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RESEARCH PAPER

USING CAJANUS CAJAN IN BIOMASS TRANSFER TECHNOLOGY TO INCREASE YIELD OF TOMATO (LYCOPERSICON ESCULENTUM MILL.)

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ABSTRACT:

The experiment was conducted at the Tono Irrigation Project site in the Upper East Region of Ghana. The objective was to investigate the effect of Cajanus cajan mulch and fertilizer application on the growth and yield of tomato (Lycopersiconesculentum). The split plot design, with treatments randomised within each block was used. Fertilizer was applied at three levels (0 kg N/ha, 75 kg N/ha and 150 kg N/ha) as main plot treatments and Cajanus cajan mulch at two levels (0 tons/ha and 15 tons/ha) as sub plot treatments. Mulch, fertilizer and mulch/fertilizer interaction had a significant effect on the growth (height and leaf area) of tomato. Tomato growth was highest at the highest rate of mulch and fertilizer interaction (15 tons/ha and 150 kg N/ha). Highest yield (9.35 tons/ha) was obtained at the highest rate of mulch/fertilizer interaction (15 tons/ha and 150 kg N/ha) and lowest yield (2.8 tons/ha) at control (No mulch and No fertilizer). However, fruit size was highest at half rate of fertilizer and mulch interaction (75 kg N/ha and 15 tons/ha). This accounted for the increase in marketable yield for the treatment. Half rate of fertilizer and mulch (75 kg N/ha and 15 tons/ha) gave the highest profit. Therefore, the use of Cajanus cajan mulch would reduce the dependence on inorganic fertilizers and ensure a sustained improvement in tomato yield.

Keywords: *Yield, Growth, Biomass transfer, Mulch, Fertilizer***.**

INTRODUCTION

Tomato growing is one of the major enterprises of horticulture and is becoming increasingly popular owing to a greater appreciation of their food value. They are an important part of the diet of millions of people all over the world, more particularly in the tropics (Williams *et al*., 1991). It is produced mainly for domestic consumption in West Africa. In Ghana, tomato is the most important crop in established dry season gardens in the Northern and Upper Regions and in the Southern Volta Region. In Northern Ghana, it is the main occupation of farmers in both dry and wet seasons and is the major source of income to farmers (Norman, 1992).

Much of the agricultural land in the humid tropics is currently used for traditional farming based on bush fallow. This is a low productivity but biologically stable system with long fallow periods that can sustain agricultural production for many generations (Kang and Wilson, 1987). However, with increase in human population the fallow period is now shorter, resulting in land degradation and substantial decline in crop yield. The use of fertilizer inputs alone has largely been ineffective in overcoming these problems (Lal and Greenland, 1986). Also, over the years, the continuous use of inorganic fertilizers has resulted in poor soil structure in most of the agricultural lands and hence poor yields are obtained. The current trend demands an alternative means of supplementing fertilizer application, so as to provide a source of sustained rural income generation and reduce rural-urban migration.

Agroforestry as an alternative can improve soil fertility, soil physical conditions and at the same time provide better water retention ability of the soil (Omoro and Nair, 1993). The incorporation of woody species into crop production systems is one option that has received significant attention in recent years (Kang *et al.*, 1990). Biomass transfer is a form of agroforestry and is known to serve as an alternative for the reliance on inorganic fertilizer and also provide much needed organic matter to maintain soil productivity. In biomass transfer, trees are grown as a block planting and pruning from them applied to crop soils on another site. The benefits from the mulch are obtained with no competition from the growing trees for nutrients (Young, 1989).

Despite the potential of pigeonpea (*Cajanus cajan*) to produce food, improve soil fertility, fodder and firewood, its use as a perennial component in agroforestry system is under exploited. The perennial nature enables it to withstand harsh environmental conditions and recover after the removal of stresses. It is an alternative choice for small holders because an edible grain yield is not usually obtained from agroforestry species. Pigeonpea is part of the farming system in Northern Ghana, where they are normally used as boundary planting. The familiarity of the people with pigeonpea would enhance its acceptability. It is thought that using pigeonpea as mulch may be easily accepted than *Leucaena leucocephala* and *Gliricidia sepium*.

The study was conducted to compare the effect of *Cajanus cajan* mulch and inorganic fertilizer on the growth and yield of tomato.

METHODOLOGY

The experiment was carried out at the Tono Irrigation Project in the Kassena Nankana District of the Upper East Region of Ghana. The area lies roughly between latitudes 10^0 45^1 N and 1^0 West longitude, with an altitude of 202 metres.

The study area normally experiences a mean daily air temperatures decline from a peak of about 32°C in April to 25°C in August with corresponding low radiation. During harmattan, daily maximum air temperatures can reach 45°C resulting in extremely high evaporation rates. The average annual rainfall in the area is about 990 mm. The soil type for the experiment was sandy loam.

A Split plot design with four replicates was used. The three main plots treatments were, No Fertilizer (F0; 0 kg N/ha), ½ rate of recommended fertilizer (F1/2; 75 kg N/ha) and Full rate of recommended fertilizer (F1; 150 kg N/ha). The sub plot treatment were No mulch (M0) and mulch at 15 tons/ha (M1)). Each sub-plot was 3.3 m x 3.0 m containing 20 tomato plants, planted at a distance of 100 cm x 50 cm. The distance between sub-plots was 50cm and the replicates were 5 m apart. Records were taken randomly from 5 plants in each sub-plot and an average taken to represent the result of each sub-plot.

Nursing of tomato seeds

Nursing of seeds was done on seed beds. Seeds were sown in rows with 5cm between the rows. Seeds were pressed to about 1.5-2 cm depth in the soil after having been dressed with Furadan. Seeds were pressed slightly and moistened after sowing to create the necessary conditions for seed germination. Seedbed was protected from the bright sunshine and excessive drying by covering them with grass. Watering was done twice a day (morning and evening). Tomato seedlings were gradually exposed to sunlight and given less water.

Transplanting of tomato seedlings

Tomato seedlings were transplanted at four weeks after sowing seeds at nursery. The seedlings were transplanted in the evening after the soil was moistened.

Fertilization of experiment

Fertilizer rates of 150 kg N ha^{-1} and 75 kg N ha^{-1} were applied on plots which required the full rate of fertilizer and half rate of fertilizer respectively. These rates of fertilizer applications are the recommended rates used by farmers at the Tono Irrigation Project site. The band placement method of application was used. Fertilizer was placed about 4 -6 cm away from the plant.

Mulching of experimental plot

Cajanus cajan was pruned after the pods have been harvested. Prunings were put on tomato beds two weeks before the transplanting of tomato. This is to ensure synchronization of nutrient release with that of plant requirement. Fifteen tons/ha of *Cajanus cajan* was applied to sub-plots that required mulching.

Weeding of experimental site

Weeding was done three times at four weekly intervals except the first weeding. Weeding was done manually using the hoe.

Spraying of seedlings

Spraying of tomato was done four times at three (3) week's interval, using fungicides (Dithane) and insecticide (Karate). Both the Dithane and the Karate were mixed at a rate of 1 kg/ha and 2.4 litres/ha in a knapsack sprayer before being applied to the experimental field.

Harvesting of tomato

Tomato was harvested at 13-14 weeks after planting. Harvesting was done every other day from each sub-plot when the fruits have turned pink and ripened and the overall yield of each sub-plot was weighed to obtain the fruit yield. Fruits were later separated based on their marketable yield.

Data Analysis

The GenStat Release package was employed in the data analysis. Duncan's Multiple Range Test (DMRT) was used to compare the difference between the treatments. Differences were considered to be statistically significant at 5% probability level.

RESULTS

Effect of Mulch and Fertilizer on Plant Growth

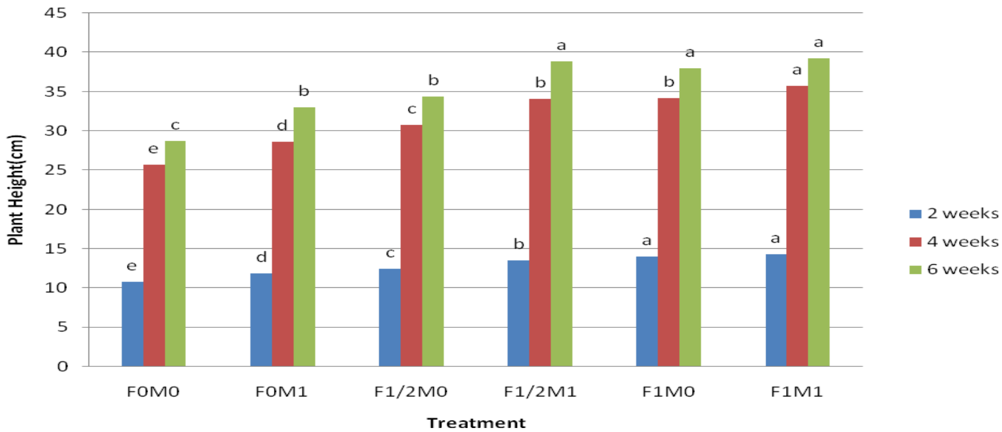
Tomato plants in mulched and fertilizer plots were taller than those in the control plot. An increase in plant height and leaf area was observed at 2 Weeks After Planting (WAP) onwards. Statistical analysis of the data indicated that there was a significant effect ($P \leq 0.05$) on plant height and leaf area with mulch/fertilizer combination (Fig. 1 and Fig. 2). F0M0 treatment recorded the lowest plant height and leaf area, whilst the highest plant height and leaf area was recorded at full rate of fertilizer and 15 tons/ha of mulch interaction (F1M1).

Effect of Mulch and Fertilizer on Number of Flowers and Flower Abortion at First Truss

The mulch and fertilizer interaction had a significant effect on number of flowers and flower abortion at first truss. The number of flowers at first truss increased by 44.5%, 44.5%, 55.5%, 60% and 66.6% with respect to the control treatment (F0M0) for F0M1, F1/2M0, F1/2M1, F1M0 and F1M1 treatments, respectively. Flower abortion decreased by 11.9%, 16.6%, 28.5%, 35.7% and 40.4% with respect to control treatment (F0M0) for F0M1, F1/2M0, F1/2M1, F1M0 and F1M1, respectively (Table 1).

Effect of Mulch and Fertilizer on Fruit Yield and number of tomato fruits

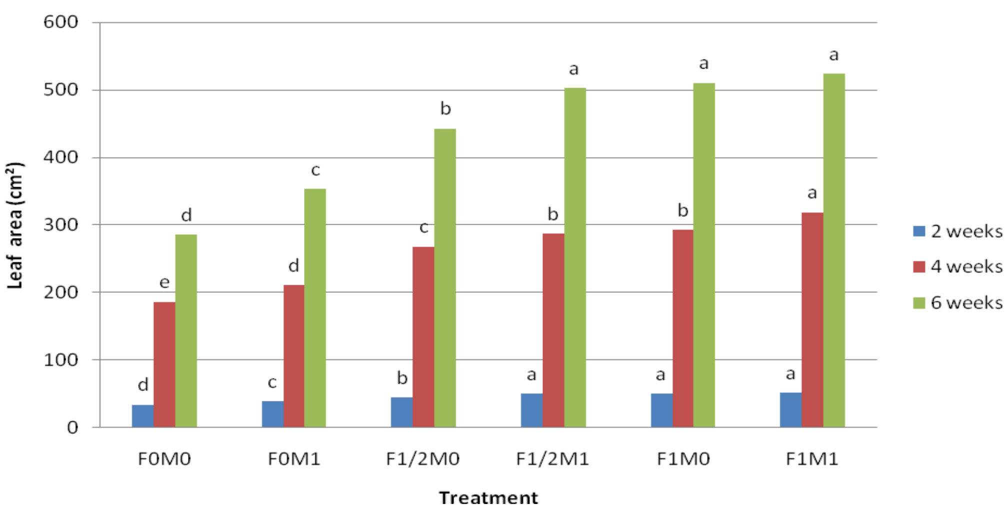
Mulch and fertilizer interaction significantly increased the yield of tomato (Table 2). F1M1



C.V. (%)	(2 weeks)	3.03	S.E.	(2 weeks)	0.13
C.V. (%)	(4 weeks)	4.63	S.E.	(4 weeks)	0.29
C.V. (%)	(6 weeks)	4.90	S.E.	(6 weeks)	0.50

**Figures of same letters are not significantly different by Duncan Multiple Range Test (DMRT) at P = 0.05*

Fig. 1: Effect of mulch and fertilizer interaction on plant height



C.V. (%)	(2 weeks)	4.46	S.E.	(2 weeks)	1.23
C.V. (%)	(4 weeks)	2.82	S.E.	(4 weeks)	2.50
C.V. (%)	(6 weeks)	4.60	S.E.	(6 weeks)	7.03

**Figures of same letters are not significantly different by Duncan Multiple Range Test (DMRT) at P = 0.05*

Fig. 2: Effect of mulch and fertilizer interaction on leaf area

(150 kg N/ha and 15 tons ha^{-1} of mulch) gave higher tomato yield than the rest of the treatments interactions. However, F1M0 (150 kg N/ha and No mulch) and F1/2M1 (75 kg N/ha with 15 tons/ha of mulch) did not differ significantly from each other. F0M0 (No fertilizer and No mulch) gave the lowest yield (Table 2).

Table 1: Effect of mulch and fertilizer on number of flowers and flower abortion at first truss

Treatment	Mean number of flowers	Mean number of flowers aborted
FOMO	4.5[c]	4.2[a]
FOM1	6.5[b]	3.7[b]
F1/2MO	6.5[b]	3.4[b]
F1/2M1	7.0[ab]	3.0[c]
FIMO	7.2[a]	2.7[c]
FIMI	7.5[a]	2.5[c]
C.V(%)	10.03	15.61
Standard error	3.18	4.14

**Mean of the same letters are not significantly different by DMRT at P=0.05*

Table 2: Effect of mulch and fertilizer interactions on fruit yield and number of fruits of tomato

Treatment	Yield (tons/ha)	Number of fruits (10^3)/ha
FOMO	2.80[e]	40.23[e]
FOM1	5.05[d]	71.68[d]
F1/2MO	7.97[c]	113.15[c]
F1/2M1	9.14[b]	129.50[b]
FIMO	9.19[b]	131.45[b]
FIMI	9.35[a]	134.45[a]
C.V(%)	2.82	2.44
Standard error	1.18	1.14

**Mean of the same letters are not significantly different by DMRT at P=0.05*

Effect of Mulch and Fertilizer on Marketable Yield and fruit size

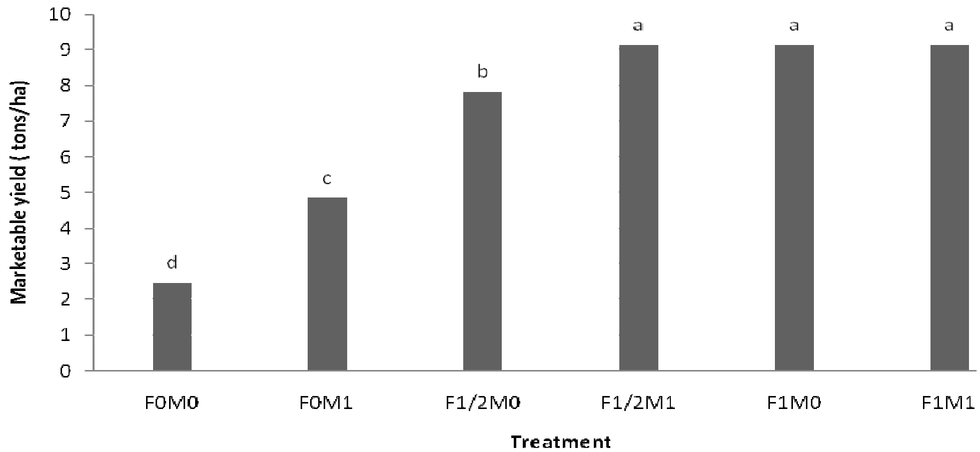
The highest marketable yield was obtained at F1/2M1 (75 kg N/ha and 15 tons/ha of mulch) and the lowest marketable yield was at No Mulch and No Fertilizer (F0M0) (Fig. 3). Tomato fruit size was much influenced by mulch and fertilizer treatments. In the mulch/fertilizer interaction, the least fruit size was observed in the control plot of F0M0 (No mulch and No fertilizer). Fruit size was highest in F1/2M1 (75 kg N/ha with 15 tons/ha). However, there was no significant difference between F0M1 and F1/2M0 (Fig. 4).

DISCUSSION

Effect of mulch and fertilizer on plant growth

Tomato plants in the mulch and fertilizer plots were taller than those in the control plots. The trend obtained showed the effect of nutrients released from mulch and fertilizer on plant height. At 6 WAP, the height of tomato increased at a decreasing rate. The probable reason for this phenomenon is that, at this stage tomato de-emphasises on height growth but the effect of the mulch and fertilized treatments resulted in producing branches.

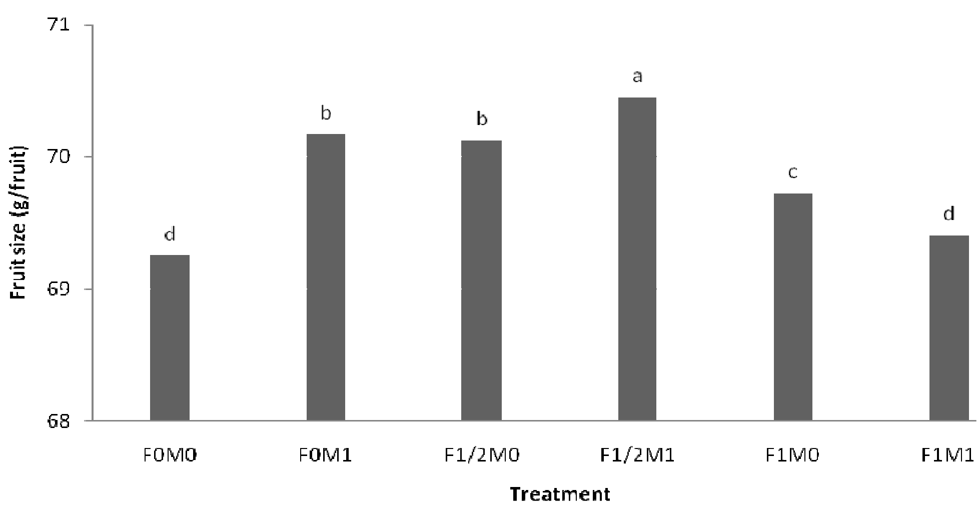
Fertilizer application is more effective when applied to mulched soil than bare soil. According to Dupriez and De-leener (1989) when soil-feeding crops is rich in organic nutrients such as those derived from mulch, cultivated plants are often harder and healthier than when nutrients come straight from factory made minerals. Tomato plants subjected to mulching and fertilization exhibited the highest plant height when compared with other treatment combinations (Liasu and Achakzai, 2007). Similarly the tomato subjected to mulching and fertilizer application exhibited the highest number of leaves/plant and number of nodes/plant (Liasu and Achakzai, 2007). Mulch and fertilizer had



C.V. (%) 3.13 S.E. 0.2

**Figures of same letters are not significantly different by Duncan Multiple Range Test (DMRT) at P = 0.05*

Fig. 3: Effect of mulch and fertilizer interaction on marketable yield



C.V. (%) 2.3 S.E 0.9

**Figures of same letters are not significantly different by Duncan Multiple Range Test (DMRT) at P = 0.05*

Fig. 4: Effect of mulch and fertilizer interaction on fruit size

complementary effect on nutrient availability to plants because mulch when it decomposes releases nutrients and organic matter (humus) which when supplied into the soil increases the growth of plants (Liasu and Achakzai, 2007).

Humus increase nutrient retention capacity of the soil, by increasing effective cation exchange capacity (Muller-Samann and Kotschi, 1994). Mulch covers the soil thereby reducing the rate of removal of water from the soil surface to the atmosphere and protects the soil and its organic content from direct contact with warm air thus increasing microbial activity consequently encouraging decomposition. This could have accounted for the increased growth of tomato. The application of NPK fertilizer to the tomato supplements the nutrients content of the soil by making available essential elements required for healthy growth of the plant (Liasu and Achakzai, 2007). Rahman *et al*. (2006) reported increase in plant height of tomato mulched with rice straw while lowest height was observed in control (unmulched). Mulching the soil has been reported to prevent water loss and facilitate mineral uptake to the plant. Tejedor *et al*. (2003) has reported that mulches help prevent soil salinity. On a sandy loam, Atherton and Rudich (1986) found that applications of potassium increased plant height by up to 65%. Omission of calcium from the nutrient solution reduced plant height and the number of leaves formed (Atherton and Rudich, 1986). An inadequate supply of magnesium may depress both growth and the yield of fruit of tomato (Adatia and Winsor, 1971). An increase in plant growth observed in this research conforms to that reported by Atherton and Rudich (1986). An increase in leaf area was obtained in all the treatments compared to the control.

Mulch and fertilizer treatments increased leaf area of tomato at 150 kg N/ha and 15 tons/ha of mulch (F1M1). Extending the vegetative period on the other hand may allow the formation of greater number and areas of leaves to support the growth of fruits and inflorescence. It is possible that the nutrients released from the fertilizer and mulch treatments stimulated rapid vegetative growth of plants to encourage the rapid development of leaves which photosynthesize sugars needed to fuel subsequent flowering and fruiting. The increase in leaf area might have contributed to the delayed number of days to fruit set and first harvest. This result is similar to that of Palada *et al,* (1992) who reported that mulch induced more leaves formation.

Effect of Mulch and Fertilizer on Number of Flowers and Flower Abortion at First Truss

There was a general increase in number of flowers and reduced flower abortion in all the mulch, fertilizer and mulch/fertilizer treatments (Table 1).

Differences in the rate of flower formation lead to differences in fruit production at particular stages in the growth of the crop. Short-term increases in yield can be attributed to formation of large number of flowers within an inflorescence. The results obtained could be due to the nutrients released by fertilizer, which reduced flower abortion and increased flower number at first truss. Though, there was no significant effect of mulch and fertilizer on soil chemical properties, there was a general increase of nitrogen, phosphorus and potassium in all the treatments compared to the control. An increase of these nutrients could have accounted for the increase in flower number and reduced flower abortion. According to Menary and Van staden (1976) phosphorus deficiency reduced the number of flower buds formed and delayed anthesis.

Effect of mulch and fertilizer on yield and number of tomato fruits

The increase in yield and number of tomato fruits in both higher rates of mulch and fertilizer treatments can be attributed to a network of factors that affect tomato performance. These factors include the release of nutrients from mulch and fertilizer, favourable soil moisture and temperature and the suppression of weeds by mulch treatment. According to Liasu and

Achakzai (2007) the number of fruits produced during the first week of fruit production was highest in mulched and fertilized tomato plants with a mean of 18 fruits/plant, followed by those growing in unmulched and fertilized soils with a mean of 12 fruits/plant. In mulched and unfertilized tomato plants mean number of fruits was 8 fruits/plant while unmulched and unfertilized plants the mean number of the fruits was 6 fruits/plant. In general, the cover of mulch creates a favourable microclimate for the activities of soil microorganism which help improve and maintain the biological and physicochemical qualities of the soil thereby improving the yield performance (Liasu and Achakzai, 2007). Hochmuth *et al.* (2001) observed that best fruit yield was obtained under plastic mulch. The increased yield of tomato under *Cajanus cajan* mulch (15 tons/ha) and fertilizer at 150 kg N/ha and 15 tons/ha of mulch (F1M1) can be attributed to the conservation of moisture, reduction of temperature in the top soil and suppression of weed growth.

Mulch and fertilizer reduced soil temperature and increased soil moisture content and these values are favourable for increased fruit yield of tomato. These findings conform to other experiments involving mulches. Lal (1978) achieved 38, 10 and 22% yields in three consecutive years for maize under mulch. Lal (1975) found that very good yields were obtained when yams were mulched, compared with an almost crop failure without mulch.

In Western Kenya, *Sesbania sesban*, *Leucaena leucocephala*, with pruning left on the soil; yields of maize and beans, the following year were increased by 78% compared with plots that had previously been fallowed (Onim *et al*, 1990).

Effect of mulch and fertilizer on marketable yield and fruit size

The nutrients levels in the soil after harvesting of tomato were not significantly different among the treatments. This suggests that as soon as nutrients are released from mulch and fertilizer, the tomato plant quickly used these up and this could have accounted for the increase fruit yield of tomato. The amount of nutrients taken by crops depends on the number of fruits and the amount of dry matter produced. This in turn is influenced by a number of genetic and environmental variables (Shukla and Naik, 1993). Marketable yield increased with increase in mulch and fertilizer application. However, half rate of recommended fertilizer application (75 kg N/ha) and 15t/ha mulch (F1/2M1), full rate of fertilizer application (150 kg N/ha) without mulch (F1M0) and full rate of fertilizer application (150 kg N/ha) and 15 tons/ha of mulch (F1M1) did not differ significantly (Fig. 3).

These results obtained could be explained by the decrease in fruit size observed at the high rate of fertilizer and mulch application (Fig 4). This means that, although the higher rate of fertilizer and mulch (ie. F1/2M0, F1M0, F1M1) produced the highest fruit yield and differed significantly from each other, these treatments did not show any significant difference in marketable yield and this can be attributed to the reduced fruit size observed in F1M0 and F1M1 treatments (Fig. 4). Quinn (1973) has shown that mulching the soil surface with grass in the wet season increased marketable yield and reduced weed growth.

Fruit size was highest at the half rate of fertilizer and mulch (F1/2M1) and lowest at No fertilizer and No mulch (F0M0) (Fig 4). No significant difference was observed between F0M0 and F1M1. Increases in the number of flowers and reduction of flower abortion (Table 1) in F1M1, increased the fruit yield (Table 2) and this could have accounted for the reduction in fruit size for the treatment (Fig. 4). According to Liasu and Achakzai (2007) tomato plants growing in mulched and fertilized soils had the biggest sizes of fruits whiles those growing in unmulched and fertilized soils had moderating sizes though not as big as that of mulched fertilized tomato plants. These results contradicts with this study where half rate of fertilizer and mulch (F1/2M1) had the biggest fruit size than 150 kg N/ha and 15 tons/ha of mulch (F1M1) which recorded the highest yield. This is probably because achieving higher yield and at the same time increase in fruit size is difficult to attain.

Cajanus cajan proves as the most suitable agroforestry species for irrigated areas where perennial trees are not recommend. The rapid decomposition rate of the species was vital in the increase attained in tomato yield.

CONCLUSION

Sustainable agriculture requires frequent additions of nutrients and organic materials for maintaining crop growth and yield. Although inorganic fertilizers provided these nutrients, timely supply and cost of fertilizers often prohibit its use. Mulching has provided an alternative for this reliance on inorganic fertilizers and provides the much needed organic material to maintain soil productivity. The use of 15 tons/ ha of *Cajanus cajan* mulch and the 75 kg N/ha has showed to be the most viable option for small scale farmers in the locality. Savings are accrued due to the reduction in fertilizer application.

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