). Weathers in the tropics with

low sunshine and high night temperatures result in excessive vegetative growth at the expense of fruiting and leads to an increase in diseases (Purseglove, 1987). Yields are higher with irrigation than during the wet season. A light, free-draining, fertile loam with a pH of 5-7 is best for the crop, but they can be grown on a variety of soils (FAO, 1979; Purseglove, 1987).

Flowering is not affected by photoperiod. Inflorescences, which arise terminally are borne opposite and sometimes between leaves due to the method of branching of axis. Flowers pendent, hermaphrodite, hypogynous and regular (Purseglove, 1987; Cobley, 1986). Dehiscence of the anthers is introversely longitudinal 1-2 days after the opening of the corolla. If the pollen is shed, as the style grows up through the anther tube, self-fertilization occurs, as is also the case when the style is short and the stigma is not exerted beyond the connivant anthers. In long style forms, the stigma projects beyond the anther cone and cross-pollination can occur. Cross-pollination tends to be higher in tropical than temperate regions (Purseglove, 1987). Purseglove (1987) also observed that growth of the pollen tube is slow and fertilization takes place 50 hours or more after pollination in favourable conditions. The optimum temperature for the germination of pollen and the growth of the pollen tube is about 25°C.

Seeds of tomato are nursed on beds sterilized with methyl bromide or formaldehyde. Seedlings are ready for transplanting from 3-5 weeks (FAO, 1979; Purseglove, 1987). Purseglove (1987) also stated that tomato can also be propagated easily from cuttings and can be grafted. Intergeneric grafting is possible and tomato has been grafted onto potato, tobacco, various Solanum species and onto the tree tomato (*Cyphomandra betacea* q.v.). He further said the crop benefits a lot from heavy organic manuring and mulching. The land should be thoroughly cultivated before planting. The usual spacing is 90cm - 120cm x 60cm but 90cm x 30cm has been found to give higher yields. The crop receives a dressing of 125kg of Sulphate of Ammonia per hectare, 2 weeks after planting and a further 125kg when the first fruits set, together with 125kg of muriate of potash. Yields of 1-6 tons per acre (2.5 - 15 tons/ha) are obtained on growers farms (Purseglove, 1987). The fertilizer requirements for high producing varieties is 100 to 150 kg/ha N, 65 to 110 kg/ha P and 160 to 240 kg/ha K (FAO, 1979).

Several diseases and pests attack tomato. Popular among them include the bacterial wilt caused by *Pseudomonas solanacearum* E.F. Son, Fusarium wilt caused by *Fusarium bulbigencon* Cooke, Sclerotium wilt caused by *Sclerotium rulfsii* Sacc, Septoria leaf-spot caused by *Septeria lycoper-*

sici and early blight caused by *Phytophthera infestans* (Ment) de Bary. Fungi and various organisms also cause damping-off of seedlings and fruit rots. A number of insects including leaf miners, flower midges and caterpillars also attack tomatoes. Prophylactic and preventive spraying is recommended in all cases (Purseglove, 1987; Cobley, 1986).

2.5.1 Water Requirement in Tomatoes

Total water requirements (ETm) after transplanting, of a tomato crop grown in the field for 90 to 120 days are 400 to 600mm, depending on the climate. Water requirements related to reference evaporation (ETo) in mm/period are given by the crop factor (Kc) for different crop development stages: during the initial stage (10-15 days) it is 0.4 - 0.5, while it is 0.7 - 0.8 during the development stage (20-30 days). The mid-season stage (30-40 days) requires 0.8 - 0.9 and at harvest between 0.6 - 0.65 (FAO, 1979). Water supply is adjusted according to the use of the product, eg. for salad or tomato paste. Highest yields of salad tomatoes are obtained by frequent, light irrigation.

The crop is most sensitive to water deficit during and immediately after transplanting and during flowering and fruit formation. Water deficit during the flowering period causes flower drop. Moderate water deficit during the

vegetative period enhances root growth. For high yield and good quality, the crop needs a controlled supply of water throughout the growing season. Whereas under water limiting conditions some water savings may be made during the vegetative and ripening periods. FAO (1979) suggested that water supply should preferably be directed toward maximizing production per hectare rather than extending the cultivated area under limited water supply. The crop performance according to FAO (1979) is sensitive to the irrigation practices. In general, a prolonged severe water deficit limits growth and reduces yields which cannot be corrected by heavy watering later on. Highest demand for water is during flowering. However, withholding irrigation during this period is sometimes recommended to force less mature plants into flowering in order to obtain uniform flowering and ripening. Care should normally be exercised in this to avoid damage to the mature plants. Excessive watering during the flowering period has been shown to increase flower drop and reduce fruit set. Also this may cause excessive vegeta-tive growth and a delay in ripening. Water supply during and after fruit set must be limited to a rate which will prevent stimulation of new growth at the expense of fruit development. Heavy, irregular irrigations or dry periods alternating with wet periods should be avoided. When water supply is limited, FAO (1979) suggests that applica-tion for a salad crop be concentrated during periods of transplan-

ting, flowering and yield formation. For a crop grown for paste production, a more extensive irrigation may be applied with last heavy irrigation applied prior to flowering.

Surface irrigation by furrow is commonly used for tomato cultivation. Under sprinkler irrigation, the occurrence of fungal diseases and possibly bacterial canker may become a major problem. Again, under sprinkler, fruit set may be reduced with an increase in fruit rotting. In the case of poor quality water, leaf burn will occur with sprinkler irrigation. This may be reduced by sprinkling at night and shifting of sprinkler lines with the direction of the prevailing wind. Due to the crops specific demands for a high soil water content without leaf wetting, trickle or drip irrigation has been successfully applied (FAO, 1979).

2.5.2 Cultural requirements of Tomatoes in the Tropics

In a potted experiment conducted in the UST, Kumasi, between 1974 and 1978 to determine the effect of planting dates on improved Zuarungu tomato, positive correlation was established between mean number, mean weight and mean percentage of fruit yield per plant while the parameters of cracked fruits studied were also positively correlated (Asante, 1979; B.Sc dissertation). The results established that August planting was most suitable, though November, December and January also gave reasonably high yields.

Floral initiation was earlier with plantings in January to April. Plants planted from April and May showed early floral opening. The results further showed that planting in January to June and December had the same period to fruit set and gave earlier fruit set, while planting in July to October had comparatively longer periods to fruit set. Planting from May to July gave the highest percentage of good fruits per plant while August, September and January plantings were most susceptible to fruit cracking. In general, time of planting should be such that it does not coincide with extreme dry or wet periods of the year (Crops Research Institute of Ghana Manual, June 1974).

Norman (1985) in his book stated that in the 1960s, Samundri (1964), in evaluating factors of importance in tomato production reported that spacing proved to be the most important factor affecting yield of tomatoes.

In a research conducted in UST, Ghana, on the effect of spacing and non-staking on the yield of tomato (*Lycopersicon esculentum*) C.V. improved Zuarungu, it was noticed that plant spacings adopted had no significant effect on flower bud initiation, flower bud opening, fruit set and fruit maturity. However a trend for closer spacing to develop some of the above characters earlier was observed (Kwakye-Adams, 1974; B.Sc. dissertation). The total marketable and grade 1

fruits were significantly higher for plants with intermediate spacing (60.96cm x 60.96cm). The lowest yield came from the closest spacing (60.96 x 30.48cm) while 60.96 x 45.72cm, 60.96 x 76.20cm and 60.96 x 91.44cm gave results in-between the two extremes.

In related experiments conducted in the Horticulture Department of the UST, Ghana, as their B.Sc. dissertation, Abasi (1974) and Amankwa (1974) independently adopted spacings of 60cm x 30cm, 60cm x 45cm, 60cm x 60cm, 60cm x 75cm, 60cm x 90cm) and 61cm x 30.5cm, 61cm x 45.7cm, 61cm x 61cm, 61cm x 76.25cm, 61cm x 91.5cm respectively. With all other treatments being uniform, Abasi observed that total yield per hectare of marketable fruits, grades, flower bud initiation and flower bud opening showed significant difference for the various spacings of staked tomato but not for the non-staked tomato. The estimated fruit yield per hectare indicated that there was a progressive increase in fruit weight with wider spacing. While fruit yield at 90cm x 60cm was highest, yield of spacings 60cm x 90cm and 75cm x 60cm were not significantly different; yields of these two spacings were however significantly higher than the rest of the spacings. Results from Amankwa's work showed that 61 x 91.5cm, 61 x 76.25cm and 61 x 61cm gave the highest yields followed by 61 x 30.5cm with 61 x 45.7cm giving the lowest yield. The best marketable yield came from a spacing of 61

x 91.5cm followed by 61 x 61cm, 61 x 30.5cm and 61 x 45.7cm in that order. Thus spacing was shown by both works to have a significant effect on yield and yield components of tomato.

The Crops Research Institute of Ghana carrying out agronomic research on crops in Ghana released a crop production guide (June 1974) with the following recommended spacings for staked determinate and unstaked indeterminate tomato: staked determinate - 45cm x 60cm, 60cm x 60cm and 60cm x 75cm; unstaked indeterminate 60cm x 90cm or 90cm x 90cm. These recommendations are similar to those obtained by Abasi (1974) and Amankwa (1974).

Norman (1985) recommended that for unstaked tomato, spacings of 60-90cm x 30-60cm be used in the dry season, while spacings of 60-90cm x 60-90cm be used in the wet season. With staked tomato spacings of 60 x 45cm or 60 x 60cm were recommended.

In a BSc. research conducted by Degbor (1981) in UST, Ghana to determine the response of three cultivars of tomato - Zuarungu improved, aliconte and Roma V.F., to the time of nitrogen fertilizer application, the following treatments were adopted:

a) Broadcast at time of transplanting.

b) Broadcast at transplanting and side dressing at flowering.

c) Broadcast at transplanting, side dressing at fruit set.

d) Broadcast at transplanting, side dressing at flowering and 4-weeks after.

e) Broadcast at transplanting, side dressing at fruit set and three weeks after.

For all three cultivars, fertilizing at flowering gave higher fruit weight per plant than fertilizing at fruit set. For all 3 cultivars, third fertilizer treatment was necessary for higher fruit yield. Broadcast at time of planting alone gave the poorest yield for all the three cultivars, whereas broadcast at transplanting and side dressing at flowering and 4 weeks after gave the best yield of marketable fruits for all 3 cultivars. In south-western Nigeria, Fawasi (1977 cited by Norman, 1985) recommended 360 kg/ha N.P.K. 15-15-15 in two equal splits before flowering, but not later than fruit set. Sobulo (1980 cited by Norman, 1985) reported that Boron is the most limiting trace element for high tomato fruit yield in the Savanna, followed by Zinc and Iron. Uzo (1971) stated that tomato responded well to high fertilizer applications of 220 kgN/ha, 99 kg/ha P2O5 and 658 kg/ha K2O in south-eastern Nigeria. In Ghana, N.P.K.

15-15-15 at the rate of 45-60 kg/ha of N, P_2O_5 and K_2O have been recommended for pre-plant fertilization (Norman, 1985).

The effects of 6 irrigation periods (at the vegetative, flowering, fruiting, combination of 2 of these phases, or during the entire growing period) and 4 levels of K fertilizer (0, 40, 80, and 120 kg KCl/ha) on the yield and yield components of tomato (Var Marglobe) were studied in two greenhouse trials in Sri Lanka. The response of the yield and the yield components to the irrigation was significant. The highest yield (1.443 kg/plant) was obtained when the plants were irrigated during the entire growing period. The vegetative phase and the fruiting phase required water to produce high yields, while the absence of water during the fruiting phase reduced the fruit quality. The response of tomato to potassium increased up to 80kg KCl/ha. A split application of K gave higher yields than a single basal application. The highest yields were obtained with applications at planting and at fruit set (Norman, 1985).

In a BSc. dissertation on the study of the effect of three irrigation frequencies (4, 7, and 14 days interval) on tomato (Zuarungu improved), Opaye (1978) indicated that fruits from 4 day irrigation frequency were fewer but larger than those obtained from the other treatments. The 14 day

irrigation frequency produced taller plants with smaller leaves and fruits and a lower fruit set than in the other two treatments.

2.6 Estimation of Project Worth

Tomato cultivation in Ghana is carried out purely with a commercial motive. It is therefore appropriate in a research of this nature to carry out a basic economic analysis of the results so as to be able to recommend the most technical and economic alternative to farmers. This is possible by first identifying costs and benefits and attaching value to them or pricing them. It then becomes possible to determine which among various alternatives to accept and which to reject. The problem then arises as to how to evaluate projects that will last several years and that have differently shaped future costs and benefits streams. Additionally, the difficulty with evaluating projects of varying sizes arises. The usual method of addressing these two problems is through discounting.

Three main decision criteria that employ discounted measures and are suitable for application to agricultural and for that matter agroforestry projects are the Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost (B/C) ratio. The arithmetic of these discounted measures, and the way we interpret the measures and their limitations is

exactly the same whether we are using them for financial or economic analysis. The difference is only whether we apply the techniques to financial prices or to economic values.

A negative NPV means that the present worth of revenues are not sufficient to defray the present worth of cost at the chosen discount rate. If the NPV is positive, the project is estimated to earn a surplus. If the NPV is zero, it implies that discounted costs are equal to discounted revenues. Projects with NPV of zero or greater are worth selecting, provided the NPV has been discounted at the opportunity cost of capital.

The decision rule in using the IRR measure of project is to accept all projects having an IRR above the opportunity cost of capital (in this case the prevailing borrowing interest rate of agricultural loans).

A B/C ratio of 1 or more implies that the present value of the benefits is equal to or more than the present value of cost and one is recovering his investment. A negative B/C ratio indicates that one is not recovering his investment and it would be better to put the money in a bank at the prevailing interest rate than to invest it in a project. Theoretically, the greater the B/C ratio, the more attractive the project.

It should be noted from the onset that there is no one best technique for estimating project worth (although some are better than others, and some are especially deficient) be it an agricultural, industrial or agroforestry project. Secondly, these financial and economic measures of investment worth should be considered as only tools of decision making. There are many non-quantitative and non-economic criteria for making project decisions and the three techniques above are only to improve the decision making process (and to give some idea of the economic cost of non-economic decisions), but not to substitute for judgement.

CHAPTER 3

MATERIALS AND METHODS

3.1 Site and Soil

The research was conducted on the Akumadan Vegetable Irrigation Project in the Ashanti Region of Ghana from 12th December, 1994 to 7th April, 1995. The soils here belong to the Akumadan-Bekwai/Oda complex associations (Adu, 1992). According to Adu (1992), soils in this association are confined to two fairly small patches: one a corridor extending from Suame-Tafo in Kumasi south-eastwards to Jachi-Trebuom; the other is situated north-west of Kumasi in a loop stretching from Adankwami to Dwinyaikwanta. The Akumadan series in this complex association are very deep, red and well-drained. Occurring as collars around the edges of the Akumadan soils are the Domenase series which are brown dominantly concretionary drift soils overlying ironpan.

The profile of the Akumadan series consist from 30cm of very dark greyish brown silty loam grading into dark brown silty loam. Underlying this is a reddish brown clay loam subsoil usually 120cm - 150cm or more thick. The sub-soil is usually underlain by ironpan or cemented quartz gravel,

stones and ironstone concretions. Detailed analytical data for the Akumadan series is presented in Table 3.1. Soil analysis conducted on the research site taken up to 30cm depth, before the start of the experiment are as follows:

pH: 5.0

Organic Carbon: 0.66%

Total N: 0.06%

Effective CEC: 4.5me/100g

Exchangeable acidity: 0.80me/100g

Base saturation: 82.2%

Total exchangeable bases: 3.7me/100g

Table 3.1: Analytical data for the Akumadan series.

Horizon	Depth (cm)	% Particle Size(mm)			% Organic matter (oven dry)				P.H 1:1
		Sand (2-.06)	Sitl. (06-.002)	Clay .002	C	N	C/N	OM (cx 1.72	
Ap	0-8	34.5	37.0	28.0	3.17	-	-	5.45	4.9
B21	0-20	30.2	30.2	39.6	1.18	-	-	2.03	4.7
B22	20-48	24.3	27.2	48.5	0.68	-	-	1017	4.8
B23	48-152	30.2	36.0	33.8	0.58	-	-	1.00	5.1
B24	152-198	30.2	38.3	31.5	0.35	-	-	0.60	5.3
B25	198-236	40.8	33.2	26.0	0.23	-	-	0.39	5.4
B26	236-257	-	-	-	0.19	-	-	0.33	5.4

Ho-ri-zon	Extracable cations m.e/100g						Tot. exch Bases	base satn %	Ca/Mg	Mg/K
	CEC	Ca	Mg	Mn	K	Na				
AP	16.77	3.08	1.26	.28	.25	.17	5.07	29	2.44	5.40
B21	12.43	.81	.33	.23	.10	.13	1.60	13	2.45	3.30
B22	9.52	.52	.19	.07	.07	.15	.97	10	2.73	4.75
B23	11.15	.55	.19	.06	.08	.02	1.03	10	2.87	2.37
B24	11.20	.42	.11	.04	.05	.12	.75	7	3.82	2.20
B25	10.19	.36	.14	.01	.04	.13	.58	6	2.57	3.50
B26	8.62	.51	.10	.01	.05	.16	.80	10	5.10	2.00

Source: Adu, S.V. (1992).

3.2 Climate and Vegetation

The Akumadan area forms part of the rain forest of Ghana with an evergreen forest. As a result of persistent bushfires and intensive agricultural activities including timber exploitation, the vegetation is now predominantly secondary with an open canopy system and the undergrowth being shrubs and climbers. Due to unfavourable climatic conditions in recent times, vegetation resembling the transitional vegetation that occurs between the Savanna and the forest vegetation exist. Mean annual rainfall in the area is 125cm with the major rainfall occurring from May-October while the minor rainy season occurs from November to April. Annual mean monthly temperatures stand at 26°C while sunshine hours per day averages 6-5 with longer sunshine hours occurring in the dry season while May to October experiences shorter sunshine hours.

3.3 Design and Field Layout

A split-plot design with the main-plots and sub-plots randomised completely was used. There were 3 blocks with 4 levels of nitrogen fertilizer (0, 50, 100 and 150 kgN/ha) as the main-plots and 3 levels of *Leucaena leucocephala* mulch (0, 5 and 10 tons/ha) as the sub-plot treatments randomised in each block. There were 20 tomato plants per sub-plot spaced at 90cm x 60cm and observations and recordings were done on 6 randomly selected plants from the inner row of

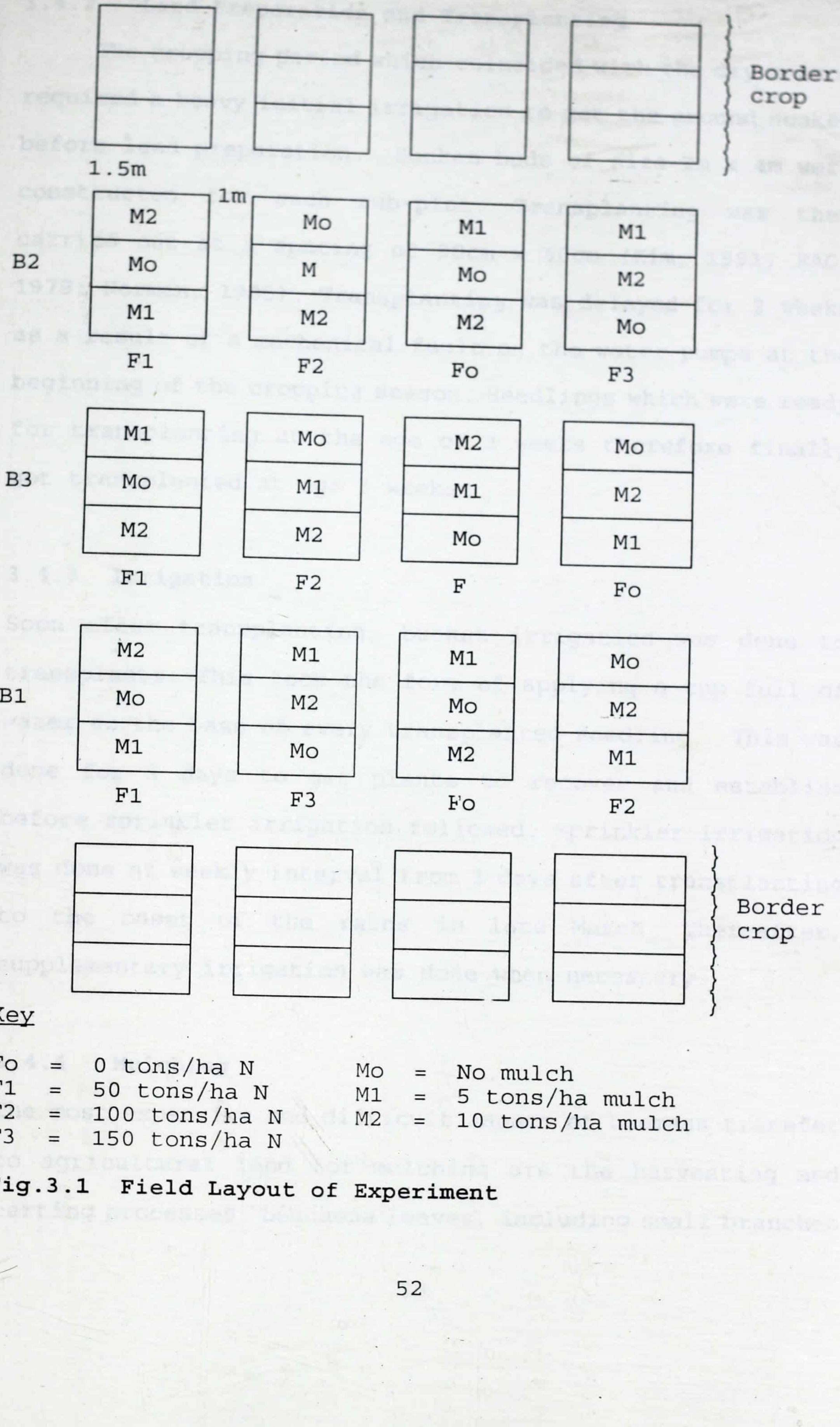
each sub-plot. In a bid to further minimise on experimental error, each of the main-plots were separated by a path of 1m width while each of the sub-plots were separated by a path of 0.5m width. In addition, there were a block of tomato on either end of the research plots to serve as border crop. The field layout is represented on Figure 3.1.

3.4 Field operations

3.4.1 Nursery Maintenance

Nursery beds were prepared to a fine soil tilth as raised beds. Seeds of tomato variety (Laureno 70), were nursed at the rate of 400gm/ha. Light watering using a bucket was done each morning till seeds germinated. Watering was then heavy every other day till transplanting.

While in the nursery, the soil was stirred 3 times before transplanting while kocide 101, a fungicide and karate, an insecticide, were sprayed two and three weeks after nursing at the recommended rates of 1.5kg/ha and 2.4 litres/ha respectively. Fertilizer solution was also applied once before transplanting at the rate of 100g of N.P.K. 15-15-15- per 10 litres of water when plants were two weeks old.



Key

Fo	=	0 tons/ha N	Mo	=	No mulch
F1	=	50 tons/ha N	M1	=	5 tons/ha mulch
F2	=	100 tons/ha N	M2	=	10 tons/ha mulch
F3	=	150 tons/ha N			

Fig.3.1 Field Layout of Experiment

3.4.2 Land Preparation and Transplanting

The cropping period which coincided with the dry season required a heavy initial irrigation to get the ground soaked before land preparation. Sunken beds of size 2m x 4m were constructed for each sub-plot. Transplanting was then carried out at a spacing of 90cm x 60cm (Kim, 1991; FAO, 1979; Norman, 1985). Transplanting was delayed for 2 weeks as a result of a mechanical fault on the water pumps at the beginning of the cropping season. Seedlings which were ready for transplanting at the age of 3 weeks therefore finally got transplanted at age 5 weeks.

3.4.3 Irrigation

Soon after transplanting, bucket irrigation was done to transplants. This took the form of applying a cup full of water to the base of every transplanted seedling. This was done for 3 days to get plants to recover and establish before sprinkler irrigation followed. Sprinkler irrigation was done at weekly interval from 3 days after transplanting to the onset of the rains in late March. Thereafter, supplementary irrigation was done when necessary.

3.4.4 Mulching

The most expensive and difficult aspect of biomass transfer to agricultural land for mulching are the harvesting and carting processes. Leucaena leaves, including small branches



Plate 3.1: Harvesting of mulch: In the use of biomass transfer as an agroforestry practice one of the key considerations is the cost of establishing and harvesting MPTS. Harvesting is very tedious, labour involving and expensive.

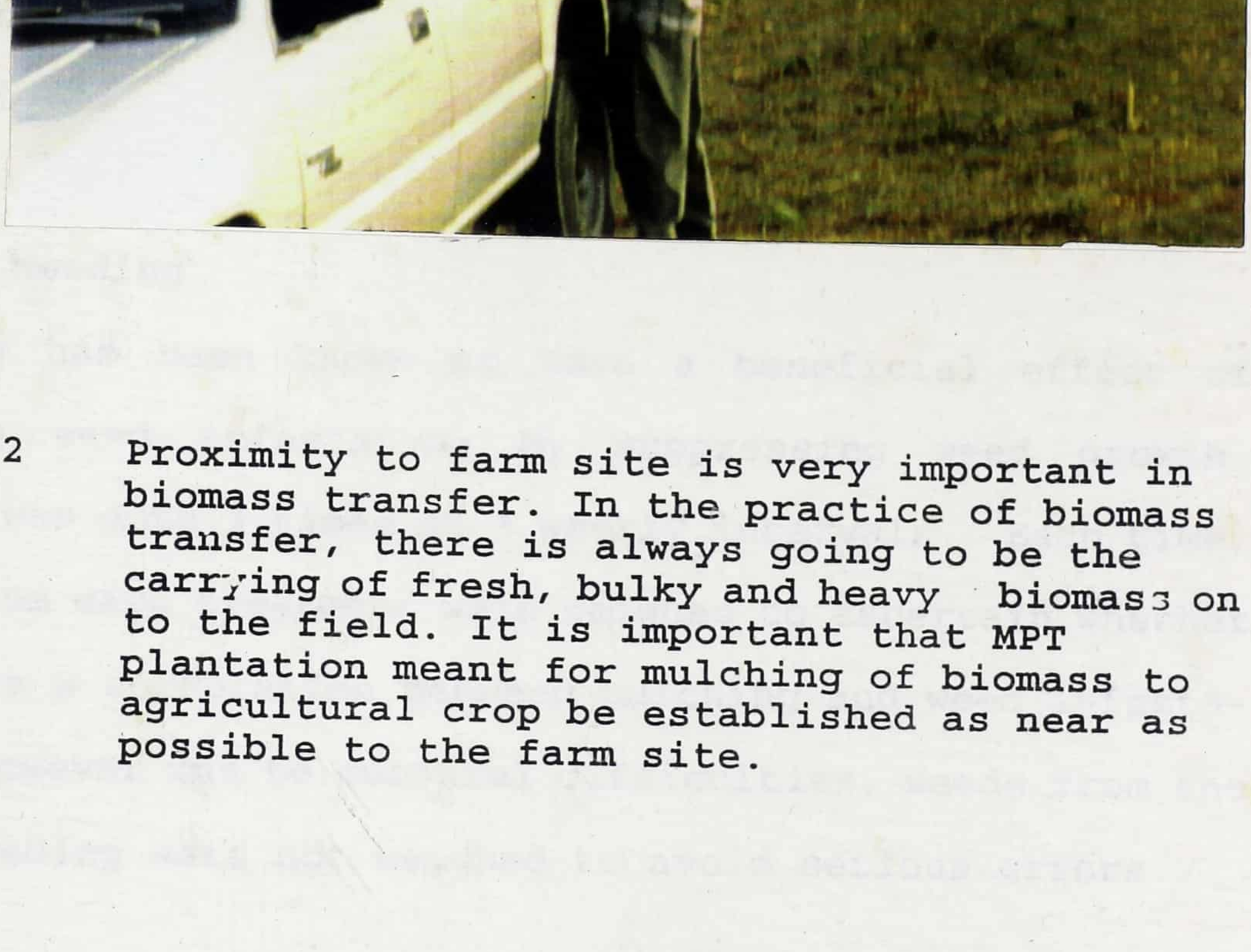


Plate 3.2 Proximity to farm site is very important in biomass transfer. In the practice of biomass transfer, there is always going to be the carrying of fresh, bulky and heavy biomass on to the field. It is important that MPT plantation meant for mulching of biomass to agricultural crop be established as near as possible to the farm site.

3.4.6 Agrochemical Application

Agrochemical application was carried out at the nursery and on the field. How it was done at the nursery has earlier been described in (3.4.1). On the field, Kocide 101, a fungicide was used for the first two applications while Dithane M54, another fungicide was used for the rest of the applications. Kerate, an insecticide was used throughout on the field to conform to what pertained on the farmers' fields. In all, 6 applications were carried out at two weekly interval on the field starting from 14 days after transplanting. Each time, the insecticide and fungicide were mixed together in a knap-sack sprayer and applied. The rates of application were 1.5kg/ha, 1kg/ha, and 2.4 litres/ha of kocide 101, Dithane M45 and karate respectively.

3.4.7 Weeding

Mulching has been known to have a beneficial effect of reducing weed infestation by suppressing weed growth. Weeding was done 3 times at 3 weekly intervals. Each time, weeds from each treatment were weighed to ascertain whether there was a correlation between mulching and weed infestation. However due to cultural difficulties, weeds from the third weeding were not weighed to avoid serious errors.

3.4.8 Harvesting and Grading

Harvesting was done using hired labour to pick fruits. Fruits were then put into 3 groups. The rotten fruits which had to be discarded, the small-sized (unmarketable) fruits and the marketable fruits. The unmarketable fruits were graded as grade 4 while the marketable fruits were further put into three grades (1 to 3) depending on their weight.

3.5 Parameters Considered

Parameters considered during the research included.

A - Plant height per treatment

B - Number of branches per plant

C - Weed weight per treatment

D - Soil nutrient analysis

E - Percentage soil moisture content

F - Soil bulk density

G - Number of unriped fruits per plant

H - Number of riped fruits per plant

I - Yield per plant

J - Marketable quality of tomato

K - Marketable yield per hectare

L - Reproductive efficiency

M - Cost of production per hectare

N - Revenue per hectare

O - Economic analysis

Parameter 'A' was obtained by measuring the height of the 6 inner plants per sub-plot and getting the average height per treatment. Parameter 'B' was obtained by counting the number of branches per the 6 inner plants of each sub-plot and working out the average number of branches per treatment. Parameter 'C' was obtained by weighing the weeds per treatment and striking the average. Parameter 'D' was carried out using soil analysis methods recommended by the American Society of Agronomy and the Soil Science Society of America in their book "Methods of Soil Analysis" (1992; A.L. Page ed). Parameter 'E' was obtained by expressing as a percentage, the ratio of the weight of the wet to the oven-dry weight of a given mass of soil obtained in a core sampler. Parameter 'F' is the ratio of the oven-dry weight of soil in a core sampler to the volume of the core sampler. Parameter 'G' was obtained counting the number of fruits per the 6 inner plants in each treatment and finding the average number of fruits using the highest number of fruit count obtained per plant. All fruits showing on the plants soon after the corolla (petals) has dropped to fruits just before ripening were considered each time a count was taken. Counting was done twice a week. Parameter 'H' was obtained by counting the total number of fruits per plant per treatment from the sample plants and finding the average. Parameter 'I' was obtained by weighing the total number of ripe fruits per plant per treatment from the 6 inner plants

and finding the average. The individual fruits per plant per treatment were also weighed and put into 4 grades to get parameter 'J'. The grades were as follows:

Grade 1 - > 60gms

Grade 2 - 50 - 60gms

Grade 3 - 25 - 49gms

Grade 4 -< 25gms (unmarketable)

Parameter 'K' was obtained by estimating yield on per hectare basis based on the results of parameters 'I' and 'J'. Parameter 'L' was calculated as a ratio of parameter 'H' to parameter 'G' expressed as a percentage. Parameter 'M' was obtained by computing the average cost of production per treatment and also calculating the average cost of production from 20 sample farmers. Parameter 'N' was got by estimating the revenue obtained from the different treatments and from the representative farmers' plot at the existing farm gate prices of tomato. Parameter 'O' was got by using results from parameters 'N' and 'M'. Here the Internal Rate of Return (IRR), the Net Present Value (NPV) and the Cost Benefit Ratio (C/B ratio) of the different treatments and that of the farmers were determined.

3.6 Observations

Observations, some of which did not necessarily form part of the research but which by no means helped to explain some of the research results were made. Firstly, there was either

a general neglect of the proper cultural practices recommended for tomato cultivation under irrigation among the project farmers probably as a result of the high cost of agricultural inputs or it was that farmers were completely ignorant of the cultural practices required to obtain good tomato yields. As a result, yields on farmers plots were very disappointing as a result of low agrochemical and fertilizer application and poor timing of their application. The cropping period was also poorly timed and flowering coincided with high temperatures while fruit ripening coincided with the early rains. As a result of all these factors, fruit rot was very high especially on farmers plots. While fruit rot was estimated to be around 20% on the research plot, it was easily 50% or more on farmers plots because of the very low rates of agrochemical application which gave way to high fungal infection.

It was also observed that a cultural rigidity syndrome had also caught up seriously with the farmers with regards to the use of Ammonium Sulphate. It was wrongly believed that high incidence of fruit rot was caused by the use of Ammonium Sulphate fertilizer. This fertilizer was therefore never used as top-dressing during flowering or around fruit set. The high levels of nitrogen required by the plant around these periods for high fruit yield was therefore lacking.

Tomato collar rot and nematodes infestation were the diseases observed. As a result, a few plants were lost on the experimental plots which were replaced. Fortunately, only one of the sample plants was affected. Plant lost was however severe on farmers plots as a result of very little fungicide application.

Although farmers were supposedly using Laureno 70 variety, they kept on extracting their own seed for re-use for such a long time that segregation set in and fruits from farmers plots were smaller than fruits from the research plot which came from breeder seed. The research plot was however infested with the noxious star grass which made weed control a very big problem.

An interesting observation was made from plots which served as border plants. On some of these plots, I gave a heavy mulch application, heavier than 10 tons/ha and just a starter solution of 100gm NPK in 10 litres of water. Yields were quite encouraging and comparable to yields on some farmers' plots. This gave a good reflection of the nutrient replacement potential of Leucaena mulch.

Time of flowering and fruit maturity was unduly delayed in the control plot (No fertilizer, no mulch) and fruits were only ready for harvesting after all other treatments were

exhausted of fruits. Samundri, (1964), quoted by Norman, (1985) observed that spacing might not have an effect on time of flowering and fruit maturity. This trend observed could therefore be caused by treatment effect.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Effect of Treatments on Soil Nutrient Status

4.1.1 General

Several authors working on hedgerow intercropping and on vegetative mulch research have reported improvements in soil chemical properties with mulch. Dalland et al., (1993) reported of higher levels of Mg, K and an improvement in the CEC position as well as an increase in soil pH under hedgerows of Leucaena. Palada et al., (1992) also reported that Leucaena mulch can reduce fertilizer requirement in vegetable production while Omoro and Nair (1993), Grewal and Singh (1992) have also reported on the positive effects of agroforestry on soil properties. However, Rosecrance et al. (1992) reported that no improvement was observed in the nitrogen, phosphorus, potassium, calcium, magnesium and organic carbon content in alley plots of *Calliandra calothyrsus* and *Gliricidia sepium* as compared to the controls. Young (1989a) on the other hand reported that application of Leucaena prunings to maize in Ibadan, Nigeria led to higher organic matter, potassium, calcium and magnesium.

As can be seen from Table 4.1, leaves of *Leucaena leucocephala* had high levels of N, P, K, Ca and Mg. Table 4.3 however show that there was only a slight or no improvement in organic carbon, organic matter content, N, P, Ca, Mg, K, Na and Al in mulched plots as compared to the control. Cation exchange capacity (CEC) was also similarly affected.

Table 4.1 Nutrient concentration in Leucaena mulch

Nutrient Element	Total Concentration (me/100g)
N	3.47
P	0.40
K	0.60
Ca	0.76
Mg	0.77

Table 4.2. Chemical analysis of the initial soil sample

Soil Property	Value
PH (1:2.5 IN H_2O)	5.0
Organic C (%)	0.66
Total N (%)	0.06
Available P (Bray P1) (mg/kg)	20.8
Total Exchangeable Bases (TEB) (me/100g)	3.70
Exchangeable Acidity (me/100g)	0.80
Effective CEC (me/100g)	4.50
Base Saturation (%)	82.2

Table 4.3 Soil chemical analysis after imposition of treatments

Sample	pH 1:2.5	C (%)	O.M (%)	Total N (%)	Avail. P mg/kg	Exchangeable Cations						Effective CEC me/100g
						Ca	Mg	K	Na	Al	H	
3 WAT												
F_oM_o	5.1	0.76	1.31	0.07	16.9	3.20	1.00	0.02	0.03	0.40	1.00	5.65
F_oM_1	5.0	0.58	1.00	0.06	11.8	2.40	0.80	0.02	0.03	0.60	0.80	4.65
F_oM_2	5.0	0.74	1.28	0.07	11.8	2.80	0.80	0.02	0.03	0.80	0.80	5.25
F_1M_o	5.3	0.74	1.28	0.07	26.1	2.80	1.20	0.01	0.03	0.60	0.60	5.24
F_1M_1	5.5	0.54	0.93	0.05	19.5	2.80	1.20	0.02	0.03	0.60	1.00	5.65
F_1M_2	5.7	0.64	1.10	0.07	15.4	3.60	1.20	0.02	0.03	0.40	0.60	5.85
F_2M_o	5.8	0.80	1.38	0.07	19.5	3.00	1.40	0.02	0.03	0.40	0.80	5.65
F_2M_1	5.8	0.56	0.97	0.06	18.2	3.20	0.80	0.02	0.03	0.20	0.80	5.05
F_2M_2	5.9	0.94	1.62	0.08	24.9	3.80	0.40	0.02	0.03	0.20	0.80	5.25
F_3M_o	5.9	0.74	1.28	0.06	18.2	3.40	0.60	0.05	0.40	0.60	1.00	5.69
F_3M_1	5.8	0.72	1.24	0.06	24.9	2.60	1.00	0.02	0.03	0.20	0.80	4.65
F_3M_2	5.6	0.90	1.55	0.09	19.5	2.80	0.80	0.02	0.03	0.40	0.80	4.85

Note: In all cases there was no significant difference between treatments and the control, and within treatments.

Sample	pH 1:2.5	C (%)	O.M (%)	Total N (%)	Avail. P mg/kg	Exchangeable Cations						Effective CEC me/100g
						Ca	Mg	K	Na	Al	H	
6 WAT												
F_oM_o	5.7	0.76	1.31	0.08	16.9	3.00	1.20	0.04	0.03	0.60	1.00	5.87
F_oM_1	5.6	0.52	1.90	0.06	22.0	3.20	0.40	0.03	0.03	1.00	1.00	5.66
F_oM_2	5.4	0.76	1.31	0.07	18.2	3.00	0.60	0.03	0.03	0.80	1.20	5.66
F_1M_o	5.4	0.86	1.48	0.07	19.5	3.40	0.80	0.03	0.03	1.20	1.20	6.66
F_1M_1	5.3	0.56	0.97	0.08	23.6	4.80	1.00	0.03	0.03	1.20	1.20	8.06
F_1M_2	5.3	0.30	0.52	0.08	19.5	3.80	1.60	0.06	0.03	1.00	1.20	7.69
F_2M_o	5.5	0.70	1.21	0.10	22.0	3.80	1.20	0.03	0.02	0.80	1.20	7.05
F_2M_1	5.5	0.40	0.69	0.06	15.4	3.00	1.20	0.03	0.03	0.06	1.20	6.06
F_2M_2	5.4	0.70	1.21	0.07	18.2	3.00	1.00	0.05	0.03	1.00	1.20	6.28
F_3M_o	5.6	0.80	1.38	0.07	24.9	3.00	2.00	0.04	0.04	0.60	1.20	6.88
F_3M_1	5.4	0.86	1.48	0.08	18/2	3.20	0.40	0.04	0.03	0.80	1.20	5.67
F_3M_2	5.3	0.90	1.55	0.06	22.0	3.60	1.20	0.06	0.03	0.80	1.20	4.85

Note: In all cases there was no significant difference between treatments and the control, and within treatments.

Table 4.3 (contd).

Sample	pH 1:2.5	C (%)	O.M (%)	Total N (%)	Avail. P mg/kg	Exchangeable Cations						Effective CEC me/100g
						Ca	Mg	K	Na	Al	H	
9 WAT												
F_oM_o	5.1	0.46	0.79	0.06	11.8	2.80	1.20	0.09	0.04	0.20	0.80	5.13
F_oM_1	5.3	0.42	0.72	0.07	15.4	3.00	1.60	0.09	0.04	0.20	1.00	5.93
F_oM_2	5.3	0.46	0.79	0.06	13.1	3.00	0.60	0.07	0.04	0.40	1.00	5.11
F_1M_o	5.2	0.34	0.59	0.07	14.3	2.40	2.00	0.09	0.04	0.40	1.00	5.93
F_1M_1	5.2	0.40	0.69	0.07	19.5	3.20	1.60	0.08	0.04	0.20	1.20	6.32
F_1M_2	5.0	0.80	1.38	0.10	18.2	4.00	1.00	0.14	0.04	0.40	0.80	6.38
F_2M_o	5.2	0.58	1.00	0.06	13.1	4.00	0.40	0.09	0.05	0.60	1.00	6.14
F_2M_1	5.1	0.82	1.41	0.07	13.1	3.00	1.40	0.08	0.04	0.60	0.60	5.52
F_2M_2	5.0	0.66	1.14	0.06	19.5	2.80	0.80	0.10	0.04	0.40	0.80	4.94
F_3M_o	5.4	0.60	1.03	0.06	13.1	3.00	1.20	0.10	0.04	0.40	1.00	5.74
F_3M_1	5.2	0.64	1.10	0.08	16.9	2.80	1.40	0.09	0.05	0.40	0.80	5.54
F_3M_2	5.0	0.96	1.66	0.11	14.3	3.20	1.20	0.11	0.04	0.20	0.80	5.55

Note: In all cases there was no significant difference between treatments and the control, and within treatments.

Table 4.3 (contd)

Sample	pH 1:2.5	C (%)	O.M (%)	Total N (%)	Avail. P mg/kg	Exchangeable Cations						Effective CEC me/100g
						Ca	Mg	K	Na	Al	H	
12 WAT												
F_oM_o	5.7	0.94	1.62	0.08	16.4	4.20	0.60	0.06	0.04	0.20	0.80	5.90
F_oM_1	5.6	0.76	1.31	0.07	13.9	4.00	1.40	0.06	0.03	0.40	0.80	6.69
F_oM_2	5.5	0.78	1.34	0.07	16.4	3.00	0.80	0.06	0.03	0.20	0.40	4.49
F_1M_o	5.5	0.70	1.21	0.06	16.4	3.40	0.80	0.05	0.03	0.40	0.40	5.08
F_1M_1	5.6	0.64	1.10	0.06	15.3	3.40	1.20	0.05	0.03	0.20	0.40	5.28
F_1M_2	5.4	0.90	1.55	0.08	12.5	4.80	0.60	0.08	0.04	0.20	0.60	6.32
F_2M_o	5.5	0.70	1.21	0.06	13.9	3.80	0.80	0.05	0.03	0.40	0.60	5.68
F_2M_1	5.5	0.82	1.41	0.06	12.5	3.40	1.60	0.08	0.02	0.40	0.40	5.90
F_2M_2	5.3	0.76	1.31	0.06	16.4	3.20	1.20	0.06	0.03	0.40	0.60	5.49
F_3M_o	5.4	0.90	1.55	0.07	9.8	3.60	0.80	0.06	0.04	0.20	0.40	5.10
F_3M_1	5.1	0.92	1.59	0.07	19.4	3.40	0.40	0.07	0.03	0.40	0.60	4.90
F_3M_2	5.0	1.00	1.72	0.09	16.4	3.40	1.20	0.07	0.03	0.20	0.80	5.70

Note: In all cases there was no significant difference between treatments and the control, and within treatments.

Table 4.3 (contd)

Sample	pH 1:2.5	C (%)	O.M (%)	Total N (%)	Avail. P mg/kg	Exchangeable Cations						Effective CEC me/100g
						Ca	Mg	K	Na	Al	H	
12 WAT												
F_oM_o	5.7	0.94	1.62	0.08	16.4	4.20	0.60	0.06	0.04	0.20	0.80	5.90
F_oM_1	5.6	0.76	1.31	0.07	13.9	4.00	1.40	0.06	0.03	0.40	0.80	6.69
F_oM_2	5.5	0.78	1.34	0.07	16.4	3.00	0.80	0.06	0.03	0.20	0.40	4.49
F_1M_o	5.5	0.70	1.21	0.06	16.4	3.40	0.80	0.05	0.03	0.40	0.40	5.08
F_1M_1	5.6	0.64	1.10	0.06	15.3	3.40	1.20	0.05	0.03	0.20	0.40	5.28
F_1M_2	5.4	0.90	1.55	0.08	12.5	4.80	0.60	0.08	0.04	0.20	0.60	6.32
F_2M_o	5.5	0.70	1.21	0.06	13.9	3.80	0.80	0.05	0.03	0.40	0.60	5.68
F_2M_1	5.5	0.82	1.41	0.06	12.5	3.40	1.60	0.08	0.02	0.40	0.40	5.90
F_2M_2	5.3	0.76	1.31	0.06	16.4	3.20	1.20	0.06	0.03	0.40	0.60	5.49
F_3M_o	5.4	0.90	1.55	0.07	9.8	3.60	0.80	0.06	0.04	0.20	0.40	5.10
F_3M_1	5.1	0.92	1.59	0.07	19.4	3.40	0.40	0.07	0.03	0.40	0.60	4.90
F_3M_2	5.0	1.00	1.72	0.09	16.4	3.40	1.20	0.07	0.03	0.20	0.80	5.70

Note: In all cases there was no significant difference between treatments and the control, and within treatments.

Table 4.3 (contd)

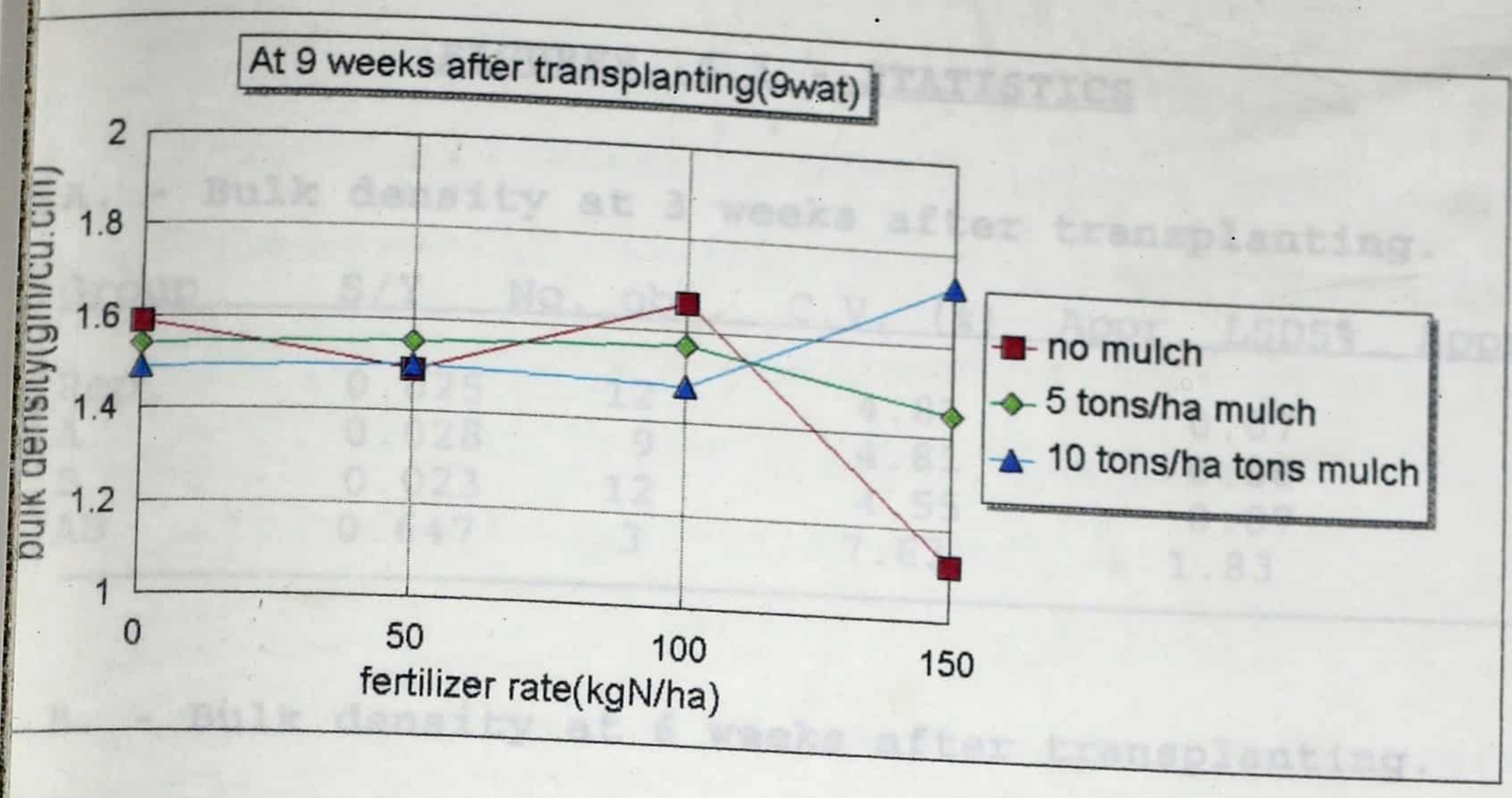
Sample	pH 1:2.5	C (%)	O.M (%)	Total N (%)	Avail. P mg/kg	Exchangeable Cations						Effective CEC me/100g
						Ca	Mg	K	Na	Al	H	
15 WAT (After Harvesting)												
F_oM_o	5.0	0.92	1.59	0.07	22.1	3.40	0.20	0.05	0.02	0.20	0.80	4.67
F_oM_1	5.2	0.84	1.45	0.06	19.4	3.20	0.40	0.05	0.03	0.60	0.60	4.88
F_oM_2	5.4	0.86	1.48	0.07	12.5	4.80	0.40	0.08	0.02	0.40	0.60	6.30
F_1M_o	5.5	0.68	1.71	0.06	16.4	3.40	0.20	0.05	0.01	0.20	0.40	4.26
F_1M_1	5.5	0.88	1.52	0.07	16.4	3.00	0.60	0.05	0.01	0.40	0.40	4.46
F_1M_2	5.6	0.92	1.59	0.08	15.3	3.20	0.80	0.05	0.01	0.40	0.60	5.06
F_2M_o	5.7	1.80	1.86	0.10	42.3	4.20	0.80	0.05	0.02	0.20	0.80	5.68
F_2M_1	5.7	0.86	1.48	0.07	8.6	3.60	0.20	0.05	0.01	0.60	0.60	5.06
F_2M_2	5.6	0.80	1.38	0.06	16.4	3.20	0.40	0.05	0.02	0.40	0.60	4.67
F_3M_o	5.7	1.02	1.76	0.08	27.8	4.40	0.40	0.08	0.02	0.40	0.80	6.10
F_3M_1	5.3	0.78	1.34	0.07	11.2	3.80	0.60	0.05	0.01	0.60	0.80	5.86
F_3M_2	5.9	0.92	1.59	0.08	6.0	3.80	1.00	0.05	0.02	0.80	1.00	5.70

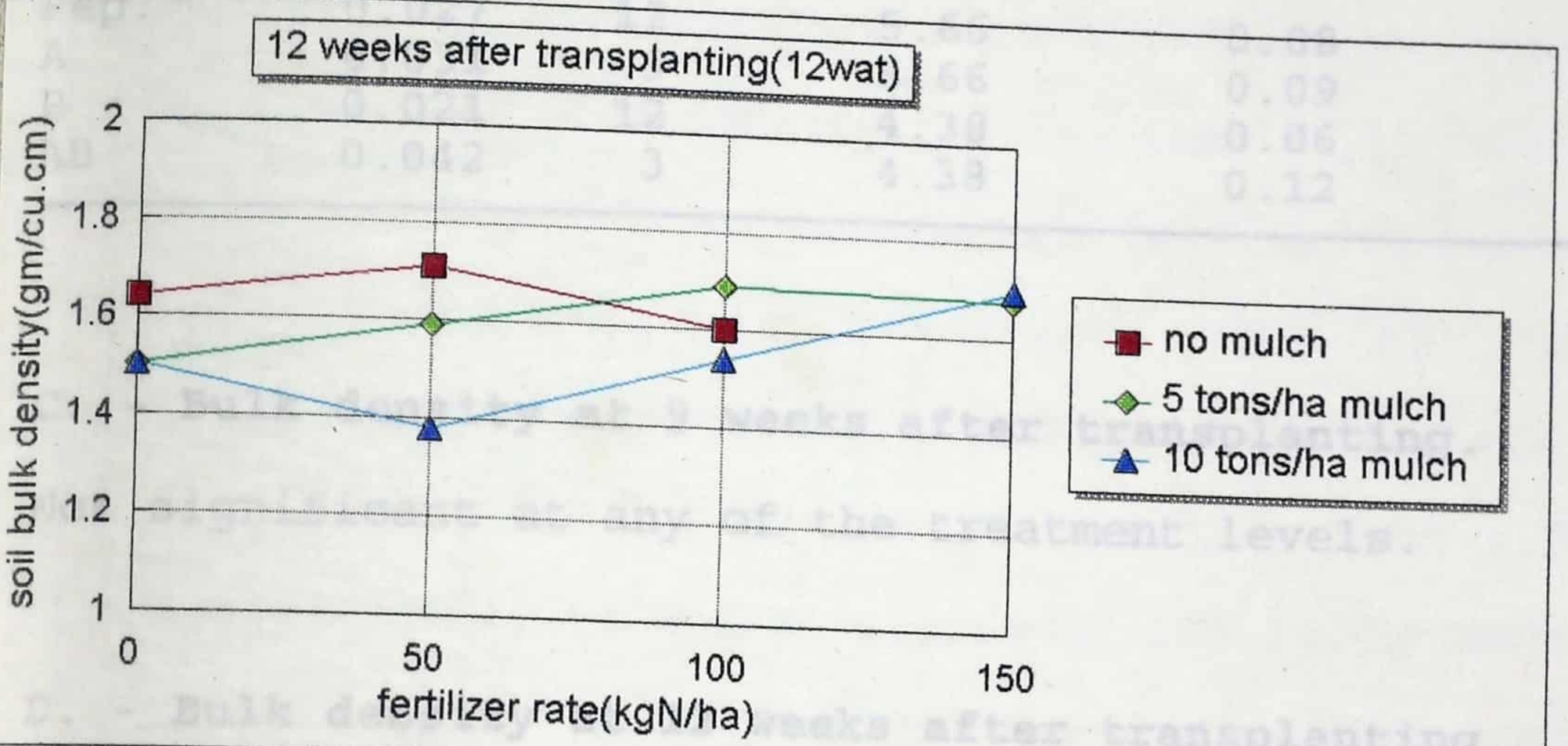
Note: In all cases there was no significant difference between treatments and the control, and within treatments.

4.2 Effect of Treatments on Soil Bulk Density

4.2.1 General

Bulk density results appear to have an inverse relationship with soil moisture content. At 9 weeks after transplanting (WAT) when soil moisture content showed high results, bulk density readings showed the lowest results during this period. At 6 WAT and 15 WAT when soil moisture content showed lower results, bulk density turned to be high. It was also observed that within the same period, bulk density turned to be reduced with increased mulch treatments as well as with increased mulch/fertilizer combinations. This trend is as a result of the effect of soil organic matter in increasing soil moisture content and decreasing soil bulk density. Dalland et al., (1993) reported of the effect of *Leucaena leucocephala* and *Flamingia congesta* mulch in reducing soil bulk density. Since soil bulk density is the ratio of the mass of a dry soil sample to a given volume, any activity that affects the mass of the soil affects the bulk density. Soil has a lower mass with increased soil organic matter and hence a reduced bulk density. Figure 4.1 shows the effect of treatments on soil bulk density.





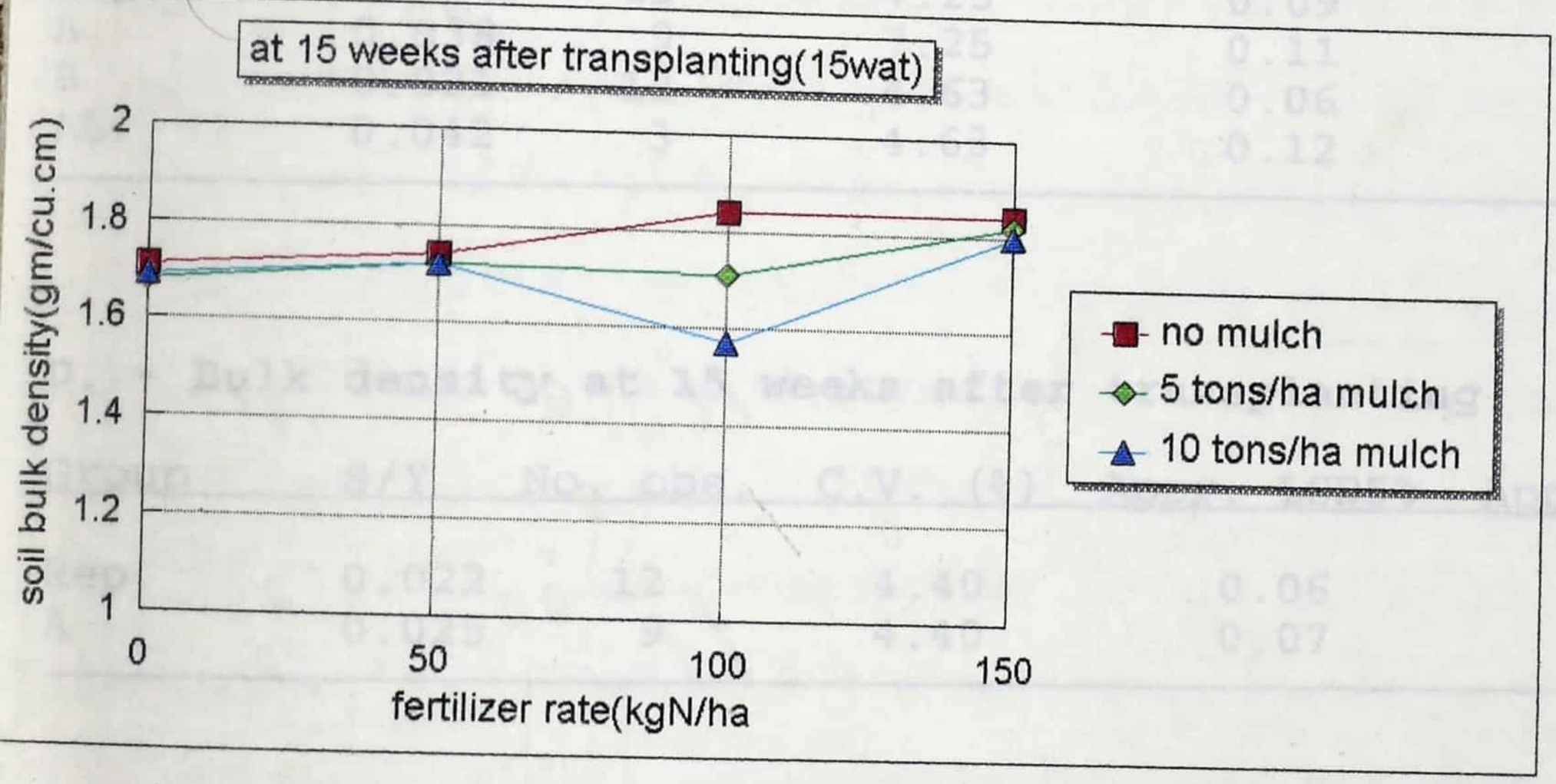


Fig.4.1b: Effect of mulch and fertilizer rates on soil bulk density.

FIGURES. 4.1 - STATISTICS

A. - Bulk density at 3 weeks after transplanting.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.025	12	4.81	0.07	0.09
A	0.028	9	4.81	0.08	0.11
B	0.023	12	4.55	0.07	0.09 **
AB	0.647	3	7.63	1.83	2.43 **

B. - Bulk density at 6 weeks after transplanting.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.027	12	5.66	0.08	0.10
A	0.031	9	5.66	0.09	0.12
B	0.021	12	4.38	0.06	0.08
AB	0.042	3	4.38	0.12	0.16 *

C. - Bulk density at 9 weeks after transplanting.

Not significant at any of the treatment levels.

D. - Bulk density at 12 weeks after transplanting.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.033	12	7.25	0.09	0.12
A	0.038	9	7.25	0.11	0.14
B	0.021	12	4.63	0.06	0.08 **
AB	0.042	3	4.63	0.12	0.16 **

D. - Bulk density at 15 weeks after transplanting.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.022	12	4.40	0.06	0.08
A	0.025	9	4.40	0.07	0.10 **

5% significant level = *
1% significant level = **

4.2.2 Results of Statistical Analysis

Fertilizer treatments had significant effect on bulk density only at 15 WAT. However, mulch and mulch/fertilizer combinations had various significant effects on soil bulk density at 3, 6, and 12 weeks after transplanting. No significant effects were observed at 9 WAT.

4.2.2.1 Effect of Treatment on Soil Bulk Density at 3 WAT

At 3 WAT, M2 (10 tons mulch/ha) and Mo (no mulch) did not differ significantly from each other but both gave significantly lower bulk density results than M1 (5 tons mulch/ha). This was however an unexpected reverse trend between the control and the mulch treatments (M1 > M2 > Mo). Mulch/fertilizer combination at 3 WAT gave a soil bulk density of the order F3M1 > F1M2 > F2M1 > F1M1 > FoMo > F2M2 >F3M2. where F3, F2, F1 and Fo represent 150, 100, 50 and 0 kgN/ha respectively. The observed trend of reduced bulk density with increased fertilizer/mulch combination such as observed in F2M2 and F3M2 treatments could be due to two factors. First the high level of nitrogen in these treatments promoted healthy plant growth and a good ground cover. This might have had an effect on reducing soil temperature and increasing the activity of soil micro-organisms activity. Secondly, these favourable conditions created might have led to efficient mulch decomposition and an increase in soil organic matter and hence a reduction in the soil weight per unit volume. The resultant effect was a reduction in soil bulk density. There were no significant differences in the

effects of F3M1, F1M2, F2M1 and F1M1 on soil bulk density at 3 WAT. However, these treatments had significantly higher bulk density than F3M2. F3M1 and F1M2 on the other hand had significantly higher bulk densities than FoMo and F2M2. F2M1, F1M1, FoMo and F2M2 did not differ significantly from each other in their soil bulk density.

4.2.2.2 Effect of Treatment on Soil Bulk Density at 6 WAT

At 6 WAT, only interaction effects showed significant differences in bulk density of the soil. From observations, bulk density effects were of the order FoMo = F1M1 = F3M2 > F3M1 > F1M2 = F2M1 = F2M2. While F2M1 and F2M2 did not differ significantly from F1M2, the rest of the treatments (FoMo, F1M1, F3M2 and F3M1) gave significantly higher bulk density than F1M2 at the 5% significance level.

4.2.2.3 Effect of Treatment on Soil Bulk Density at 12 WAT

At 12 WAT, significant effects on bulk density were observed in the mulch treatments and mulch/fertilizer interaction effects. The interaction effects at 12 WAT was significant at both the 5% and 1% significant levels. F1M2 (50 kg/haN and 10 tons/ha mulch) gave significantly lower bulk density than in the rest of the treatments. F3M2 and F2M1 did not differ significantly from each other but gave significantly higher bulk density readings than in the rest of the treatments. F3M1 and F1M1 did not also differ significantly from each other but gave significantly higher bulk density readings than in F2M2, FoMo and F1M2. Thus the order was F3M2 = F2M1 > F3M1 = F1M1 > FoMo = F1M2 = F2M2 > FIM2.

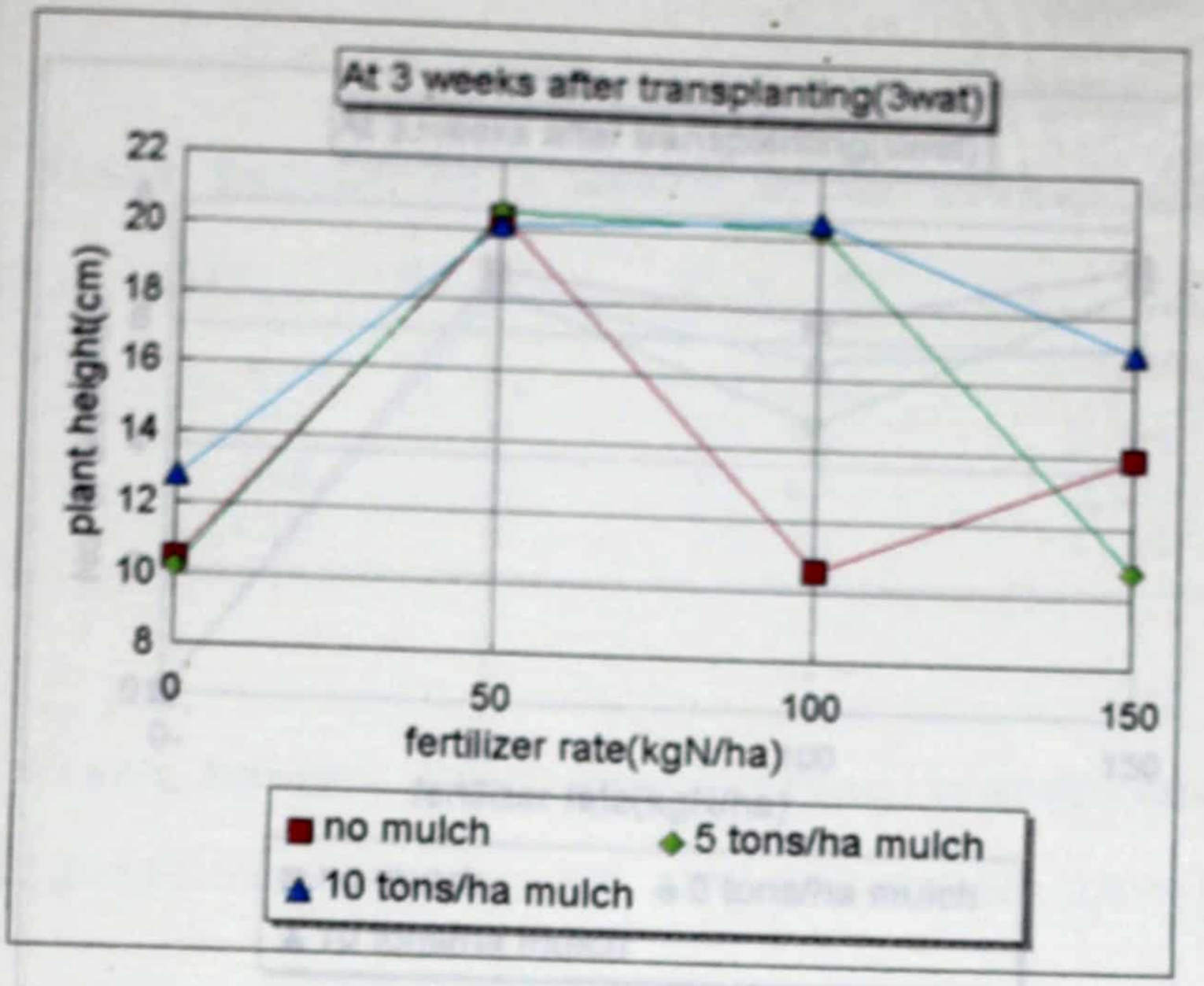
4.2.2.4 Effect of Treatment on Soil Bulk Density at 15 WAT

At 15 WAT fertilizer treatment showed a significant effect on bulk density at both the 5% and 1% significant levels. F2 and F3 had the same bulk density readings which were significantly higher than in Fo and F1. Even though F1 gave an observed higher bulk density than in Fo, these were not significantly different from each other. Hence the trend was F2 = F3 > FoF1.

4.3 Effect of treatments on the growth and development of Tomato

4.3.1 General

Figure 4.2 shows the average height of tomato and the average number of branches per plant at 3 and 6 weeks after transplanting as affected by the different treatments. From the figure, it could be observed that there was an initial increase in the height of tomato with an increase in fertilizer application but after some time, started decreasing with further increases of fertilizer application. A similar trend was observed in the fertilizer/mulch treatment combinations. At nutrient levels beyond a certain minimum, the order reverses and branching is encouraged. This could have accounted for the decreasing height with increasing fertilizer and mulch rates. Mulch appeared to provide additional nutrients to the plants and hence promoted branching.



B

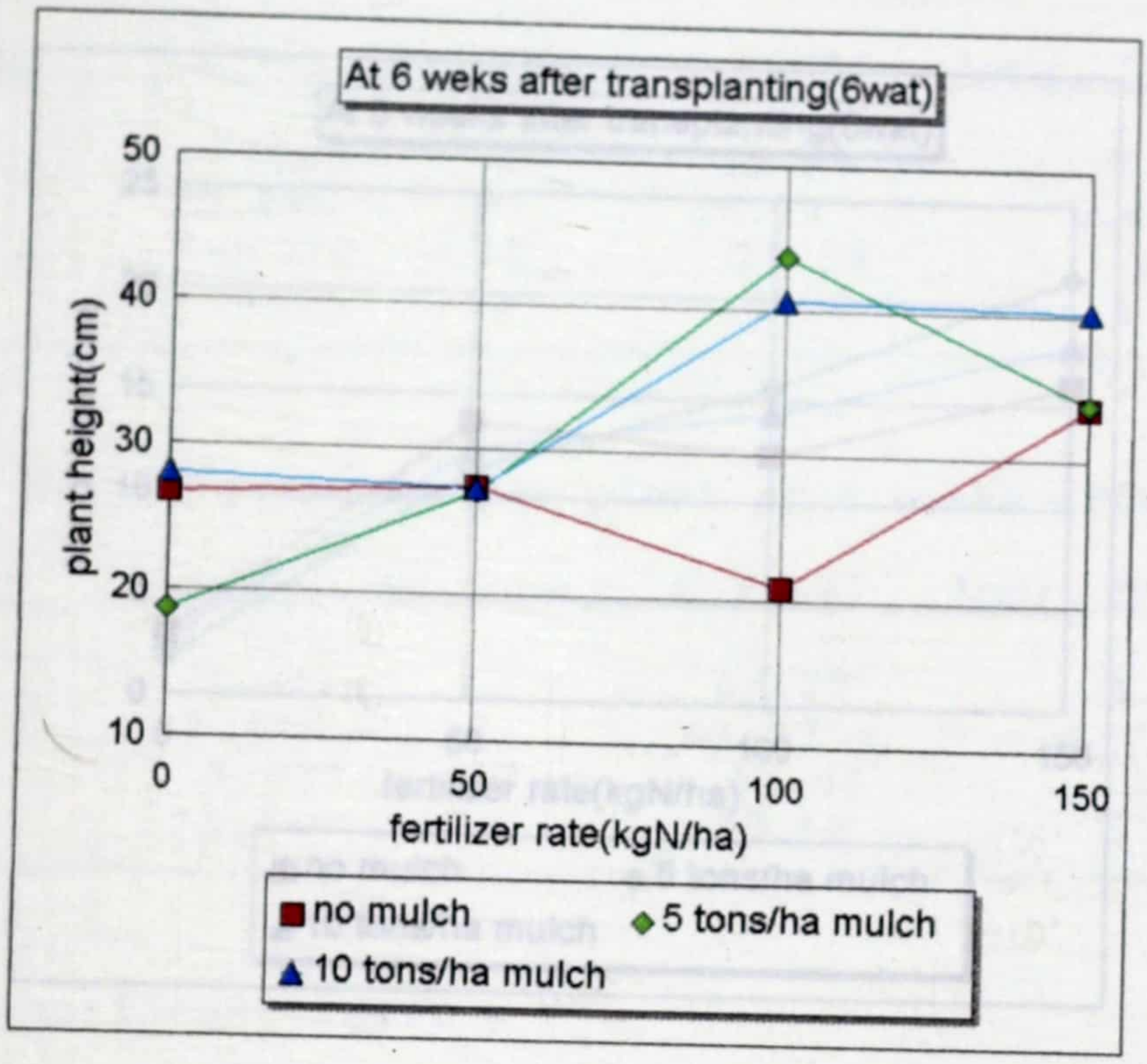
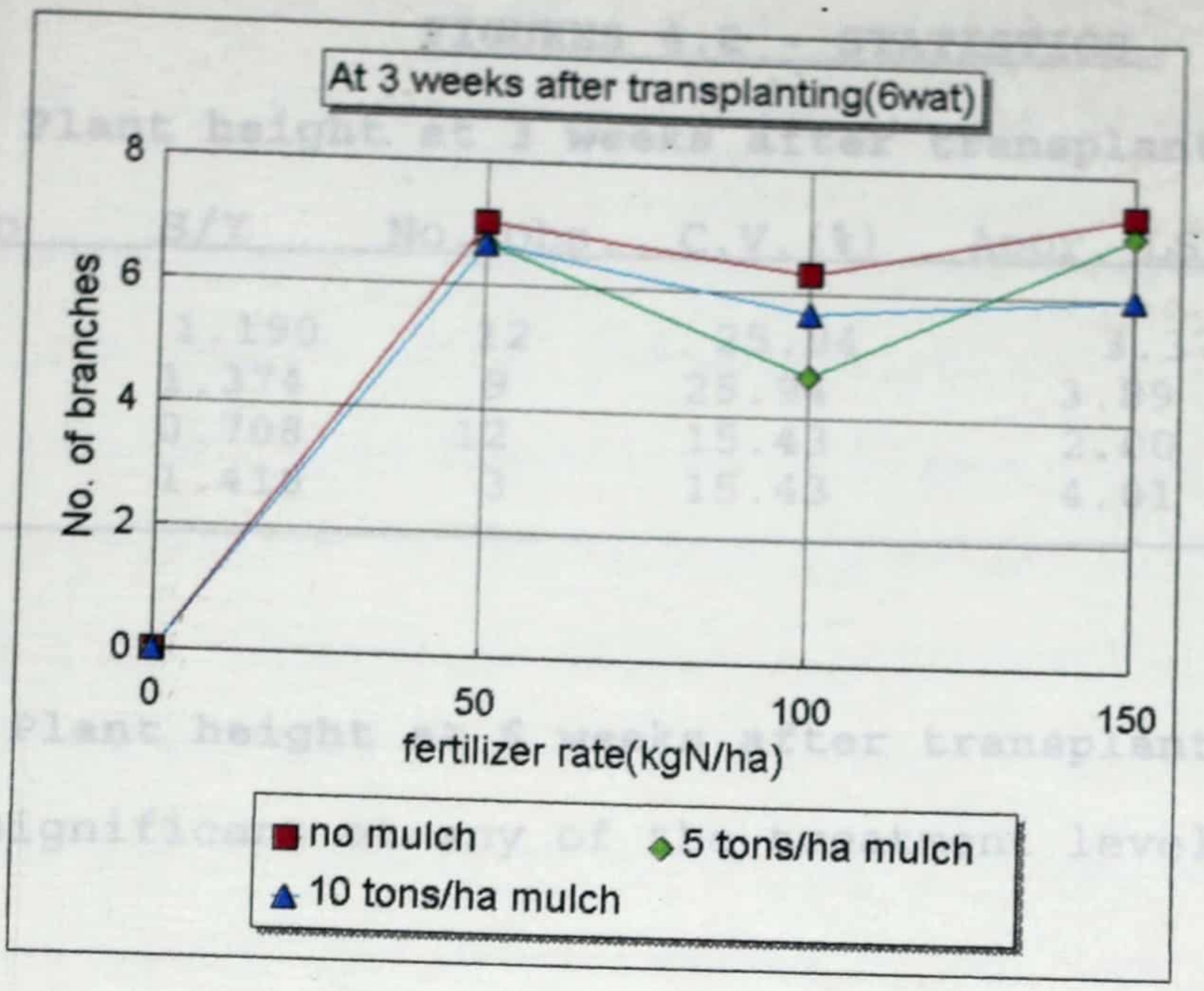


Fig.4.2a: Effect of mulch and fertilizer rates on growth and development of tomato.



B

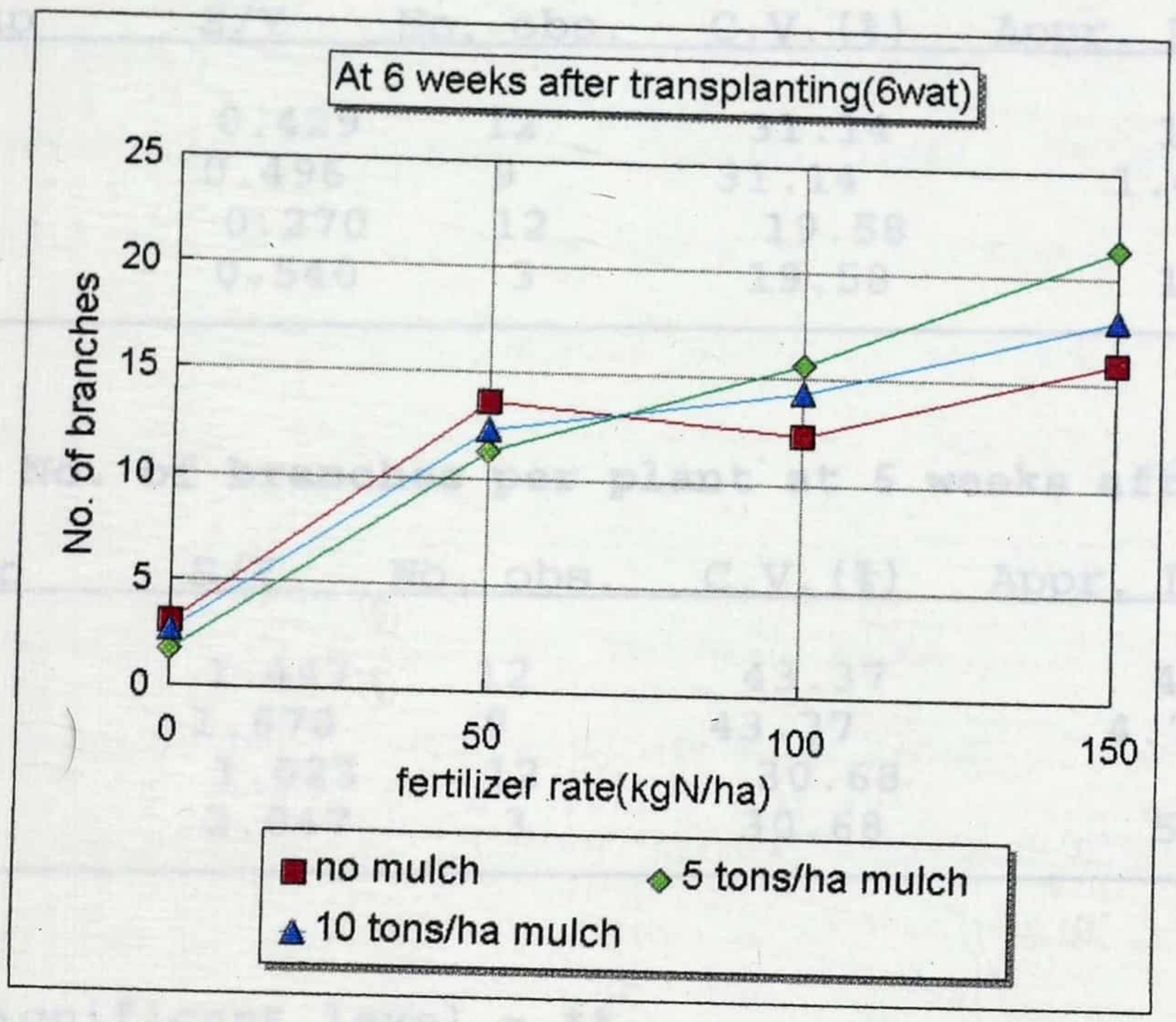


Fig. 4.2b: Effect of mulch and fertilizer rates on growth and development of tomato

FIGURES 4.2 - STATISTICS

A. - Plant height at 3 weeks after transplanting.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	1.190	12	25.94	3.37	4.48
A	1.374	9	25.94	3.89	5.17 **
B	0.708	12	15.43	2.00	2.66 *
AB	1.416	3	15.43	4.01	5.33 **

B. - Plant height at 6 weeks after transplanting.

Not significant at any of the treatment levels.

C. - No. of branches per plant at 3 weeks after transplanting.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr.LSD1%
Rep.	0.429	12	31.14	1.21	1.62
A	0.496	9	31.14	1.40	1.87 **
B	0.270	12	19.58	0.76	1.02
AB	0.540	3	19.58	1.53	2.03

D. - No. of branches per plant at 6 weeks after transplanting.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr.LSD1%
Rep.	1.447	12	43.37	4.09	5.44
A	1.670	9	43.37	4.72	6.28 **
B	1.023	12	30.68	2.89	3.85
AB	2.047	3	30.68	5.79	7.70

1% significant level = **

4.3.2 Results of Statistical analysis

4.3.2.1 Effect of Treatment on the Growth and Development of Tomato at 3 WAT

Subjecting the data to analysis of variance showed that at three weeks after transplanting (3 WAT) F1 (50kg/ha N) treatment gave significantly higher plant height than in Fo (no fertilizer), F2 (100 kg/ha N) and F3 (150 kg/ha N) which did not themselves differ significantly from each other (F1 > Fo > F2 = F3). The effect of mulch on plant height was significantly higher at M2 (10 tons/ha mulch) than at Mo (no mulch) and M1 (5 tons/ha mulch) levels. M0 and M1 did not show any significant difference in their effect on plant height (M2 > Mo = M1). Fertilizer/ mulch combinations also gave significant results to tomato height at 3 WAT. Except for the F3M1 (150 kg/ha N and 5 tons/ha mulch) interaction which did not show any significant effect on plant height, the other interaction effects; F1M1 (50 kgN/ha and 5 tons/ha mulch), F1M2 (50 kgN/ha and 10 tons/ha mulch),F2M1 (100 kgN/ha and 5 tons/ha mulch), F2M2 (100 kgN/ha and 10 tons/ha mulch) and F3M2 (150 kgN/ha and 10 tons/ha mulch) gave significantly higher plant height than in the control (FoMo).

4.3.2.2 Effect of Treatment on the Growth and Development of Tomato at 6 WAT

In the 6th week after transplanting, fertilizer/ mulch treatments had no significant effect on plant height. This could be due to the fact that mulch at this stage was completely decomposed and released nutrients to the soil in

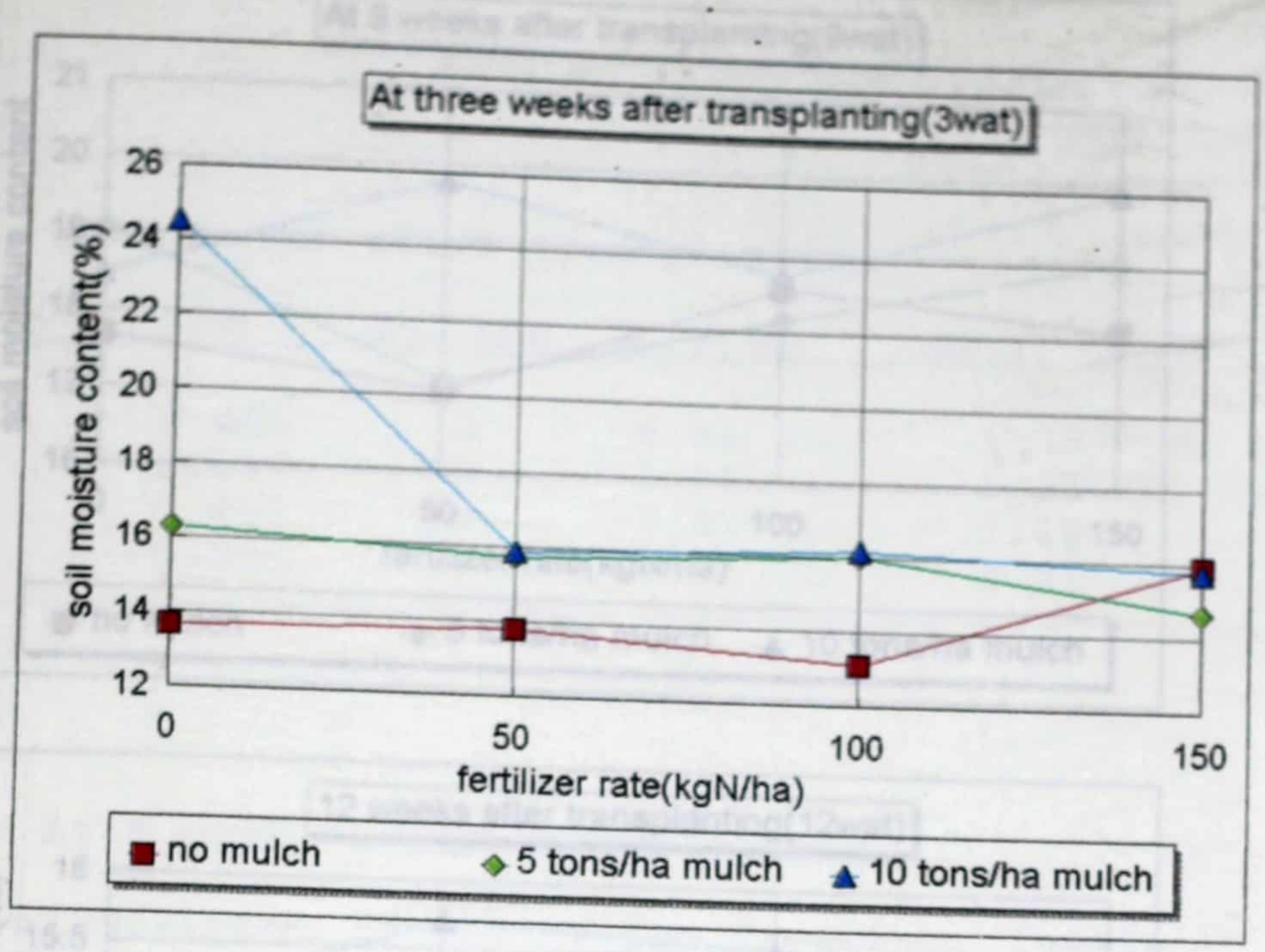
all the mulch treated plots. However F2M1 and F2M2 treated plants were significantly higher than plants of F2Mo.

With regards the effect of treatments on the number of branches, it was observed that fertilizer alone had a significant effect on the number of branches in the 3rd and 6th week after transplanting. All other treatments did not have any significant effect. Although at 3 WAT and 6 WAT, F3, F2 and F1 did not differ significantly in their effect on tomato branching, these treatments gave significantly higher branch number than in Fo.

4.4 Effect of Treatments on Soil Moisture Content

4.4.1 General

Soil moisture content showed relatively high results in the 9th week after transplanting than in the 3rd, 6th and 15th WAT. This was after the second Leucaena mulch application had been done. Results of soil moisture content at six weeks after transplanting (6 WAT), 12 WAT and 15 WAT appeared relatively lower. These trends are represented in figure 4.3. Although these trends were observed, soil organic matter which influences soil moisture content did not differ in the soil from the start to the end of the experiment.



B

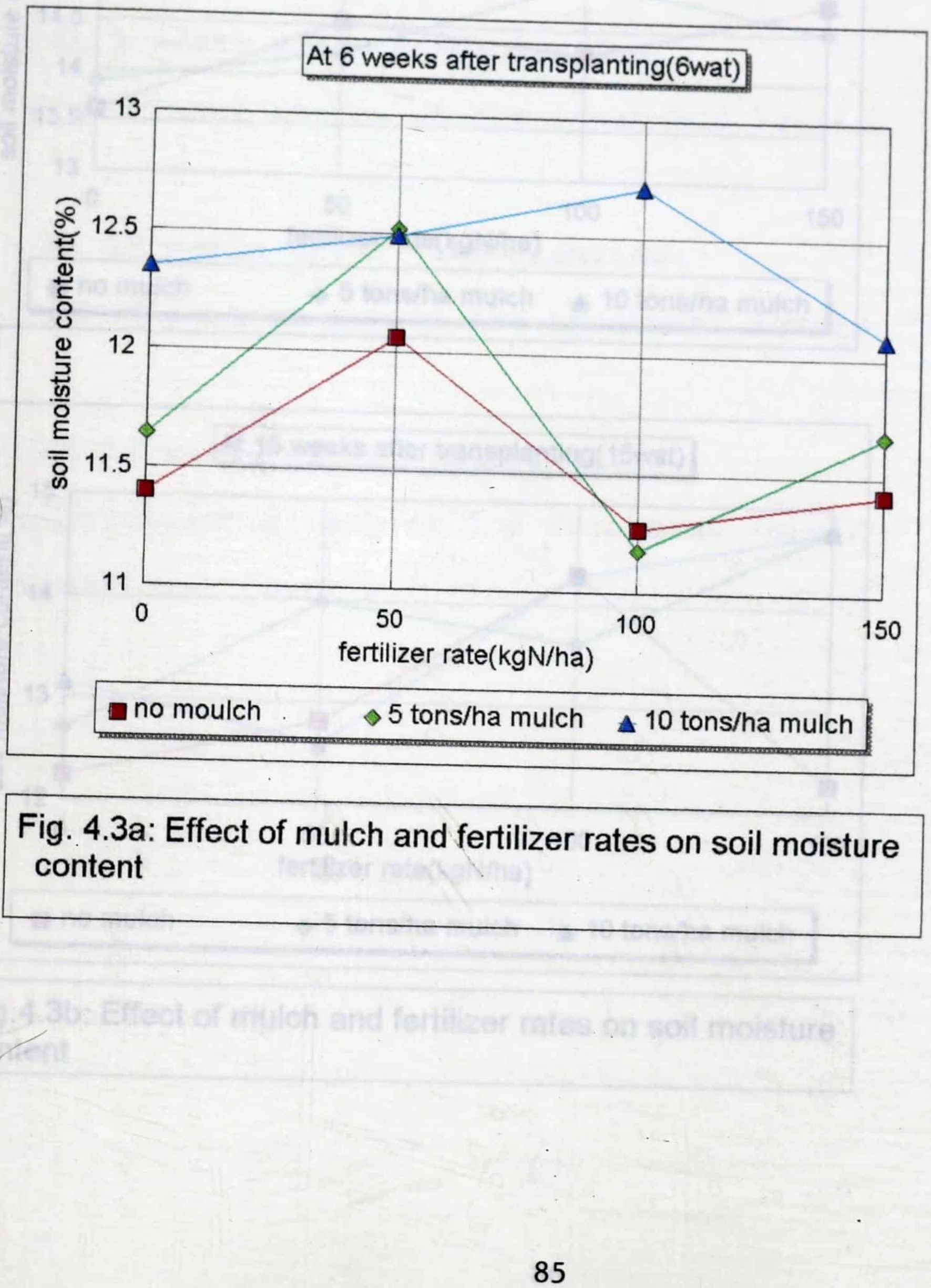
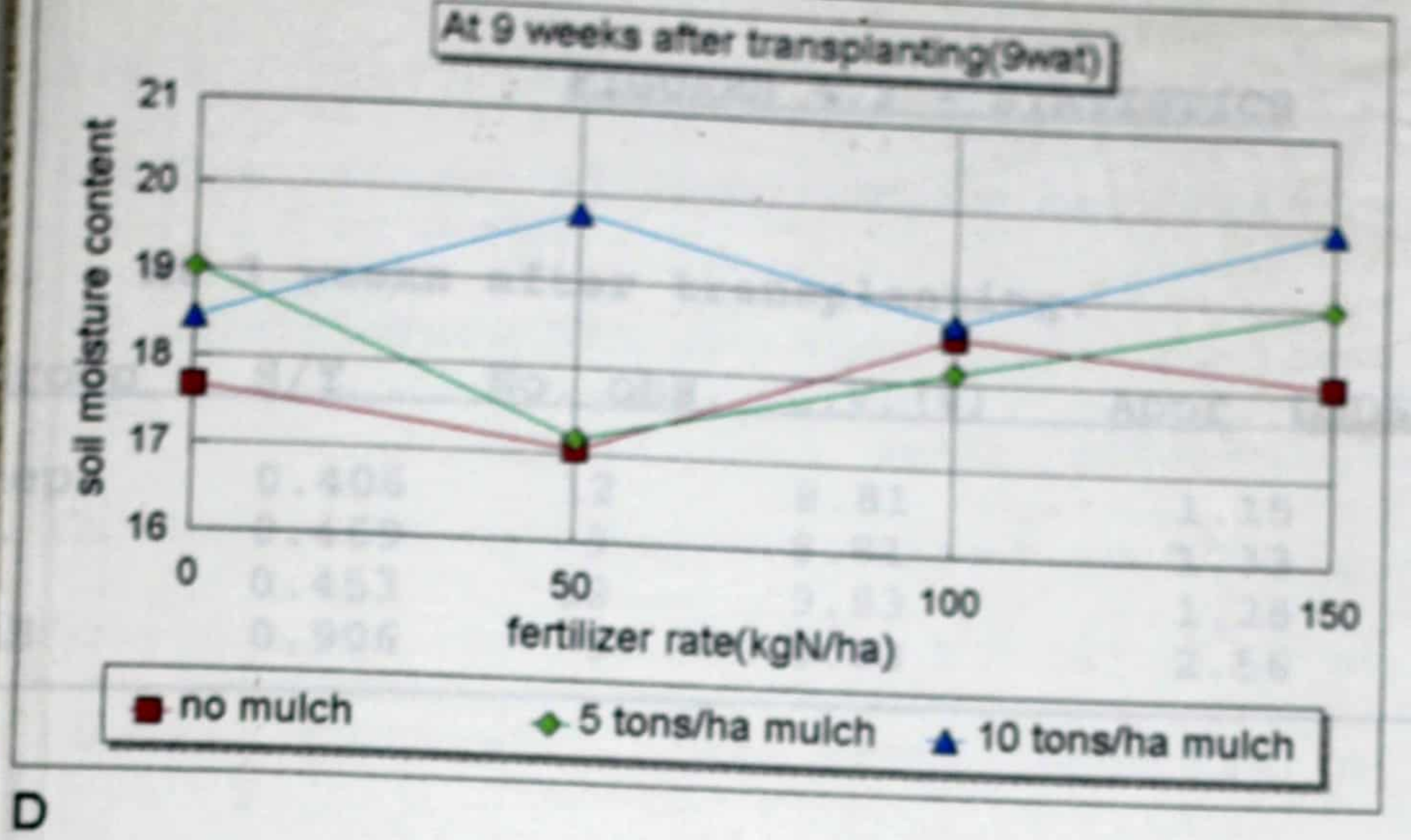
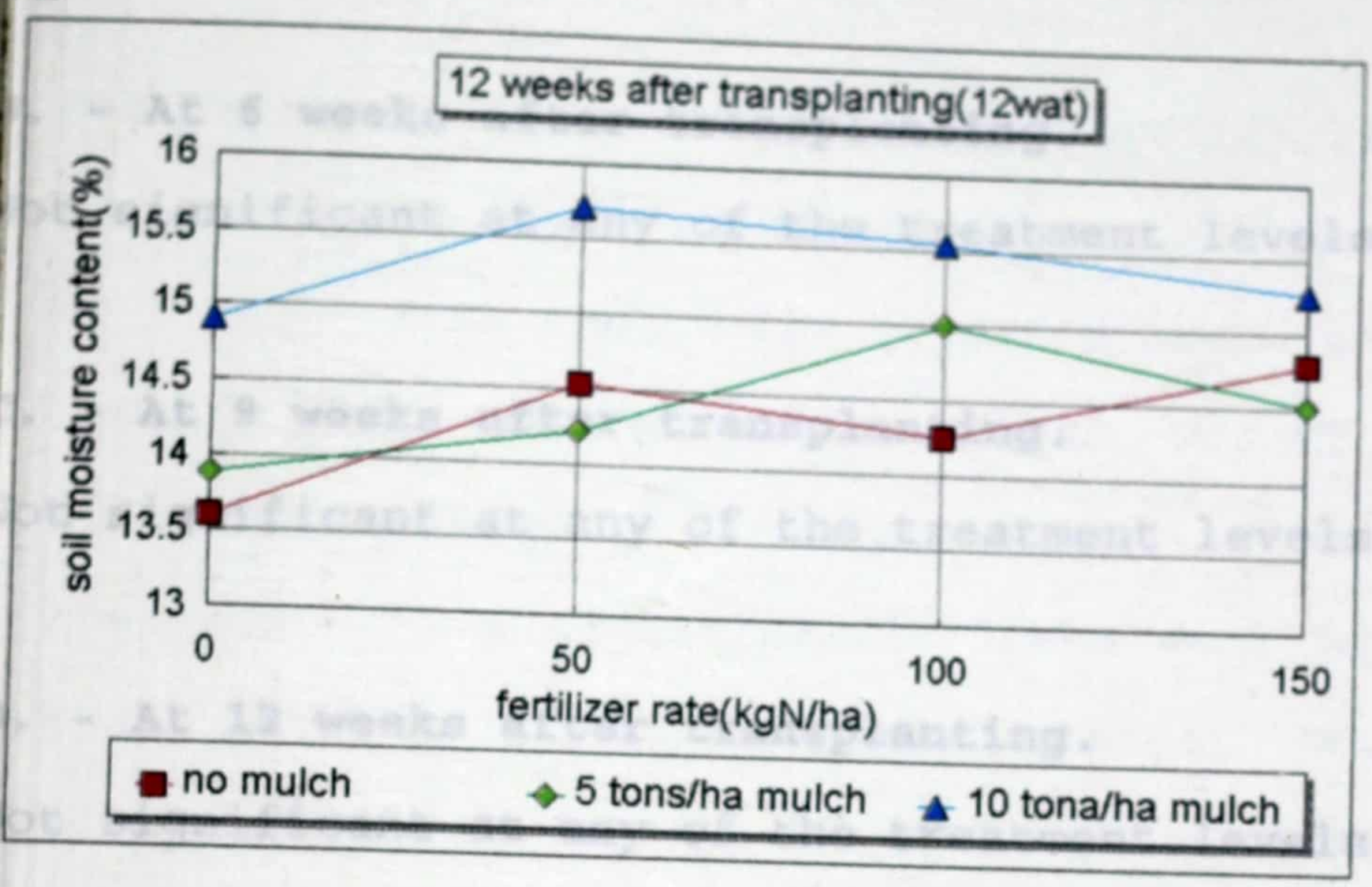


Fig. 4.3a: Effect of mulch and fertilizer rates on soil moisture content

D





E

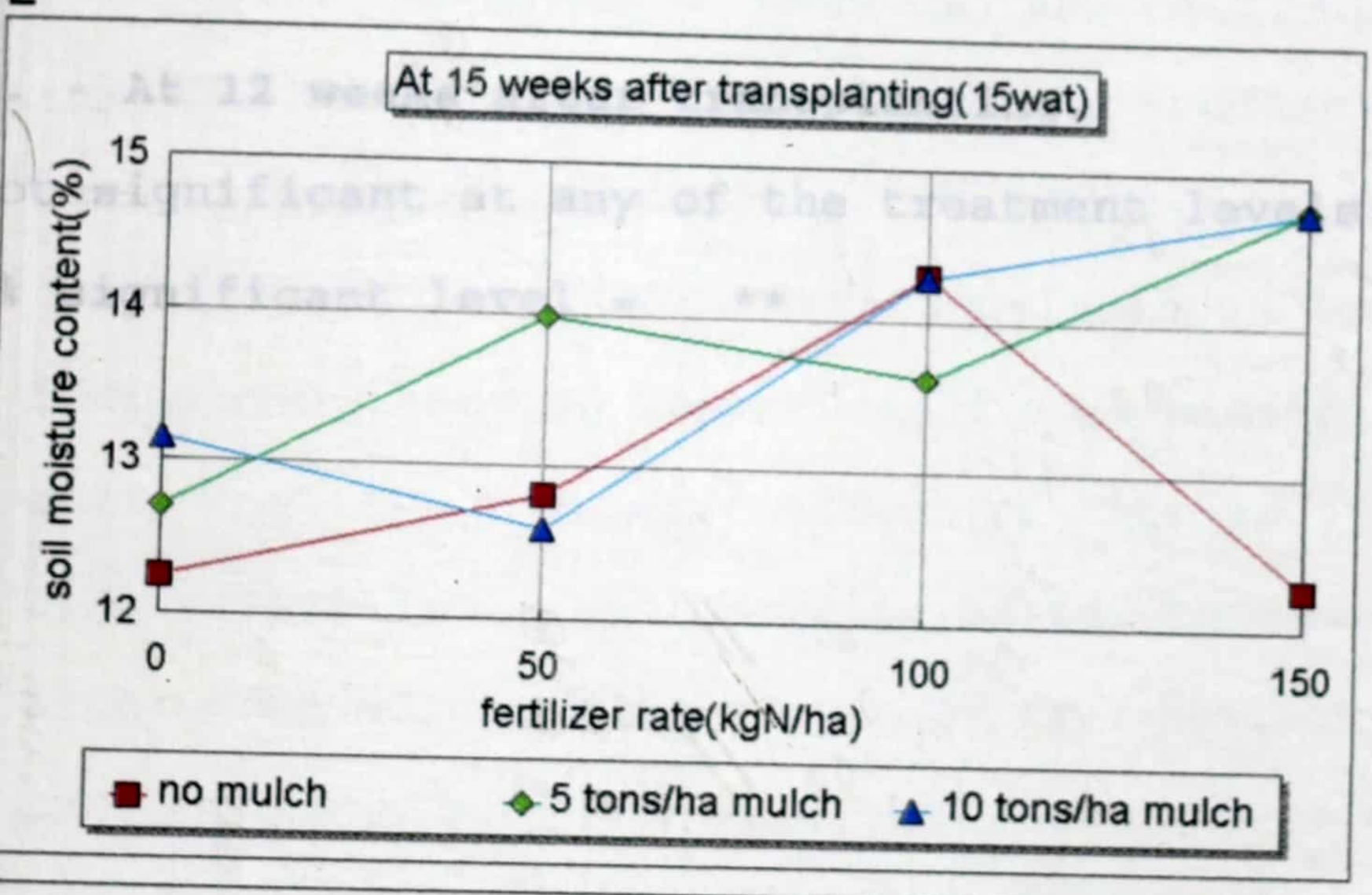


Fig.4.3b: Effect of mulch and fertilizer rates on soil moisture content

FIGURES 4.3 - STATISTICS

A. - At 3 weeks after transplanting.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.406	12	8.81	1.15	1.53 **
A	0.469	9	8.81	1.33	1.76 **
B	0.453	12	9.83	1.28	1.70 **
AB	0.906	3	9.83	2.56	3.41 **

B. - At 6 weeks after transplanting.

Not significant at any of the treatment levels.

C. - At 9 weeks after transplanting.

Not significant at any of the treatment levels.

D. - At 12 weeks after transplanting.

Not significant at any of the treatment levels.

E. - At 12 weeks after transplanting.

Not significant at any of the treatment levels.

1% significant level = **

4.4.2 Results of Statistical Analysis

4.4.2.1 Effect of Treatment on Soil Moisture Content at 3 WAT

All treatments did not show any significant effect in the 6th, 9th, 12th and 15th weeks after transplanting even though mulch treatments turned to favour improved soil moisture content of the soil. Significant effects were however shown at 3 weeks after transplanting.

Fertilizer alone, mulch alone and fertilizer/mulch combination also had significant effects on soil moisture content at 3 WAT. Even though the observed trend was F3 > F1 > Fo > F2 in their soil moisture content, F1, F2 and F0 did not differ significantly from each other. However these three treatments gave significantly lower soil moisture content than in F3. Soil moisture content could have been significantly higher in F3 (150 kgN/ha) than in the other fertilizer treatments because at this high fertilizer application level, high vegetative production might have been encouraged in tomato. This might have resulted in the creation of favourable conditions such as lowering in soil temperature leading to increased soil microbial number and activity. The resultant effect of this is the fast conversion of available soil organic matter to humus, which has a high water holding capacity. Several authors have reported the favourable effects of low soil temperature on soil microbial activities (Nair, 1984; Young, 1989). Mulch treatments of M2 and M1 gave significantly higher results

than in Mo (the control). M2 further gave significantly higher results than M1. With increased Leucaena mulch, organic matter content in the soil also increases. This increases the water holding capacity of the soil and hence soil moisture content. These trends conform with earlier research works. The effect of vegetative mulch on soil organic matter levels and soil moisture content have been variously reported by Young (1989), Nair (1984).

Fertilizer/mulch combination showed significant effects on soil moisture content at 3 WAT than in the control (FoMo). The interactions however did not differ significantly from each other in their effects. The observed trend was F2M2 > F2M1 > F1M2 > F3M2 > F1M1 > F3M1.

4.5 The Relationship Between Vegetative and Reproductive Characteristics

Yield in tomato seem to be influenced by branching. The higher the branching, the higher the number of fruits and the higher the total plant yield. The number of fruits per plant was considerably higher at the higher fertilizer/mulch combination levels due to the increased number of branching associated with these treatments. There was an increase of over 20% in branch formation from 100 kg/haN treatments to 150 kg/haN treatments and a corresponding increase of more than 26% in the number of unripe fruits. Table 4.4, gives the correlation co-efficient (r) figures between plant height, branches and yield. The regression co-efficient of

these analysis have shown that there is a weak correlation between plant height and number of branches, plant height and number of fruits and plant height and fruit yield. There was however a strong correlation between number of branches and number of fruits and fruit yield. There was a further strong correlation observed between number of riped fruits and number of unriped fruits and between number of fruits and yield. The co-efficient of determination in each of the strong correlated cases was found to be above 0.6 (ie. $r^2 > 0.6$).

Table 4.4. The relationship between plant height, branching, fruit number and yield (Figures expressed as correlation co-efficients).

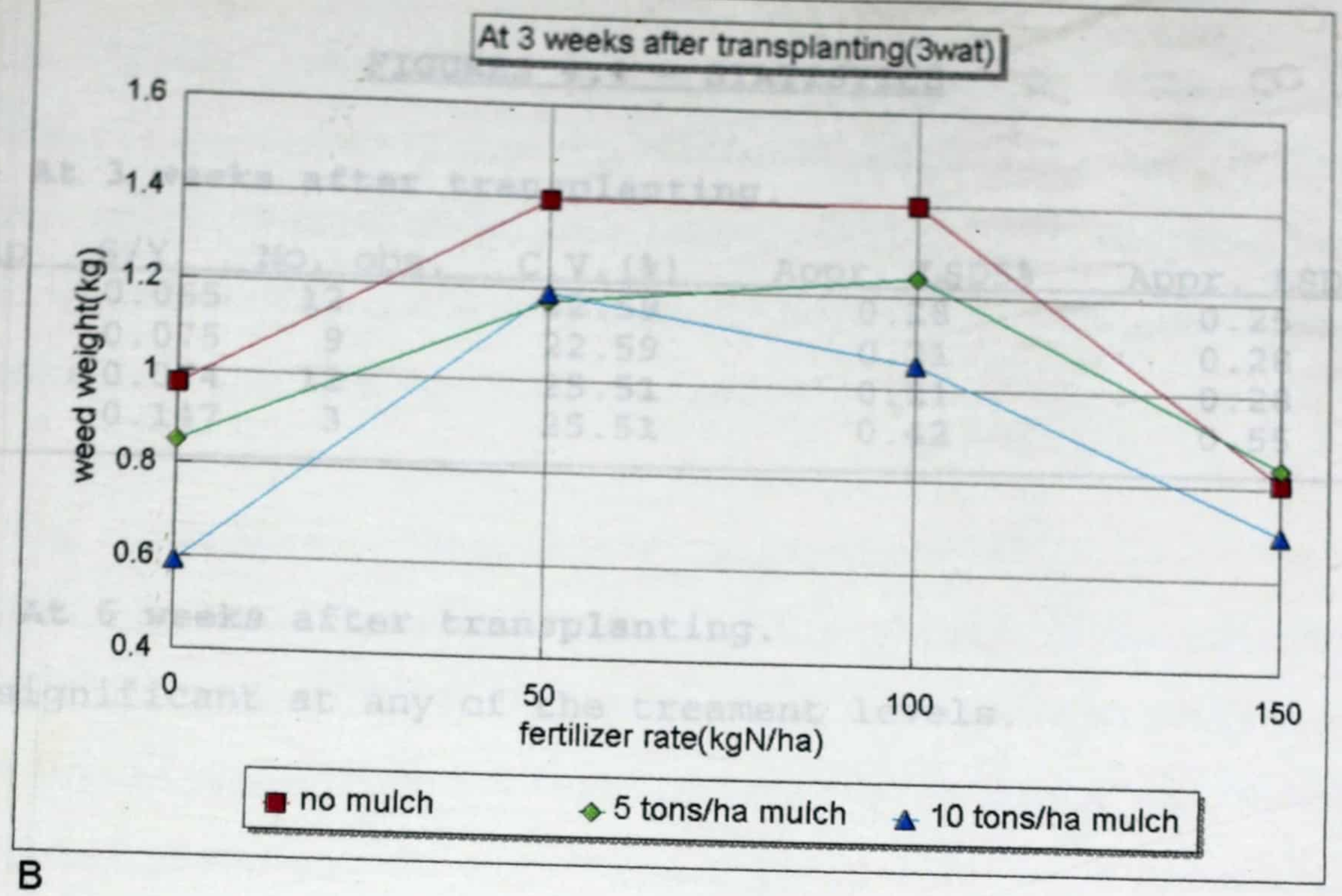
	1	2	3	4	5
1. Plant height	-	0.638	0.637	0.605	0.640
2. No. of branches	-	-	0.952	0.936	0.888
3. No. of riped fruits	-	-	-	0.994	0.965
4. No. of unriped fruits	-	-	-	-	0.970
5. Fruit Yield	-	-	-	-	-

4.6 Effect of Treatment on Weed Infestation

4.6.1 General

In a field experiment conducted for 4 consecutive years in Western Samoa, Rosecrance et al., (1992) reported a significant reduction in weed population in hedgerow intercropping with Calliandra and Gliricidia. Agboola and Udom (1967, quoted by Thurston, 1994) indicated that mulching reduced the competitive effects of weeds to such an extent that yields of maize were doubled. The reduced competitive effects of weeds could be due to the lower light intensity in the mulched environment (Webster and Wilson, 1980, quoted by Thurston, 1994). Thurston again quoted Morgan (1986) as having stated that weed growth can only be suppressed if the amount of mulch applied is heavy enough to prevent minimal light from passing through it. Otherwise, mulching may encourage weed growth.

Weed suppression may also be caused in part by shading. Since mulch increases the availability of nutrients for plant growth, the increased vegetative development which occurs as a result of mulching brings about shading and hence weed reduction. Figure 4.4 shows the effect of the different treatments on weed growth in the 3rd and 6th week after transplanting. Generally, weed infestation was higher in the 3rd week than in the sixth week. This trend is expected since after the first weeding effects of mulch and shade reduced weed infestation and lowered total amount of weed in subsequent weeding. It would also be noticed from



B

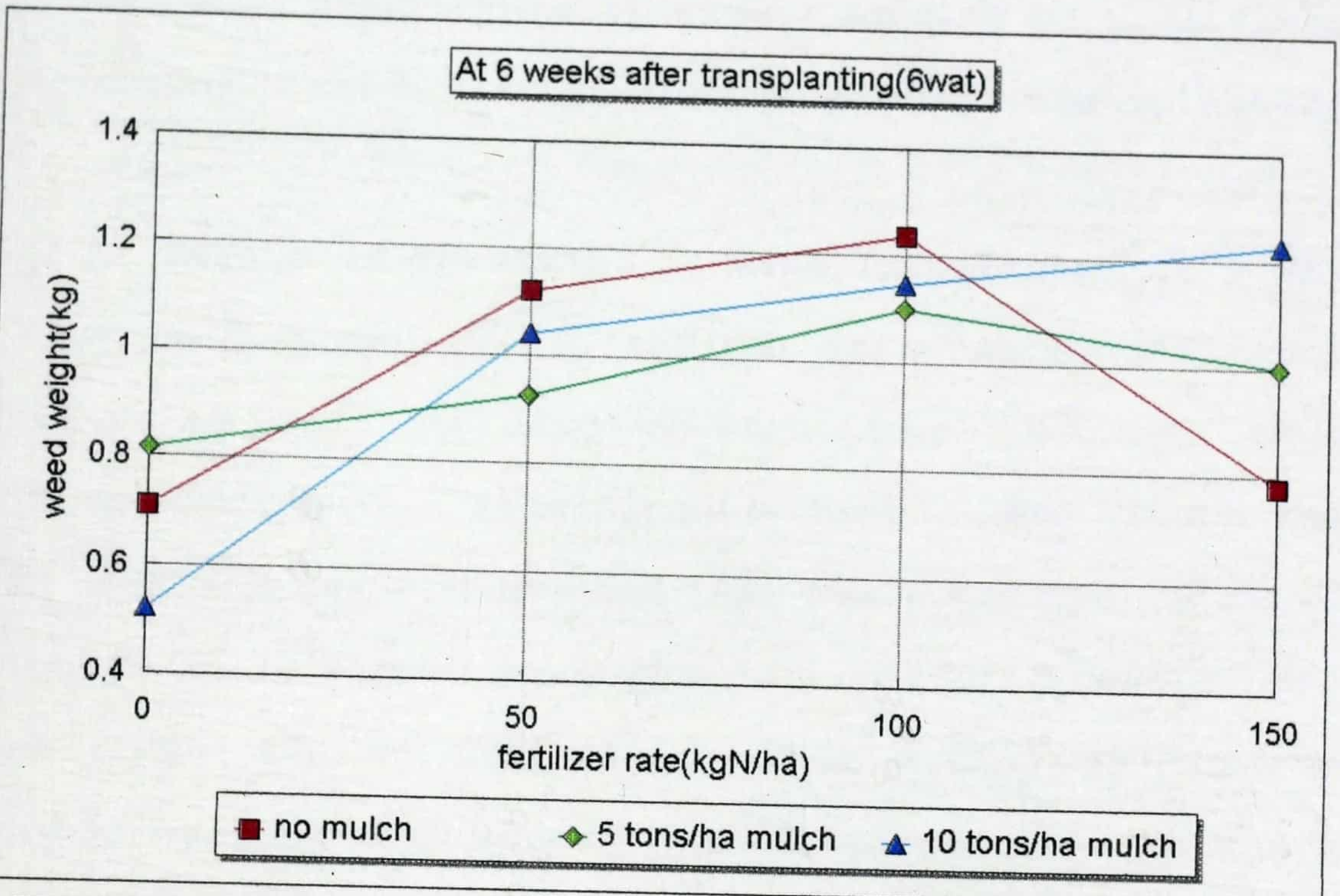


Fig.4.4: Effect of mulch and fertilizer rates on weed weight.

FIGURES 4.4 - STATISTICS

.. - **At 3 weeks after transplanting.**

roup	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%	
ep.	0.065	12	22.59	0.18	0.25	
	0.075	9	22.59	0.21	0.28	**
3	0.074	12	25.51	0.21	0.28	**
AB	0.147	3	25.51	0.42	0.55	

3. - **At 6 weeks after transplanting.**

Not significant at any of the treament levels.

the figure that the peaks, representing high weed infestation occur in plots without mulch treatment.Plots with mulch treatment showed lower results. It was however not possible to conduct this study beyond the 6th week after transplanting due to cultural restrictions.

4.6.2 Results of Statistical Analysis

Subjecting the data to statistical analysis revealed that even though fertilizer/mulch combination had no significant effect on weed growth, fertilizer treated plots and mulch treated plots showed significant effects on weed growth in the third week after transplanting. However no significant effects were observed in the sixth week after transplanting.

4.6.2.1 Effect of Treatment on Weed Infestation at 3 WAT

F2 (100 kgN/ha) and F1 (50 kgN/ha) were not significantly different in their influence on weed growth. However, these two treatments gave a significantly higher weed growth than in F3 (150 kgN/ha) treatments. All three treatments showed a significantly higher weed growth than in the control plot where there was no fertilizer. This trend was observed probably because weed growth depends among other things on ample space and on the level of soil nutrient status. The higher the nutrient status, the higher the weed growth. With Fo (control) having no fertilizer application, the nutrient status in these plots was low and hence low weed growth or weed weight. F3 which had the highest nitrogen application level could have produced lesser weeds than in

F2 and F1 due to the heavier shading of plants in this treatment. In F3, there was an observed vigorous and relatively higher vegetative production of tomato plants which provided effective shading for the soil.

Mulching of the plots was generally not too heavy so as to effectively reduce light penetration and hence weed growth. The absence of significant interaction effects on weed growth was therefore expected. Only mulch treatments had an observable reduction effect on weed growth in the 3rd week of the order M2 > M1 > Mo. However there was no significant difference between M1 (5 tons/ha mulch) treatment and no mulch treatment (control). M2 (10 tons/ha mulch) however gave significantly lower weeds than in M1 and Mo (control).

4.7 The Effect of Treatments on Number of Fruits

There was a general increase in both fruit set and tomato fruits with an increase in mulch level from Mo (no mulch) to M2 (10 tons/ha mulch) as shown on Table 4.5.

There was also an increase in the number of ripe and fruits set with increasing fertilizer rate up to the 150 kg/haN level. This is in conformity with Kim's (1991) work in which he stated that satisfactory yields using 150 kgN/ha were obtained under irrigation in Akumadan. From the Table, it could be observed that there was a lower number of both fruit set and riped fruits in treatments without mulch than in corresponding treatments with mulch.

Table 4.5. Effect of treatment on number of riped and unriped fruits.

Fertilizer Rate (kgN/ha)	0 tons/ha Mulch	5 tons/ha Mulch	10 tons/ha Mulch
0	3.5 (2.7)	7.26 (5.37)	9.17 (7.3)
50	21.43 (16.2)	25.98 (19.2)	29.37 (21.33)
100	25.15 (19.0)	27.3 (21.47)	28.62 (23.17)
150	34.36 (24.57)	35.17 (26.7)	42.0 (29.1)

Riped fruits in brackets.

STATISTICS

A. - Riped fruits.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.375	12	7.22	1.06	1.41
A	0.434	9	7.22	1.23	1.63
**					
B	0.249	12	4.80	0.71	0.94
**					
AB	0.499	3	4.80	1.41	1.88

B. - Unriped fruits.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.460	12	6.60	1.30	1.73
A	0.531	9	6.60	1.50	2.00
**					
B	0.352	12	5.06	1.00	1.33
*					
AB	0.704	3	5.06	1.99	2.65
**					

This confirms the positive role of mulch in enhancing higher fruit set and reducing fruit drop in vegetables (Thurston et al., 1994; Omoro and Nair, 1993). The interaction effects gave generally more fruits (both ripe and fruit set) per plant than fertilizer alone for the same reason. Fruit abscission was observed to be reduced at the 10 tons/ha mulch levels and their interactions than at the 5 tons/ha mulch level.

4.7.1 Results of Statistical Analysis

Analysis of variance of the data on number of fruits per plant showed that mulch/fertilizer combination had no significant effect on the average number of ripe fruits per plant. However fertilizer treatment alone and mulch treatment alone showed significant effects on the number of ripe fruits per plant. F3, F2 and F1 apart from showing significantly higher results than in the control (Fo) also differed significantly from each other. In order of significance we had F3 > F2 > F1. The order of significance for mulch treated plots was also M2 > M1 > Mo.

Fertilizer alone also had significant effect on the number of fruit set per plant. While all treatments gave significantly higher fruit number than the control, the treatments themselves differed significantly, in the order F3 > F2 > F1. Mulch gave a similar significance in fruit set as in ripe fruits (ie. M2 > M1 > Mo). This effect of mulch in the two situations could be due to the role of

Leucaena in improving soil physical, chemical and biological properties and hence yield (Young, 1989a; Omoro and Nair, 1993).

Mulch/fertilizer interaction gave significant results with fruit set. All interaction effects produced signifi-cantly higher fruit set than in the control. F3M2 (150 kgN/ha and 10 tons/ha mulch) gave significantly higher fruit set than in the rest of the interaction effects. F3M1 (150 kgN/ha and 5 tons/ha mulch) gave significantly higher results than in F1M2 (50 kgN/ha and 10 tons/ha mulch), F2M1 (100 kgN/ha and 5 tons/ha mulch) and F1M1 (50 tons N/ha and 5 tons/ha mulch). F1M2 and F2M2 did not differ significantly from each other but these gave significantly higher results than in F2M1 and F1M1. F1M1 in turn gave significantly lower results than F2M1 at the 5% significant level. Thus in order of significance we have F3M2 > F3M1 > F1M2 = F2M2 > F2M1 > F1M1 > FoMo. A combination of Leucaena mulch with fertilizer can thus be said to promote higher fruit set with increased nitrogen application. This effect is better achieved at higher mulch combination levels of 10 tons/ha fresh weight or more.

4.8 Effect of Treatment on Total Ripe Fruit Weight Per Plant

Table 4.6 shows the trend in total ripe fruit weight per plant with the various levels of treatment. There is a general increase in total ripe fruit weight per plant with increase in treatment levels. This increase is highest with mulch levels of 10 tons/ha whether as a pure mulch treatment or in a fertilizer/mulch combination.

Table 4.6. Effect of treatment on total ripe fruit weight per plant (kg).

Fertilizer Rate (kgN/ha)	O tons/ha mulch	5 tons/ha mulch	10 tons/ha mulch
0	0.103	0.27	0.34
50	0.70	0.69	1.015
100	1.013	1.005	1.19
150	1.33	1.159	1.641

Statistics

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.021	12	8.47	0.06	0.08
A **	0.025	9	8.47	0.07	0.09
B **	0.018	12	7.03	0.05	0.07
AB **	0.035	3	7.03	0.10	0.13

4.8.1 Results of statistical analysis

Fertilizer alone, mulch alone and fertilizer/mulch combinations gave significantly higher ripe fruit weight per plant. With regards to fertilizer levels, the exhibited significance was of the order F3 > F2 > F1 > Fo. In the mulch treatments M2 > M1 > Mo. Palada et al., (1992) indicated that Leucaena can reduce fertilizer requirement for vegetable production. The trend could therefore be as a result of increased soil fertility with increased mulch application.

All the treatment combination effects resulted in significantly higher total weight of ripe fruits per plant than in the control. F3M2 combination gave significantly higher results than in the rest of the combinations. Even though from observations F2M2 gave slightly higher fruit weight per plant than in F3M1 treatments and F1M2 gave slightly higher fruit weight per plant than in F2M1, these were not significantly different from each other. However, F2M2 and F3M1 treatments gave significantly higher results than F1M2 and F2M1 treatments. F1M2 and F2M1 treatments in turn gave significantly higher fruit weight per plant than F1M1 treatments. Thus in order of significance it is F3M2 > F2M2 = F3M1 > F1M2 = F2M1 > F1M1 > FoMo.

4.9 Effect of Treatment on Fruit Yield and Fruit Quality

Table 4.7 presents the marketable quality of tomato as affected by the various treatments and the obtained marketable yield per hectare of each treatment. From the table, it could be observed that the control plot of no fertilizer and no mulch had the highest non-marketable sized fruits of (< 25g) about 26.3% and the lowest marketable yield. At 10 tons/ha mulch level it was observed that all fruits were of market quality (> 25g). This shows that Leucaena mulch improves tomato fruit size.

However, in combination with fertilizer, Leucaena mulch turned to give a lower percentage of market quality fruit than in similar treatments using fertilizer alone. This is however compensated for by the higher fruit weight in the mulch/ fertilizer treatments especially at the 10 tons/ha mulch combination level. This overall positive effect of Leucaena mulch seem to be expressed at a certain minimum mulch level above 5 tons/ha since the 5 tons/ha mulch combinations with fertilizer turned to give a higher percentage of non-marketable sized fruits and a lower total yield than similar treatments with fertilizer alone. The possible explanation could come from the fact that decomposing bacteria initially use nitrogen in the soil as a source of energy for its decomposition activity (Rusell, 1988). This initial soil nitrogen utilization by bacteria possibly lowers the initial nitrogen level in mulch/

Table 4.7. Market quality and yield of tomato

Treatment	Marketable Quality (%)				Marketable Yield per ha (tons)
	Non-marketable Quality < 25g	Grade 3 25-49g	Grade 2 50-60g	Grade 1 > 60g	
FoMo	26.3	52.6	15.8	5.3	1.42
FoM1	20.8	29.2	29.2	20.8	4.0
FoM2	-	50.0	36.4	13.6	6.36
F1Mo	8.5	30.5	22.0	39.0	12.04
F1M1	11.1	29.6	29.6	29.7	11.47
F1M2	12.7	38.0	15.2	34.1	16.57
F2Mo	8.0	12.7	21.8	57.5	17.43
F2M1	25.0	14.8	20.4	39.8	17.89
F2M2	19.6	22.5	24.6	33.3	17.89
F3Mo	14.4	28.9	30.9	25.8	21.29
F3M1	19.6	23.4	21.5	35.5	17.43
F3M2	15.6	23.1	17.7	43.6	25.90

STATISTICS

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.054	12	6.80	0.15	0.20
A	0.062	9	6.80	0.18	0.23 **
B	0.044	12	5.63	0.13	0.17 **
AB	0.089	3	5.63	0.25	0.33 **

fertilizer combinations as compared to similar treatments of fertilizer alone. The release of nitrogen from Leucaena during decomposition is high enough to more than compensate for this initial nitrogen lost at the 10 tons/ha mulch levels. This compensation is not realised at a lower mulch level of 5 tons/ha. Hence the trend FxM2 > FxMo > FxM1 for both market quality and total fruit yield.

4.9.1 Results of statistical analysis

Statistical analysis showed that there were significant difference in yield per hectare in all treatments. Fertilizer had a significant effect on yield at the 1% significant level. Fertilizer treatments also differed significantly from each other in the order F3 > F2 > F1 > Fo. Leucaena mulch at 10 tons/ha and 5 tons/ha levels gave significantly higher marketable yield per hectare than where there was no mulch. M2 further gave significantly higher yield than M1.

All interaction effects showed significantly higher yield than in the control (no mulch and no fertilizer). F3M2 gave significantly higher results than the rest of the interaction effects. F2M2, F3M1 and F1M2 did not differ significantly from each other even though the observed trend was F2M2 > F3M1 > F1M2. However, these three treatments gave significantly higher yields than in F2M1 and F1M1. F2M1 in turn gave significantly higher marketable yield per hectare than F1M1 (F3M2 > F2M2 = F3M1 = F1M2 > F2M1 > F1M1 > FoMo).

Statistical analysis also showed that all treatments had significant effects on marketable fruit quality (grade 1 (< 60g),grade 2 (50-60g) and grade 3 (25-49g)). All fertilizer treatments gave significantly higher total marketable quality fruits than where there was no fertilizer (control). At 150 kgN/ha total marketable quality fruits were significantly higher than in the other treatments. In other of significance it was F3 > F2 > F1 > Fo. Mulch had a highly significant effect on market-able fruit quality. Mulch treatments showed significantly higher fruit quality than the control. The order of significance was M2 > M1> Mo. All interaction effects gave significantly higher marketable fruit quality than in the control. F1M2 and F2M2 were not significantly different in their effect but gave significantly higher results than F1M1 and F2M1 which were not also significantly different from each other. The order of significance was F3M2 >F3M1> F2M2 = F1M2 > F1M1 = F2M1 > FoMo. From the results, it appears the higher the mulch/fertilizer combination, the better the marketable fruit quality.

4.10 Comparison of Reproductive Efficiency with Fruit Yield

At the lowest reproductive efficiency of 69.3%, average yield per plant was highest (1.641 kg). This observation occurs at a treatment level of 150 kgN/ha combined with 10 tons/ha Leucaena mulch as shown on table 4.8. At this treatment level, even though fruit drop was very high, the

Table 4.8: Comparison of reproductive efficiency with fruit yield.

Treatment	Average No. of Unripe Fruits	Average No. of Ripe Fruits	Reproductive Efficiency (%)	Average Weight of Fruits Per Plant (kg)
FoMo	3.5	2.70	77.1	0.103
FoM1	7.26	5.37	74.0	0.270
FoM2	9.17	7.30	79.6	0.340
F1Mo	21.43	16.20	75.6	0.699
F1M1	25.98	19.20	73.9	0.689
F1M2	29.37	21.33	72.6	1.015
F2Mo	25.15	19.0	75.5	1.013
F2M1	27.30	21.47	78.6	1.005
F2M2	28.62	23.17	81.0	1.190
F3Mo	34.36	24.57	71.5	1.330
F3M1	35.17	26.7	75.9	1.159
F3M2	42.0	29.1	69.3	1.641

average weight of ripe fruits was correspondingly high resulting in the overall high yield. Coupled with this is the very high fruit set at this treatment level which gave buffering to the high fruit drop. Fruit drop was observed to have been caused by fruit rot and early fruit abscission.

Diseases and pests infestation in tomato turns to be high with high applications of nitrogen fertilizer. The plant is also particularly prone to diseases under very moist conditions. The setting in of rains around the time of fruiting and fruit ripening therefore accounted for the high fruit rot which was higher in the 10 tons/ha mulch and 150 kgN/ha combinations than in the other treatments which had lower nitrogen application.

Mulch application alone was observed to give a higher reproductive efficiency at the 10 tons/ha mulch level than at the 5 tons/ha mulch level. At a combination level of 10 tons/ha mulch with 100 kgN/ha, reproductive efficiency was highest even though total yield per plant was slightly low due to the production of small sized fruits. In general, mulch appeared to have a positive influence on fruit set, fruit drop and the weight and/or size of fruits and hence the yield.

4.10.1 Results of statistical analysis

Mulch treatments and mulch/fertilizer interaction effects had no significant effect on reproductive efficiency. However, fertilizer treated plots showed significant effects on reproductive efficiency at the 1% significant levels. Fo, F1 and F2 did not differ significantly from each other but gave significantly higher reproductive efficiency than in F3 treatments. The overall higher yields as observed in F3 treatments was therefore due to the heavy fruit set and high individual fruit weight in these treatments.

4.11 Economic Analysis

4.11.1 Production Costs and Revenue Per Hectare

Table 4.9 below represents the average cost of production per hectare of tomato for the various treatments as well as the average cost of production per hectare on the farmers' plots. It also gives the average marketable yield obtained per hectare of each treatment and the revenue accruing from the sale of tomato at the farm gate.

Yield of tomato under irrigation is determined by a combination of factors including the moisture holding ability of the soil, efficient soil aeration and a high cation exchange capacity of the soil. In addition to these, cultural factors such as adequate and proper timing of fertilizer application, proper rate and timing of application of agro-chemicals, adequate spacing and proper timing of cropping season also determine the yield of

irrigated tomato. The various yield trends can therefore be explained by assigning all or some of the above reasons. The farmers' yield for instance is lower than yield obtained at the 50 kgN/ha level even though on the average the

Table 4.9: Average production cost, yield, and revenue per hectare.

Treatment	Production Cost (¢)	Marketable Yield (tons)	Revenue (¢)	Profit Margin (¢)
MoFo	557,888.68	1.4	519,000.00	-38,888.68
MoF1	784,542.00	12.0	4,444,000.00	3,659,458.00
MoF2	958,664.96	17.4	6,444,000.00	5,485,335.04
MoF3	1,115,734.00	21.7	7,815,000.00	6,699,266.00
M1Fo	606,575.55	4.0	1,481,000.00	874,424.45
M1F1	815,479.01	11.5	4,259,000.00	3,443,520.99
M1F2	989,557.50	14.1	5,222,000.00	4,232,442.50
M1F3	1,184,705.50	17.4	6,444,000.00	5,259,294.50
M2Fo	647,963.27	6.4	2,370,000.00	1,722,036.73
M2F1	888,167.57	16.6	6,148,000.00	6,259,832.43
M2F2	1,045,735.10	17.9	6,630,000.00	5,584,264.90
M2F3	1,220,331.10	25.9	9,593,000.00	8,372,668.90
Farmers	753,943.41	9.	3,444,000.00	2,690,056.59

farmers used more fertilizer (77 kgN/ha). This could have been because of low and improper agro-chemical (insecticide and fungicide) application. This allowed for more insect and disease attack on farmers plots than on the research plot and hence a high fruit rot resulting in low yields. The high yield of 25.9 tons/ha for the 10 tons/ha mulch and 150 kgN/ha combination as compared to yield from 150 kgN/ha treatment alone (21.7 tons/ha) could be due to a number of factors. Mulch of Leucaena added more nutrients to the soil on decomposition, improved upon soil aeration, improved the water holding and cation exchange capacities of the soil and could even have had an effect on temperature moderation of the soil and hence increased microbial activity. All these factors enhance high yield of tomato. The above suggestions of the effect of mulch on yield have been collaborated by a number of researchers. Young (1989); Palada et al., (1992); Nair (1984); Omoro and Nair (1993); Grewal and Singh (1992), and Dalland et. al. (1993), have variously talked of the beneficial effects of tree mulches in improving soil chemical and physical properties and hence yields.

Revenue obtained from the sale of tomato has a direct relationship to the yield obtained. This is unlike production cost which is not directly related to yield. The higher the yield, the higher the revenue and vice-versa.

4.11.2. Determination of NPV, IRR and B/C Ratio

The NPV, IRR and B/C ratio were calculated using the prevailing borrowing interest rate of 30% on agricultural loans as exist in the Ghana Commercial Bank. Table 4.10 shows the cost and revenue breakdown in tomato production on a per hectare basis for the 3 months of cropping period. It should be noted that all the revenue came in the 3rd month when final harvesting was done. From Table 4.10, the NPV, IRR and B/C ratio of the system can be worked out (Table 4.11).

Table 4.10. Estimated production cost and revenue per Hectare (¢)

Treatment	1st Month	2nd Month	3rd Month	Revenue
MoFo	384,000	85,000	89,000	519,000
MoF1	485,000	138,000	164,000	4,444,000
MoF2	573,000	183,000	203,000	6,444,000
MoF3	658,000	224,000	234,000	7,815,000
M1Fo	400,000	102,000	105,000	1,481,000
M1F1	498,000	155,000	162,000	4,259,000
M1F2	589,000	200,000	201,000	5,222,000
M1F3	674,000	240,000	271,000	6,444,000
M2Fo	417,000	118,000	113,000	2,370,000
M2F1	515,000	171,000	202,000	6,148,000
M2F2	606,000	216,000	224,000	6,630,000
M2F3	691,000	256,000	273,000	9,593,000
Farmers	512,000	144,000	98,000	3,444,000

Table 4.11. NPV, IRR and B/C ratio of the production system

Treatment	NPV	IRR	B/C Ratio	Ranking with B/C Ratio
MoFo	-149,966	28	0.6	13
MoF1	+1,494,277	73	4.3	6
MoF2	+2,281,127	74	5.2	4
MoF3	+2,810,745	75	5.4	2
M1Fo	+258,096	58	1.7	12
M1F1	+1,389,413	72	3.9	9
M1F2	+1,713,214	72	4.0	8
M1F3	+2,148,329	73	4.3	6
M2Fo	+542,563	67	2.6	11
M2F1	+2,208,163	75	5.4	2
M2F2	+2,208,163	74	4.9	5
M2F3	+3,557,669	75	6.2	1
Farmers	+1,043,454	70	3.2	10

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The research was conducted with the view to assessing the fertilizer replacement potential of *Leucaena leucocephala* mulch, as well as to evaluate the effect of Leucaena mulch on yield and growth of tomato and to relate the yields to their economic acceptability by conducting economic analysis.

The results of the research have shown that although Leucaena mulch did not seem to have a significant effect on improving soil chemical status, it significantly affected tomato growth and yield, fruit set, fruit weight, reproductive efficiency and fruit quality of tomato. Thus Leucaena mulch reduces chemical fertilizer use in tomato cultivation as has been demonstrated by treatment F1M2 (50 kgN/ha combined with 10 tons/ha mulch). At this treatment level, yields were found to compare favourably with treatments with higher fertilizer levels (e.g. M2F2 and M1F3). However, for mulch to be very effective, rates higher than 5 tons/ha of fresh Leucaena leaf prunings should be used. There is therefore the need for further research to be conducted using high Leucaena mulch combinations with various rates of fertilizer.

The role of weeds in hampering the growth and development of most crops cannot be over-emphasized. The fact that Leucaena mulch is able to reduce weed infestation in irrigated tomato cultivation is an added advantage. The significant effect of Leucaena mulch shown on soil moisture content and soil bulk density further enhanced tomato growth, development and fruit production. The high yields of 16.6 tons/ha, 17.9 tons/ha and 25.9 tons/ha obtained for M2F1, M2F2 and M2F3 respectively is partly attributable to these residual effects of Leucaena mulch on soil properties which favour high fruit production.

From the economic point of view it should be borne in mind that all projects with a positive NPV and projects with IRR in excess of the opportunity cost of capital (in this case the prevailing borrowing interest rates on farm loans) are acceptable as economically viable. Also projects with a B/C ratio of one (1) or higher are considered viable. It would therefore be observed that apart from the control, all other treatments give economic returns. However some treatments are more economical than others as shown in the ranking of the B/C ratios. Interesting enough F1M2 again features prominently as a very viable treatment combination, which places second to F2M3 in the B/C ratio rating.

In terms of sustainable production which is the basis of this study, coupled with the long run negative effects of excessive fertilizer use on the productivity of soil, the

LIST OF REFERENCES

Abasi (1974). The effect of spacing and staking on the yield of tomato (*Lycopersicon esculentus*, c.v. improved Zuarungu). A B.Sc dissertation; Faculty of Agriculture, U.S.T., Kumasi, Ghana.

Adu, S.V. (1992). Soils of the Kumasi region, Ashanti Region, Ghana. Soil Research Institute, Kumasi, Ghana.

Aiyelaagbe, I.O.O. and Jolaoso, M.A., (1992). Growth and yield response of papaya to intercropping with vegetable crops in South-western Nigeria. Agroforestry Systems 19, No.1.

Amankwa (1974). The effect of spacing on the yield of tomato (*Lycopersicon esculentus*, c.v. improved Zuarungu). A B.Sc dissertation; Faculty of Agriculture, U.S.T., Kumasi, Ghana.

Asante, 1979. The effect of planting dates on the yield of tomato (*Lycopersicon esculentus*, c.v. improved Zuarungu). A B.Sc. dissertation, Faculty of Agriculture, U.S.T., Kumasi, Ghana.

Asmah, A.E. (1994). Pesticides and the environment. Envirosense (A. Newspaper on Environment), Vol.1, No.3, pp.7. Published by the Enviro-Sense Project, Kaneshi, Ghana.

Avery, M.E., Cannell, M.G. and Ong, C.K. (1991). Biophysical research for Asian Agroforestry. Ed. Winrock International, U.S.A. and South Asia Books, USA.

Banful, B.K., 1994. Effect of Leucaena leucocephala and Flemingia congesta mulches on the growth and yield of plantain. M.Sc Thesis, Fac. of Agric, Legon, Ghana. (Unpublished).

Baumer, M. (1990). Agroforestry and desertification, ICRAF Publication, Kenya.

Brady, N.C. (1990). Nature and properties of soil. 10th Edition, New York, etc. Macmillan.

Carlowitz, P.G. Von (1984). Multipurpose trees and shrubs. Opportunities and limitations. ICRAF Working Paper 17.

Cobley, L.S., 1986. An introduction to the botany of tropical crops. Longman Inc. New York.

Coe, R. (1994). Through the looking glass: 10 Common problems in alley-cropping research. Agroforestry Today, Vol.6, No.1, pp.9-11. ICRAF Publication, Nairobi, Kenya.

CRI (Crops Research Institute) (CSIR), 1974. Guide to the production of some crops in Ghana. Kumasi, Ghana.

Dalland A.; Vaje, P.I.; Mathews, R.D. and Singh, B.R. (1993). The potential of alley cropping in the improvement of cultivation systems in the high rainfall areas of Zambia III. Effects on soil chemical and physical properties. In: Agro-forestry Systems 21, 117-132, ICRAF, Nairobi.

Danso, A.A. and Morgan, P. (1993). Alley cropping rice (Oryza sativa var Barafita) with Casia (Sena siamea). Soil fertility and crop production. Agroforestry Systems 21:147-157, ICRAF Publication.

Degbor, 1981. The response of three cultivars of tomato (Zuarungu improved, Aliconte and Roma V.F.) to the time of fertilizer application. A B.Sc. dissertation, Faculty of Agriculture, U.S.T., Kumasi, Ghana.

Doorenbos, J. and Kassan, A.H., 1979. Irrigation and Drainage Paper. In: Yield Response to Water. F.A.O., Rome.

FAO (1979). Yield responses to water. Irrigation and Drainage Paper 33.

Gittinger, J.P. (1982). Economic analysis of agricultural projects. The Johns Hopkins University Press, Baltimore, London.

Grewal, S.S. and Singh, G. (1992). Researchers in Northern India test an Agroforestry System that makes profit and conserves the soil. In: Agroforestry Today, Vol.4, No.3. ICRAF, Nairobi.

Hulugalle, N.R. and Ndi, J.N. (1993). Effect of no-tillage and alley cropping on soil properties and crop yields in a typical Kandiudult of Southern Cameroon. Agroforestry Systems 22, No.3, ICRAF Publication.

Huxley and Westley eds (1989). Multipurpose trees. Selection and testing for Agroforestry. ICRAF, Kenya.

IFIA (International Fertilizer Industry Association), 1985. Fertilizers and Agriculture; 39th Year., No.89. Marbeuf, Paris.

Karim, A.B., Rhodes, E.R. and Savill, P.S. (1991). Effect of cutting height and cutting interval on dry matter yield of *Leucaena leucocephala* (Lam) De Wit. Agroforestry Systems, Vol.16, No.2.

Kassan, A.H. and Doorenbos, J., 1979. Yield response to water. F.A.O. Irrigation and Drainage Paper, No.33.

Kim, J. 1991. Report on fertilizer trials of vegetables on Akumadan irigation project (Unpublished), IDA, Accra, Ghana.

Kwakye-Adams, 1974. The effect of spacing and non-staking on the yield of tomato (*Lycopersicon esculentum*, c.v. improved Zuarungu). A B.Sc. dissertation, Faculty of Agriculture, U.S.T., Kumasi, Ghana.

MacDicken, K.G. and Vergara, N.T. ed. (1990). Agroforestry - Classification and management. ICRAF Publication, Nairobi, Kenya.

Nair, P.K.R. (1985). Agroforestry Systems, Vol.3. ICRAF, Nairobi.

Nair, P.K.R. (1984). Soil productivity aspect of Agro-forestry. ICRAF, Kenya.

Nair, P.K.R. (1989). Agroforestry Systems in the tropics. Forest Science Vol.31. Kluwer Academic Publishers.

Norman, J.C., 1985. Tropical vegetable crops. Published by Arthur, H. and Stockwell Ltd. Elms Court, Ilfracombe, Deven, U.K.

Omoro, L.M.A. and Nair, P.K.R. (1993). Effect of mulching with multipurpose tree prunings on soil and water run-off under semi-arid conditions in Kenya. In Agroforestry Systems 22, No.3, ICRAF Publication.

Opaye, 1978. The effect of irrigation frequencies on tomato yield (improved Zuarungu). A B.Sc. dissertation, Faculty of Agriculture, U.S.T., Kumasi, Ghana.

Page, A.L. (eds) 1992. Methods of soil analysis. American Society of Agronomy and the Soil Science Society of America, USA.

Palada, M.C.; B.T. Kang and S.L. Classen (1992). Effect of alley cropping with Leucaena leucocephala and fertilizer application on yields of vegetable crops. In: Agroforestry System 19, No.2. ICRAF, Kenya.

Purseglove, J.W., 1987. Tropical crops; Dicotyledons. John Wiley & Sons Inc. New York.

Quashie-Sam, S.J., Agyeman, K.O. and Avila, M. eds (1993). Agroforestry technologies and research priorities for the development of cocoa/food crop/oil palm system in humid lowlands of Ghana, AFRENA Report No.35, ICRAF, Nairobi.

Rosecrance, R.C., Rogers, S. and Tofinga, M. 1992. Effect of alley cropped Calliandra calothyrsus and Gliricidia sepium hedges on weed growth, soil properties, and taro yields in Western Samoa. Agroforestry Systems, Vol.19, No.1.

Russel, E.W. (1988). Soil conditions and plant growth. 11th edition. Harlow (etc). Longman (etc).

Thurston, D.; Smith, M.; Abawi, G. and Kearl, S. (eds) (1994). Tapado slash/mulch: How farmers use it and what researchers know about it. CATIE and CIIFAD Publication. Cornell Univ., Ithaca, New York.

Young, A. (1988). Agroforestry and its potential to contribute to land development. Journal of Biogeography Vol.15. pp.19-30.

Young, A. (1989a). Agroforestry for soil conservation. CAB International, Wallingford, UK.

Young, A. (1989b). 10 hypothesis in Agroforestry for the conservation or improvement of soil fertility. In Agroforestry Today, Vol.1, No.1, ICRAF Publication.

APPENDICES

Appendix 1. Average Plant Height (cm)

1.1 Average Plant Height at Three Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	10.6	10.2	10.5	10.4
FoM1	10.2	10:4	10.0	10.2
FoM2	8.0	10.3	20.1	12.8
F1Mo	20.2	20.4	20.5	20.4**
F1M1	20.6	20.6	20.3	20.5**
F1M2	20.0	20.3	20.1	20.1**
F2Mo	10.7	10.9	10.1	10.6
F2M1	20.2	20.4	20.2	20.3**
F2M2	20.2	20.8	20.6	20.5**
F3Mo	10.8	10.7	20.4	14.0
F3M1	11.0	11.0	20.2	10.7
F3M2	20.1	10.6	20.1	16.9**
Mean	15.2	14.7	17.8	15.9

* Significant at 1% and 5% probability levels.

* Significant at 5% probability level.

1.2 Average Plant Height at Six Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	30.0	20.0	30.0	26.7
FoM1	20.0	15.0	21.0	18.7
FoM2	30.0	20.0	34.0	28.0
F1Mo	20.6	30.8	30.8	27.4
F1M1	20.7	30.6	30.0	27.1
F1M2	20.9	30.4	30.4	27.2
F2Mo	20.8	20.8	20.8	20.8
F2M1	20.6	50.4	60.0	43.7
F2M2	40.7	40.6	40.4	40.6
F3Mo	20.4	20.3	60.0	33.6
F3M1	30.8	40.0	30.7	33.3
F3M2	30.0	30.4	30.0	30.1
Mean	25.5	29.1	34.8	29.8

Appendix 2. Average Number of Branches per Plant

2.1 Average Number of Branches at Three Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	0	0	0	0.0
FoM1	0	0	0	0.0
FoM2	0	0	0	0.0
F1Mo	8	6	7	7.0**
F1M1	8	6	6	6.7
F1M2	7	6	7	6.7
F2Mo	5	7	7	6.3**
F2M1	5	3	6	4.7
F2M2	6	4	7	4.7
F3Mo	8	8	6	7.3**
F3M1	7	7	7	7.0
F3M2	4	8	6	6.0
Mean	4.8	4.6	4.9	4.8

2.2 Average Number of Branches at Six Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	4	2	3	3.0
FoM1	5	0	0	1.7
FoM2	4	2	2	2.7
F1Mo	9	16	16	13.7**
F1M1	10	13	11	11.3
F1M2	9	9	19	12.3
F2Mo	12	12	13	8.7**
F2M1	16	16	15	15.7
F2M2	8	11	24	14.3
F3Mo	16	15	17	16.0**
F3M1	20	16	28	21.3
F3M2	20	14	20	18.0
Mean	10.2	10.5	14.0	11.6

Appendix 3. Average Weed Weight Per Treatment (kg)

3.1 Average Weed Weight per Plant at Three Weeks After Planting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	0.28	1.30	0.65	0.74*
FoM1	0.53	0.70	0.60	0.61
FoM2	0.35	0.68	0.50	0.51
F1Mo	1.54	1.78	0.86	1.39**
F1M1	1.12	1.20	1.20	1.17
F1M2	1.18	1.32	1.07	1.19
F2Mo	1.53	1.40	1.40	1.44**
F2M1	0.88	1.18	1.30	1.12
F2M2	1.30	1.40	0.70	1.13
F3Mo	1.28	1.10	1.06	1.5**
F3M1	0.71	0.76	1.06	0.84
F3M2	0.41	1.01	0.68	0.70
Mean	0.93	1.15	0.92	1.00

3.2 Average Weed Weight per Treatment Six Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	0.58	0.40	1.02	0.67
FoM1	1.00	0.60	1.03	0.88
FoM2	0.62	0.50	0.54	0.55
F1Mo	1.12	1.54	0.70	1.12
F1M1	1.06	0.90	0.82	0.93
F1M2	0.84	0.86	0.82	0.84
F2Mo	1.16	1.27	1.20	1.21
F2M1	0.90	1.00	1.20	1.03
F2M2	0.98	1.21	1.08	1.09
F3Mo	0.74	1.20	0.40	0.78
F3M1	1.20	1.10	0.70	1.00
F3M2	1.36	1.40	0.52	1.09
Mean	0.96	1.00	0.84	0.93

Appendix 4. Average Number of Ripe Fruits per Plant

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	2.4	2.0	3.7	2.7
FoM1	5.2	5.5	5.4	5.4**
FoM2	7.3	7.0	7.6	7.3**
F1Mo	16.0	16.4	16.2	16.2**
F1M1	19.2	20.5	17.9	19.2
F1M2	21.5	22.0	20.5	21.3
F2Mo	18.2	20.8	18.0	19.0**
F2M1	21.6	20.8	22.0	21.5
F2M2	23.0	24.1	22.4	23.2
F3Mo	24.0	24.5	25.2	24.6**
F3M1	28.0	24.7	27.4	26.7
F3M2	28.5	28.6	30.2	29.1
Mean	17.9	18.1	18.0	18.0

Appendix 5. Average Total Weight of Ripe Fruits per Plant (kg)

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	0.103	0.100	0.106	0.103
FoM1	0.270	0.281	0.260	0.270**
FoM2	0.350	0.334	0.336	0.340**
F1Mo	0.690	0.700	0.710	0.700**
F1M1	0.699	0.701	0.670	0.690**
F1M2	1.015	1.016	1.013	1.015**
F2Mo	0.80	1.20	1.04	1.013
F2M1	1.00	1.006	1.009	1.005**
F2M2	1.191	1.180	1.199	1.190**
F3Mo	1.40	1.31	1.28	1.330**
F3M1	1.157	1.18	1.14	1.159**
F3M2	1.70	1.623	1.60	1.641**
Mean	0.865	0.886	0.864	0.871

Appendix 6. Average Number of Fruit Set per Plant

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	3.07	2.6	4.83	3.50
FoM1	7.0	6.76	8.01	5.92**
FoM2	9.40	8.0	10.1	9.17**
F1Mo	22.0	20.8	21.5	21.43**
F1M1	26.7	26.60	24.65	25.98**
F1M2	28.6	29.5	30.0	29.37**
F2Mo	24.94	25.8	24.70	25.15**
F2M1	28.0	26.0	27.9	27.30**
F2M2	28.4	30.33	27.12	28.62**
F3Mo	35.0	33.33	34.76	34.36**
F3M1	35.4	34.0	36.1	35.17**
F3M2	39.8	40.4	45.8	42.00**
Mean	24.03	23.34	24.62	24.00

Appendix 7. Estimated Marketable Yield per Hectare (tons)

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	1.42	1.38	1.46	1.42
FoM1	4.00	4.16	3.85	4.00**
FoM2	6.55	6.25	6.28	6.36**
F1Mo	11.87	12.04	12.22	12.04**
F1M1	11.62	11.65	11.14	11.47**
F1M2	13.76	20.65	17.89	16.57**
F2Mo	13.76	20.65	17.89	17.43**
F2M1	14.03	14.11	14.15	14.10**
F2M2	17.91	17.74	18.03	17.89**
F3Mo	22.41	20.97	20.49	21.29**
F3M1	17.40	17.74	17.14	17.43**
F3M2	26.83	25.62	25.25	25.90**
Mean	13.70	14.07	13.70	13.83

Appendix 8. Soil Moisture Content per Treatment (%)

8.1 Soil Moisture Content per Treatment at Three Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	17.93	12.99	10.12	13.68
FoM1	17.43	15.35	16.14	16.31**
FoM2	27.34	22.99	23.10	24.48**
F1Mo	16.26	14.14	11.01	13.80
F1M1	18.09	14.60	14.46	15.72
F1M2	15.31	15.59	16.71	15.87
F2Mo	12.64	13.99	12.71	13.11
F2M1	18.71	14.14	15.15	16.00
F2M2	16.17	15.61	16.24	16.19*
F3Mo	18.37	14.73	14.62	15.91**
F3M1	14.93	14.00	15.10	14.68
F3M2	16.59	14.29	16.37	15.75
Mean	17.53**	15.20	15.14	15.96

8.2 **Soil Moisture Content per Treatment at Six Weeks After Transplanting**

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	10.98	11.28	11.94	11.40
FoM1	11.32	11.48	12.12	11.64
FoM2	12.10	11.81	13.13	12.35
F1Mo	10.74	10.86	14.57	12.06
F1M1	11.76	13.93	11.88	12.52
F1M2	12.63	11.31	13.54	12.49
F2Mo	10.87	11.70	11.24	11.27
F2M1	11.46	10.91	11.16	11.18
F2M2	12.75	12.52	12.85	12.71
F3Mo	11.02	12.12	11.13	11.42
F3M1	12.13	12.04	10.84	11.67
F3M2	12.57	12.48	11.18	12.08
Mean	11.69	11.87	12.13	11.90

8.3. Soil Moisture Content per Treatment at 9 Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	16.22	17.56	19.20	17.66
FoM1	18.41	16.41	22.27	19.03
FoM2	19.40	16.94	19.05	18.46
F1Mo	16.97	17.20	17.05	17.07
F1M1	17.11	16.54	17.91	17.19
F1M2	20.34	18.53	20.52	19.80
F2Mo	17.23	17.97	20.39	18.53
F2M1	19.12	16.82	18.43	18.12
F2M2	19.04	18.47	18.59	18.70
F3Mo	17.66	19.37	17.20	18.08
F3M1	19.38	19.06	18.50	18.98
F3M2	22.14	18.68	15.89	18.90
Mean	18.58	17.80	18.75	18.38

8.4. Soil Moisture Content per Treatment at 12 Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	13.11	13.15	14.54	13.60
FoM1	14.32	13.69	13.64	13.88
FoM2	16.24	12.68	15.80	14.91
F1Mo	13.39	14.83	15.40	14.54
F1M1	14.94	13.01	14.71	14.22
F1M2	16.41	15.23	15.49	15.71
F2Mo	13.15	13.90	15.71	14.25
F2M1	15.46	15.63	13.91	15.00
F2M2	16.17	16.03	14.44	15.55
F3Mo	14.10	16.32	13.96	14.79
F3M1	15.01	14.29	14.24	14.51
F3M2	16.26	16.07	13.44	15.26
Mean	14.88	14.57	14.61	14.69

8.5. Soil Moisture Content per Treatment at 15 Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	11.44	12.27	13.03	12.25
FoM1	12.98	11.41	13.70	12.70
FoM2	13.47	11.92	14.16	13.15
F1Mo	12.16	12.06	14.35	12.82
F1M1	14.06	13.96	13.92	13.98
F1M2	15.13	13.38	9.26	13.59
F2Mo	12.08	13.74	17.08	14.30
F2M1	13.74	13.69	13.44	13.62
F2M2	14.35	14.23	14.29	14.29
F3Mo	11.98	12.20	12.62	12.27
F3M1	14.94	14.21	15.14	14.76
F3M2	16.04	15.67	12.53	14.75
Mean	13.53	13.22	13.62	13.46

Appendix 9. Soil Bulk Density per Treatment

9.1 Soil Bulk Density per Treatment at Three Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	1.87	1.60	1.54	1.67
FoM1	1.96	2.00	1.89	1.95**
FoM2	1.70	1.78	1.72	1.73**
F1Mo	1.78	1.74	1.83	1.78
F1M1	1.87	1.77	1.65	1.75
F1M2	1.81	1.83	1.80	1.81**
F2Mo	1.76	1.92	1.84	1.84
F2M1	1.71	1.90	1.69	1.77**
F2M2	1.67	1.73	1.58	1.66
F3Mo	1.70	1.87	1.86	1.81
F3M1	1.95	1.89	1.83	1.89**
F3M2	1.55	1.62	1.54	1.57
Mean	1.78	1.80	1.73	1.77

9.2 Soil Bulk Density per Treatment at 6 Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	1.74	1.78	1.62	1.71*
FoM1	1.58	1.57	1.50	1.55
FoM2	1.64	1.83	1.69	1.72
F1Mo	1.71	1.64	1.72	1.69
F1M1	1.69	1.72	1.73	1.71
F1M2	1.45	1.55	1.64	1.55
F2Mo	1.70	1.73	1.71	1.71
F2M1	1.61	1.58	1.68	1.62
F2M2	1.52	1.56	1.69	1.59
F3Mo	1.63	1.78	1.58	1.66
F3M1	1.84	1.65	1.58	1.69*
F3M2	1.67	1.72	1.75	1.71
Mean	1.65	1.68	1.66	

9.3 Soil Bulk Density per Treatment at 9 Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	1.52	1.38	1.57	1.49
FoM1	1.53	1.50	1.60	1.54
FoM2	1.46	1.52	1.48	1.49
F1Mo	1.50	1.55	1.42	1.49
F1M1	1.55	1.59	1.50	1.55
F1M2	1.46	1.47	1.56	1.50
F2Mo	1.65	1.79	1.53	1.66
F2M1	1.58	1.70	1.42	1.57
F2M2	1.41	1.48	1.56	1.48
F3Mo	1.64	1.52	1.62	1.12
F3M1	1.37	1.55	1.43	1.45
F3M2	1.71	1.73	1.76	1.73
Mean	1.53	1.45	1.54	1.51

9.4 Soil Bulk Density per Treatment at 12 Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	1.54	1.56	1.48	1.53*
FoM1	1.50	1.66	1.34	1.50
FoM2	1.42	1.62	1.46	1.50*
F1Mo	1.65	1.69	1.58	1.64
F1M1	1.56	1.57	1.64	1.59**
F1M2	1.40	1.31	1.43	1.38
F2Mo	1.77	1.73	1.64	1.71
F2M1	1.17	1.79	1.56	1.69**
F2M2	1.54	1.66	1.41	1.54*
F3Mo	1.63	1.58	1.60	1.60
F3M1	1.70	1.73	1.60	1.68**
F3M2	1.66	1.61	1.84	1.70**
Mean	1.59	1.63	1.55	1.59

9.5 Soil Bulk Density per Treatment at 15 Weeks After Transplanting

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	1.73	1.75	1.65	1.71
FoM1	1.71	1.60	1.72	1.68
FoM2	1.68	1.71	1.69	1.69
F1Mo	1.83	1.80	1.60	1.74
F1M1	1.77	1.62	1.76	1.72
F1M2	1.74	1.71	1.70	1.72
F2Mo	1.87	1.84	1.82	1.84••
F2M1	1.70	1.79	1.64	1.71
F2M2	1.53	1.51	1.66	1.57
F3Mo	1.83	1.75	1.94	1.84••
F3M1	1.70	1.79	1.64	1.71
F3M2	1.53	1.51	1.66	1.57
Mean	1.74	1.75	1.73	1.74

Appendix 11. Total Marketable Fruits/Plants

Treatment	Block 1	Block 2	Block 3	Mean
FoMo	1.77	1.47	2.73	1.99
FoM1	4.12	4.36	4.28	4.25**
FoM2	7.30	7.00	7.60	7.30**
F1Mo	14.64	15.01	14.82	1..82**
F1M1	17.07	18.22	15.91	17.07**
F1M2	18.77	19.21	17.90	18.63**
F2Mo	16.74	19.14	16.56	17.48**
F2M1	16.20	15.60	16.50	16.10**
F2M2	18.49	19.38	18.01	18.63**
F3Mo	20.54	19.78	21.57	20.63**
F3M1	22.51	19.86	22.03	21.47**
F3M2	24.05	24.14	25.49	24.56**
Mean	15.18	15.26	15.28	15.24

A- FERTILIZER TREATMENT
B- MULCH TREATMENT
AB-INTERACTION EFFECT

Appendix 12. Plant Height (cm) Three Weeks After Transplanting

Analysis of Variance

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	63.85	31.924	1.88	0.232
A	3	401.34	133.781	7.87**	0.016
Error	6	102.02	17.003		
B	2	87.47	43.737	7.27*	0.005
AB	6	135.67	22.612	3.77*	0.015
Error	16	96.27	6.017		

* - Significant at 5% probability level.

** - Significant at 1% and 5% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	1.190	12	25.94	3.37	4.48
A	1.374	9	25.94	3.89	5.17
B	0.708	12	15.43	2.00	2.66
AB	1.416	3	15.43	4.01	5.33

Appendix 13. Plant height - Six Weeks After Transplanting

Analysis of Variance

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	536.96	268.481	4.16	0.073
A	3	627.47	209.156	3.24	0.102
Error	6	387.18	64.530		
B	2	133.35	66.674	0.76	
AB	6	968.44	161.407	1.83	0.155
Error	16	1407.81	87.988		

Appendix 14. Number of Branches/Plant - 3 Weeks After Transplanting

Analysis of Variance

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.72	0.361	0.16	
A	3	282.89	94.296	42.16**	0.000
Error	6	13.28	2.213		
B	2	2.72	1.361	1.56	0.241
AB	6	4.61	0.769	0.88	
Error	16	14.00	0.875		

** - Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr.LSD1%
Rep.	0.429	12	31.14	1.21	1.62
A	0.496	9	31.14	1.40	1.87
B	0.270	12	19.58	0.76	1.02
AB	0.540	3	19.58	1.53	2.03

Appendix 15. Number of Branches/Plant Six Weeks After Transplanting

Analysis of Variance

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	108.22	54.111	2.15	0.197
A	3	1197.33	399.111	15.89**	0.002
Error	6	150.67	25.111		
B	2	29.56	14.778	1.18	0.333
AB	6	108.00	18.000	1.43	0.262
Error	16	201.11	12.569		

** - Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr.LSD1%
Rep.	1.447	12	43.37	4.09	5.44
A	1.670	9	43.37	4.72	6.28
B	1.023	12	30.68	2.89	3.85
AB	2.047	3	30.68	5.79	7.70

Appendix 16. Weed Weight/TRT (kg) 3 Weeks After Transplanting

Analysis of Variance

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.42	0.208	4.07	0.076
A	3	2.45	0.815	15.96**	0.002
Error	6	0.31	0.051		
B	2	0.61	0.304	4.66*	0.025
AB	6	0.08	0.013	0.20	
Error	16	1.04	0.065		

* Significant at 5% probability level.

** - Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.065	12	22.59	0.18	0.25
A	0.075	9	22.59	0.21	0.28
B	0.074	12	25.51	0.21	0.28
AB	0.147	3	25.51	0.42	0.55

Appendix 17. Weed Weight/TRT (kg) 6 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.18	0.088	0.50	
A	3	0.79	0.264	1.52	0.303
Error	6	1.05	0.174		
B	2	0.03	0.014	0.42	
AB	6	0.46	0.77	2.34	0.081
Error	16	0.52	0.033		

Appendix 18. Average Number of Ripe Fruits/Plant

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.19	0.093	0.06	
A	3	2288.01	762.668	450.89**	0.000
Error	6	10.15	1.691		
B	2	127.97	63.986	85.76**	0.000
AB	6	1.14	0.190	0.25	
Error	16	11.94	0.746		

** Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.375	12	7.22	1.06	1.41
A	0.434	9	7.22	1.23	1.63
B	0.249	12	4.80	0.71	0.94
AB	0.499	3	4.80	1.41	1.88

Appendix 19. Average Total Weight of Ripe Fruits/Plant (kg)

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.00	0.002	0.35	
A	3	6.31	2.103	386.41**	0.000
Error	6	0.03	0.005		
B	2	0.55	0.276	73.43**	0.000
AB	6	0.17	0.028	7.34**	0.000
Error	16	0.06	0.004		

** Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.021	12	8.47	0.06	0.08
A	0.025	9	8.47	0.07	0.09
B	0.018	12	7.03	0.05	0.07
AB	0.035	3	7.03	0.10	0.13

Appendix 20. Average Number of Unripe Fruits/Plant

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	5.49	2.745	1.08	0.396
A	3	4379.20	1459.734	575.80**	0.000
Error	6	15.21	2.535		
B	2	229.50	114.751	77.07*	0.000
AB	6	39.53	6.588	4.42**	0.008
Error	16	23.82	1.489		

** Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.460	12	6.60	1.30	1.73
A	0.531	9	6.60	1.50	2.00
B	0.352	12	5.06	1.00	1.33
AB	0.704	3	5.06	1.99	2.65

Appendix 21. Estimated Marketable Yield/Hectare (tons)

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	1.12	0.561	0.36	
A	3	1482.25	494.085	320.88**	0.000
Error	6	9.24	1.540		
B	2	156.79	78.395	71.22**	0.000
AB	6	60.34	10.057	9.14**	0.000
Error	16	17.61	1.101		

** Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.358	12	8.98	1.01	1.35
A	0.414	9	8.98	1.17	1.56
B	0.303	12	7.59	0.86	1.14
AB	0.606	3	7.59	1.71	2.28

APPENDIX 22. TABLE OF MEAN

REP. 1	A 2	B 3	PLT HT. 4	PLT HT. 5	NO. B/P 6	NO. B/P 7	WT. TRT 8	WT. TRT 9	A.N RFP 10	ATW RFP 11	A.N UFP 12	E.M Y/H 13
1	1	1	15.2	25.5	4.8	10.2	0.93	0.96	17.9	0.865	24.03	13.70
2	1	1	14.7	29.1	4.6	10.5	1.15	1.00	18.1	0.886	23.68	14.07
3	1	1	17.8	34.8	4.9	14.0	0.92	0.84	18.0	0.864	24.62	13.70
1	1	1	11.1	24.4	0.0	2.4	0.62	0.70	5.1	0.238	6.64	3.93
1	2	1	20.3	27.2	6.8	12.4	1.25	0.96	18.9	0.802	25.59	13.36
1	3	1	17.1	35.0	5.6	12.9	1.23	1.11	21.2	1.069	27.02	16.47
1	4	1	15.0	32.5	6.8	18.4	0.90	0.96	26.8	1.377	37.18	21.54
1	1	1	13.8	27.1	5.2	10.3	1.18	0.94	15.6	0.787	21.11	13.05
1	1	2	16.3	30.8	4.6	12.5	0.94	0.96	18.2	0.781	23.93	11.75
1	1	3	17.6	31.5	4.6	11.8	0.88	0.89	20.2	1.046	27.29	16.68
1	1	1	10.4	26.7	0.0	3.0	0.74	0.67	2.7	0.103	3.50	1.42
1	1	2	10.2	18.7	0.0	1.7	0.61	0.88	5.4	0.270	7.26	4.00
1	1	3	12.8	28.0	0.0	2.7	0.51	0.55	7.3	0.340	9.17	6.36
1	2	1	20.4	27.4	7.0	13.7	1.39	1.12	16.2	0.700	21.43	12.04
1	2	2	20.5	27.1	6.7	11.3	1.17	0.93	19.2	0.690	25.98	11.47
1	2	3	20.1	27.2	6.7	12.3	1.19	0.84	21.3	1.015	29.37	16.57
1	3	1	10.6	20.8	6.3	8.7	1.44	1.21	19.0	1.013	25.15	17.43
1	3	2	20.3	43.7	4.7	15.7	1.12	1.03	21.5	1.005	27.30	14.10
1	3	3	20.5	40.6	5.7	14.3	1.13	1.09	23.2	1.190	28.62	17.89
1	4	1	14.0	33.6	7.3	16.0	1.15	0.78	24.6	1.330	34.36	21.29
1	4	2	14.1	33.8	7.0	21.3	0.84	1.00	26.7	1.159	35.17	17.43
1	4	3	16.9	30.1	6.0	18.0	0.70	1.09	29.1	1.641	42.00	25.90
G.MEAN			15.9	29.8	4.8	11.6	1.00	0.93	18.0	0.871	24.11	13.83
T.COUNT			36.0	36.0	36.0	36.0	36.00	36.00	36.0	36.000	36.00	36.00
DF (-3)			6.0	6.0	6.0	6.0	6.00	6.00	6.0	6.000	6.00	6.00
EMS(-3)			17.0	64.5	2.2	25.1	0.05	0.17	1.7	0.005	2.54	1.54
DF (-7)			16.0	16.0	16.0	16.0	16.00	16.00	16.0	16.000	16.00	16.00
EMS(-7)			6.0	88.0	0.9	12.6	0.07	0.03	0.7	0.004	1.49	1.10

APPENDIX 23 TABLE OF MEAN

REP.	A	B	S.M C/T 14	S.M C/T 15	S.M C/T 16	S.M C/T 17	S.M C/T 18	B.D TRT 19	B.D TRT 20	B.D TRT 21	B.D TRT 22	B.D TRT 23
1	1	1	17.53	11.69	18.58	14.88	13.53	1.78	1.65	1.53	1.59	1.74
2	1	1	15.20	11.87	17.80	14.57	13.22	1.80	1.68	1.45	1.63	1.75
3	1	1	15.14	12.13	18.75	14.61	13.62	1.73	1.66	1.54	1.55	1.73
1	1	1	18.15	11.79	18.38	14.13	12.70	1.78	1.66	1.51	1.51	1.69
1	2	1	15.13	12.36	18.02	14.82	13.13	1.79	1.65	1.51	1.54	1.73
1	3	1	15.10	11.72	18.45	14.93	14.07	1.76	1.64	1.57	1.65	1.71
1	4	1	15.44	11.72	18.65	14.85	13.93	1.76	1.69	1.43	1.66	1.82
1	1	1	14.13	11.54	17.83	14.30	12.91	1.78	1.70	1.44	1.62	1.78
1	1	2	15.68	11.75	18.33	14.40	13.77	1.84	1.64	1.53	1.61	1.73
1	1	3	18.07	12.41	18.97	15.35	13.69	1.69	1.64	1.55	1.53	1.69
1	1	1	13.68	11.40	17.66	13.60	12.25	1.67	1.71	1.49	1.53	1.71
1	1	2	16.31	11.64	19.03	13.88	12.70	1.95	1.55	1.54	1.50	1.68
1	1	3	24.48	12.35	18.46	14.91	13.15	1.73	1.72	1.49	1.50	1.69
1	2	1	13.80	12.06	17.07	14.54	12.82	1.78	1.69	1.49	1.64	1.74
1	2	2	15.72	12.52	17.19	14.22	13.98	1.76	1.71	1.55	1.59	1.72
1	2	3	15.87	12.49	19.80	15.71	12.59	1.81	1.55	1.50	1.38	1.72
1	3	1	13.11	11.27	18.53	14.25	14.30	1.84	1.71	1.66	1.71	1.84
1	3	2	16.00	11.18	18.12	15.00	13.62	1.77	1.62	1.57	1.69	1.71
1	3	3	16.19	12.71	18.70	15.55	14.29	1.66	1.59	1.48	1.54	1.57
1	4	1	15.91	11.42	18.08	14.79	12.27	1.81	1.66	1.12	1.60	1.84
1	4	2	14.68	11.67	18.98	14.51	14.76	1.89	1.69	1.45	1.68	1.82
1	4	3	15.75	12.08	18.90	15.26	14.75	1.57	1.71	1.73	1.70	1.80
G.MEAN			15.96	11.90	18.38	14.69	13.46	1.77	1.66	1.51	1.59	1.74
T.COUNT			36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00
DF (-3)			6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
EMS(-3)			1.98	1.18	4.12	1.58	1.89	0.01	0.01	0.07	0.01	0.01
DF (-7)			16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
EMS(-7)			2.46	0.76	1.83	1.25	2.31	0.01	0.01	0.08	0.01	0.01

Appendix 24. Soil Moisture Content/TRT 3 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	44.31	22.155	11.20**	0.009
A	3	58.59	19.530	9.87**	0.009
Error	6	11.87	1.979		
B	2	94.81	47.406	19.27**	0.000
AB	6	123.86	20.644	8.39**	0.000
Error	16	39.37	2.461		

** Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.406	12	8.81	1.15	1.53
A	0.469	9	8.81	1.33	1.76
B	0.453	12	9.83	1.28	1.70
AB	0.906	3	9.83	2.56	3.41

Appendix 25. Soil Moisture Content/TRT 6 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	1.16	0.582	0.49	
A	3	2.57	0.855	0.73	
Error	6	7.07	1.178		
B	2	4.92	2.458	3.25	0.065
AB	6	2.02	0.337	0.45	
Error	16	12.08	0.755		

Appendix 26. Soil Moisture Content/TRT 9 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	6.24	3.121	0.76	
A	3	1.89	0.630	0.15	
Error	6	24.70	4.116		
B	2	7.71	3.856	2.11	0.153
AB	6	11.40	1.901	1.01	
Error	16	29.25	1.828		

Appendix 25. Soil Moisture Content/TRT 6 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	1.16	0.582	0.49	
A	3	2.57	0.855	0.73	
Error	6	7.07	1.178		
B	2	4.92	2.458	3.25	0.065
AB	6	2.02	0.337	0.45	
Error	16	12.08	0.755		

Appendix 26. Soil Moisture Content/TRT 9 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	6.24	3.121	0.76	
A	3	1.89	0.630	0.15	
Error	6	24.70	4.116		
B	2	7.71	3.856	2.11	0.153
AB	6	11.40	1.901	1.01	
Error	16	29.25	1.828		

Appendix 27. Soil Moisture Content/TRT 12 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.69	0.345	0.22	
A	3	3.76	1.253	0.79	
Error 1	6	9.48	1.580		
B	2	8.14	4.071	3.25	0.065
AB	6	1.76	0.293	0.23	
Error	16	20.07	1.254		

Appendix 28. Soil Moisture Content/TRT 15 Weeks after Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	1.05	0.526	0.28	
A	3	11.51	3.838	2.03	0.211
Error	6	11.35	1.891		
B	2	5.42	2.710	1.18	0.333
AB	6	12.41	2.069	0.90	
Error	16	36.89	2.306		

Appendix 29. Bulk Density/TRT 3 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.03	0.017	2.28	0.183
A	3	0.01	0.003	0.36	
Error	6	0.04	0.007		
B	2	0.13	0.066	10.19**	0.001
AB	6	0.22	0.036	5.54**	0.002
Error	16	0.10	0.007		

** Significant at 5% and 1% probability level.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.025	12	4.81	0.07	0.09
A	0.028	9	4.81	0.08	0.11
B	0.023	12	4.55	0.07	0.09
AB	0.647	3	7.63	1.83	2.43

Appendix 30. Bulk Density/TRT 6 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.00	0.002	0.27	
A	3	0.01	0.004	0.42	
Error	6	0.05	0.009		
B	2	0.02	0.011	2.02	0.165
AB	6	0.11	0.019	3.51*	0.020
Error	16	0.08	0.005		

* Significant at 5% probability level.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.027	12	5.66	0.08	0.10
A	0.031	9	5.66	0.09	0.12
B	0.021	12	4.38	0.06	0.08
AB	0.042	3	4.38	0.12	0.16

Appendix 31. Bulk Density/TRT 9 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.06	0.031	0.45	
A	3	0.08	0.027	0.39	
Error	6	0.42	0.069		
B	2	0.08	0.041	0.53	
AB	6	0.54	0.090	1.17	0.369
Error	16	1.23	0.077		

Appendix 32. Bulk Density/TRT 12 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.04	0.018	1.36	0.325
A	3	0.16	0.053	3.97	0.070
Error	6	0.08	0.013		
B	2	0.06	0.031	5.64**	0.013
AB	6	0.13	0.021	3.86**	0.014
Error	16	0.09	0.005		

** Significantly at the 5% and 1% probability level.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.033	12	7.25	0.09	0.12
A	0.038	9	7.25	0.11	0.14
B	0.021	12	4.63	0.06	0.08
AB	0.042	3	4.63	0.12	0.16

Appendix 33. Bulk Density/TDT 15 Weeks After Transplanting

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.00	0.002	0.26	
A	3	0.09	0.029	4.97**	0.045
Error	6	0.04	0.006		
B	2	0.05	0.025	3.12	0.071
AB	6	0.07	0.012	1.50	0.240
Error	16	0.13	0.008		

** Significantly at the 5% and 1% probability level.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.022	12	4.40	0.06	0.08
A	0.025	9	4.40	0.07	0.10 **

Appendix 34. Reproductive Efficiency (%)

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	105.24	52.619	4.54	0.063
A	3	214.43	71.477	6.16**	0.029
Error	6	69.57	11.595		
B	2	4.98	2.489	0.23	
AB	6	168.76	28.127	2.56	0.062
Error	16	175.72	10.982		

** Significantly at the 5% and 1% probability level.

Group	S/Y	No. obs.	C.V. (%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.983	12	4.51	2.78	3.70
A	1.135	9	4.51	3.21	4.27
B	0.957	12	4.39	2.71	3.60
AB	1.913	3	4.39	5.41	7.20

Appendix 35. Total Marketable Quality

Source	Degree of Freedom	Sum of Squares	Mean Square	F Value	Prob.
Rep	2	0.07	0.034	0.02	
A	3	1538.77	512.922	320.83**	0.000
Error	6	9.59	1.599		
B	2	80.41	40.206	86.00**	0.000
AB	6	19.44	3.240	6.93**	0.000
Error	16	7.48	0.468		

** Significantly at the 5% and 1% probability level.

Group	S/Y	No. obs.	C.V.(%)	Appr. LSD5%	Appr. LSD1%
Rep.	0.054	12	6.80	0.15	0.20
A	0.062	9	6.80	0.18	0.23
B	0.044	12	5.63	0.13	0.17
AB	0.089	3	5.63	0.25	0.33

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