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Effect of Planting Patterns in Tomato (Lycopersicon esculentum Mill) and Maize (Zea mays L.) Intercropping on Growth, Yield and Yield Traits of the Crops in Wolaita Zone, Southern Ethiopia

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Abstract
Wolaita Zone, where large number of population density per unit area found in Ethiopia, is one of the highly populated areas of the country. The need for reasonable cropping system under intensive cropping has become major areas of agronomic research in such an area. The study was, therefore, conducted to compare the effects of different planting pattern in tomato/maize intercropping and compatible time of intercropping on the growth, yield and yield traits of the component crops. Factorial combinations of three component populations of tomato (T) and maize (M) (100T:50M, 67T:33M and 50T:50M) and five dates of maize intercropping (30 days before tomato transplanting, 15 days before tomato transplanting, at tomato transplanting, 15 days after tomato transplanting and 30 days after tomato transplanting) together with their respective sole crops were laid out as Randomized Complete Block Design with three replications. As a result, tomato in the component population of 100T:50M flowered and matured earlier while maize in 50T:50M and 100T:50M combinations were fast to reach its phenological stages. Only number of branch per plant was significantly affected by component population out of tomato growth parameters. Longitudinal fruit size was the single yield component which significantly affected by dates of maize intercropping. All growth parameters of intercropped maize were significantly affected due to the main effects. Tomato yields were highly significantly affected by component populations in that yields were higher in the 100T:50M combinations; whereas in the case of maize, both main effects significantly influenced its yield components. Yield components of sole maize were significantly higher than intercropped ones. Hence, sole tomato production would be beneficial in the study area. But where farmers fear risk of sole crop due to disease or market conditions, the 100% tomato population with 50% maize by intercropping maize 15 days after transplanting of tomato is a promising treatment in order to minimize risks.

Keywords: Component crops, intercropping, maize, planting patterns, tomato

1. Introduction

Ethiopia has diversified agro ecological conditions that favor cultivation of major food crops; however, there are limiting factors for crop production. Traditional cropping systems, poor cultivation methods, inappropriate planting time, low soil fertility, poor weed management, diseases and insect pests, low yielding varieties are the main ones (Tolera, 2003). The improvement of crop productivity is the common aim of farmers and agriculturists. Thus, the key for sustainable agriculture probably lies in increased output per unit area together with arable land expansion. However, demographic pressure has forced agricultural planners and development agencies to review the role of multiple cropping as a means to enhance agricultural production, since the extent of suitable agricultural land is static or diminishing (Midmore, 1993). In terms of cropping systems, the solutions may not only involve the mechanized rotational mono-culture cropping systems used in developed countries but also the multiple cropping systems traditionally used in developing countries (Tsubo *et al*., 2003). The main reason for using a multiple cropping system is the fact that it involves integrating crops using space and labor more efficiently (Baldy and Stigter, 1997). Biophysical reasons include better utilization of environmental factors, greater yield stability in variable environments and soil conservation practices. Socio-economic reasons include the magnitude of inputs and outputs and their contribution to the stabilization of household food supply (Beets, 1982).

Best utilization of growth resources and modified microclimate by component crops of intercropping for their better yield performance are practical only when the right planting pattern of component crops is followed. Planting pattern defines the pattern of distribution of plants over the ground, which determines the shape of the area available to the individual plants (Willey, 1979b). Increased productivity of intercropping over sole cropping has been attributed to better use of solar radiation, nutrients and water and fewer incidences of insect pest and disease (Willey, 1990). Planting pattern of intercrops is an important management practice that can improve better use of these resources and opportunities (Reddy *et al*., 1989; Willey, 1990).

Even though intercropping is traditionally common in Ethiopia including tomato on small land of the home garden with different other vegetables, no scientific attempt have been done exhaustively to determine tomato/maize intercropping system. Thus, investigating optimum component population of tomato and maize and determining the right intercropping time for maize will have great significance for sustainable production. Therefore, the study was conducted to evaluate the effect of planting pattern and time of maize intercropping on productivity of the associated crops so as to find out the effect of tomato and maize intercropping on the productivity and profitability of the system.

2. Materials and Methods

2.1 Description of the study Area

The experiment was conducted in Wolaita Zone of Southern Ethiopia, from December, 2008 to April, 2009. The experimental site is located at 37^0 7' E, and 6^0 7' N at an elevation of 1360 meter above sea level. The area has a mean annual rainfall of 549.2 mm and air temperatures of 26 ^{0}C. The soil of the study area is Nitisols (FAO/Unesco classification).

2.2 Treatments and experimental design

The determinate tomato (*Lycopersicon esculentum* Mill) cultivar ''Roma VF'' (a determinate type tomato) and maize (*Zea mays* L.) variety ''Melkssa-I'' (an early maturing variety) were used. Both crops are adaptable and suitable crops for the study area. Treatments comprised factorial combinations of three levels of component populations of tomato/maize intercropping, *i.e.* 100%T: 50%M, 67%T: 33%M, and 50%T: 50%M of recommended component population of tomato: maize density, respectively, and five levels of intercropping date of maize, *i.e.* 30 days before tomato transplanting, 15 days before tomato transplanting, just at tomato transplanting, 15 days after tomato transplanting and 30 days after tomato transplanting. Tomato transplanting was done once on the same day when the 3rd round maize was intercropped. A sole stand of maize (44,444 plant populations/ha) and tomato (33,333 plant populations/ha) were included at the time of tomato transplanting.

The experimental plots were arranged in Randomized Complete Block Design (RCBD) with three replications. Sole tomato and sole maize were the controls for comparison. In the three population combinations, row of tomato and maize were arranged alternatively simulating farmers' practices with the following adjustments for the treatments. Two rows of tomato were planted in between each maize row of 150 cm apart in the 100%T: 50%M component population. Two rows of tomato and one row of maize were planted alternatively, 75 cm apart in the case of 67%T: 33%M component population. Alternative rows of tomato were planted 75 cm apart for the component population of 50%T: 50%M. Sole tomato was transplanted at the spacing of 75 cm between rows and 40 cm between plants. While sole maize was planted at the spacing of 75 cm between rows and 30 cm between plants. Size of each plot was 9 m x 3.6 m in order to accommodate a minimum of two central rows of each component crops. A distance of 1 m between plots and replications were maintained for walk way.

2.3 Agronomic practices

About 250 g/ha (0.125 g/5 m^2) of tomato seeds were sown on the seedbed to produce seedlings from December 4, 2008 to January 10, 2009. A 100 g DAP (46% P_2O_5 and 18 % N) and 100 g urea (46% N) were applied at thinning (at first true leaf stage) to the seedlings as recommended by (Lemma, 2002). Proper nursery management (mulching, watering, shade making, thinning and weeding) practices were applied in order to produce healthy seedlings. Seedlings were hardened for a week by gradual reduction of watering frequency and shade level before transplanting to enable them withstands the field conditions. Healthy and vigorous stocky succulent seedlings were selected for transplanting.

The experimental field was ploughed and leveled. Two maize seeds were sown per hill at the rate of 20 kg/ha which was thinned to one plant per hill one month after sowing. After five weeks (at 3-4 leaf stage) uniform and vigorous seedlings of tomato were inter-planted to the plots, as per the treatments, late in the afternoon to reduce the risk of poor establishment which may occur because of strong noon sunlight. Management practices were done uniformly. Forty kg P/ha and 36 kg N/ha were applied basally at transplanting and 46 kg/ha N was side dressed at early flowering stage (Lemma, 2002). Twenty kg P/ha and 41 kg N/ha were applied basally at sowing and 23 kg N/ha was side dressed one month later to the maize, other component crop, as recommended by Gelana (unpublished). Diammonium Phosphate (DAP) fertilizer was the phosphorous source whereas Urea was the source of nitrogen nutrition. The experimental plots were kept free from weeds. Inter-cultivation, irrigation and pest management were also the other strict follow ups.

2.4 Data collection and analysis procedures

2.4.1 Phenological parameters of tomato and maize

The number of days required from planting to the 50% flowering and red ripening stage were determined as days to flowering and maturity, respectively. Similarly, for maize, the numbers of days required from planting to 50% tasseling, silking and dough formation were recorded as days to tasseling, silking and maturing, respectively.

2.4.2 Growth parameters of tomato and maize

For tomato, after counting the number of branches and leaves on ten randomly selected plants from net plot size in each treatment, their respective mean value was worked out. The maximum height attained by plants at maturity was also measured and average value was obtained. In the same manner, maize mean value of leaves per plant was computed. Moreover, leaf length and width were measured from ten sample plants just before harvesting to calculate leaf area (LA) by using methods formulated by McKee (1964):

$$LA = L \times W \times 0.733$$

Where, LA=Leaf area in cm^2, L = Maximum leaf length in cm, W= Maximum leaf width in cm and 0.733=correction factor.

Leaf area index (LAI) was also calculated as the ratio of mean leaf area of ten plants (cm^2) per area of land occupied by the plant (Diwaker and Oswalt, 1992):

$$LAI = \frac{LA}{A}$$

Where, LAI= Leaf Area Index, LA= Leaf area/plant in cm^2 and A= Area occupied/plant in cm^2.

2.4.3 Yield and yield components of tomato and maize

Number of flower trusses produced per plant at approximately 50% of maturity as well as number of fruits per cluster at red ripening stage was counted. Tomato fruits were harvested at pink to full ripe stage from rows of net plot size and physical fruit qualities were recorded. Ten randomly selected fruits collected from ten plants from the net plot were weighed and the average weight of each fruit was determined. Similarly, ten randomly selected sample fruits were floated in water of graduated jar and their displacement was recorded and average fruit volume (ml) was obtained as follows:

$$\frac{V_f - V_i}{10}$$

Where, V is calculated volume, V_f is final volume, V_i is initial volume and 10 is the number of sample fruits. The longitudinal (proximal to distal end) and cross-sectional (transverse diameter) axis was measured during peak harvest and the mean value was evaluated to determine as described by Mazumdar and Majumder (2003). The sum total of fruits of successive harvests from the net plot size was used to calculate yield per hectare. Fruits of free from defects were weighed (kg/plot) as marketable yields and converted into t/ha. Unmarketable yields, fruits with cracks, damaged by insects, diseases, birds, sunscald and blossom-end-rot *etc* were considered as unmarketable fruits and calculated for t/ha. The above unmarketable yield was calculated in percent, to know how much of it was not profitable or not sold, as follows:

$$UY\% = \frac{UY}{TY} \times 100$$

Where, UY is unmarketable yield and TY is total yield.

Concerning maize yield and yield components, the number of cobs was counted from each net plot area. The number of cobs per plant was calculated as total number of cobs harvested and divided by the number of sample plants. For fresh market sales, leaving husks on the ears (Wolfe *et al*., 1997), ten green cobs were harvested and their sum total weight was divided by ten to calculate the mean weight (g) of each husked green cobs. The sum total of all green cobs that were harvested from the net plot was weighed and converted in to tone per hectare. Fresh biomass was recorded from ten plants by harvesting above ground parts from the net plot at harvesting time after separating the husked green cob yields. The harvested above ground maize stalk was weighed cutting at ground level and the value was divided by ten to get the mean weight of each stalks. Stalk weight (t/ha) was calculated weighing all the harvested above ground stalks from net plot area after separating the green cob yield.

2.5 Data analysis

The main and interaction effects of plant population of component crops and time of intercropping maize on growth, yield parameters of the associated tomato/maize and productivity of the system were statistically analyzed using the general linear model procedure of the Statistical Analysis System (SAS, 1996). Differences between means were separated by using Least Significant Difference (LSD) test at 5% when the analysis of variance indicated the presence of significant differences (Gomez and Gomez, 1984).

3. Results and Discussion

3.1 Phenological response of component crops

3.1.1 Phenology of tomato

Component populations highly significantly ($p<0.05$) influenced both days to flowering and maturing of tomato plants. Tomato in 100T:50M component population flowered and matured earlier (Table 1). This might be due to higher competition for light that occurred among higher populations per unit area which resulted in shorter time to reach reproductive stage than those with lower total populations per unit area in which competition is lower which in turn resulted in delay of flowering and maturity. The 50T:50M combinations required much more days to reach flowering and maturity stages, *i.e.* 39 and 82 days after transplanting, respectively. Similar results were reported by Ofosu-Anim and Limbani (2002) in cucumber/okra intercropping. The effect of intercropping compared to sole cropping resulted in no significant difference on the tomato both tomato phonologies and this is confirmed by the observations of Jett *et al*. (2004) in which peak tomato harvest was not affected by intercropping or relay cropping of tomato/lettuce. This may be the result of low competition that occurred due to no overlapping of critical growth periods of the companion crops since maize was intercropped in various times.

3.1.2 Phenology of maize

Component population did significantly affect the phenological stages of maize at 0.05 probability level. Time elapsed by maize plants to reach their respective phenological stages was decreased with the increase in the maize populations within the combinations, *i.e.* maize intercropped in 100T:50M and 50T:50M population combinations flowered and matured earlier than those in 67T:33M combinations. Similar to this result, Abdulatif (2002) reported that flowering time was inversely related to maize population density (Table 1).

3.2 Growth response of tomato and maize

3.2.1 Growth response of tomato

Component populations, maize intercropping dates as well as interaction of the main effects did significantly affect number of branches per plant (Table 2). Tomato intercropped in 67T:33M population combination produced maximum number of branches (12.42) compared to the other intercropped tomato. This may be due to low competition for sun light that occurred in dense canopies of the 100T:50M and 50T:50M as the inter-row spacing of maize was relatively closer than that of 67T:33M combinations as discussed above. Thus tomatoes in component populations of 67T:33M produced larger number of branches. This is confirmed by the results of Hussain (2003) in that tomato plant height was maximum in okra and maize, but the number of branches was significantly less due to okra probably produced denser canopy followed by maize and then the least dense canopy by other intercropped vegetables (chili, potato and eggplant). The denser the canopy under which tomato was grown, the greater was the struggle to enlarge its inter-nodal length and in lesser rates the plant to increase the number of nodes and branches.

3.2.2 Growth response of maize

Numbers of leaves, total leaf area (LA), leaf area index (LAI) per plant and plant height were significantly affected by the component populations and maize intercropping dates (Table 2). Component population did significantly ($p<0.05$) influence number of leaves produced by maize (Table 3). Comparatively, maize intercropped with the ratio of 2T: 1M produced larger leaf numbers (10.25 leaves per plant). Leaf area and LAI were affected significantly ($p<0.05$) by component populations and maize intercropping dates, but not by the interaction effect. This may be due to complementary effects, *i.e.* soil moisture may be conserved in enough amounts by densely grown understory tomato. In support of this finding, Demesew (2002) reported an increase in LA per plant and LAI of intercropped maize with increase in population of haricot bean in a mixture that followed similar trend to the present result. Contrary to this finding, Tilahun (2002) noted an increase in leaf area index with increase in population of maize in a mixture with faba bean.

Concerning the maize intercropping dates, maize intercropped 30 and 15 days after tomato transplanting had larger numbers of leaves whereas those sown 30 and 15 days before tomato transplanting produced the lower numbers of leaves per plant (9.41 and 9.49), respectively. This may be due to the companion crops reaching their respective phenological stages; as a result competition would be lower. The result of the current study is supported by many other findings of different researchers. The temporal use of irradiance within intercrops of contrasting development and phenology, *i.e.* their peak demands for the same resource, do not overlap in time due to differences in phenology (Willey *et al*., 1983) or planting date (Midmore *et al*., 1988), is a prime example illustrating the more efficient use of naturally available resources by intercrops than by each crop if grown alone (Midmore, 1993). Fukai and Trenbath (1993) also reported that intercropping is most productive when intercrops differ greatly in growth duration so that their maximum requirements for growth resources occur at different times. The highest yields were obtained by intercropping of cowpea into maize when the maize plant can adequately cover the cowpea, thus sowing cowpea at 4 or 6 weeks after planting (WAP) of maize and at a 50: 50 population ratio, were best (Pitan and Odebiyi, 2001).

The small leaf number with smaller LA and LAI of the early maturing maize variety, therefore, may be suitable for intercropping. Similar to this result many findings were reported. For maize, the most important traits determining suitability for intercropping were identified by Davis and Garcia (1983) to be plant height, internodes length and leaf width. A tall maize cultivar with relatively broad leaves competed relatively severely with beans but gave a good maize yield (Davis and Woolley, 1993), but a less tall maize cultivar with relatively long internodes and narrow leaves provided the best combination of maize and bean yield. Selecting for a less competitive, more efficient plant type is not incompatible with sole cropping, but may take on additional significance in intercropping (Davis and Woolley, 1993). Soto-Guevara and Smith (1991) conducted two cycles of divergent recurrent selection in maize for sole cropping and intercropping with beans, where the selection criterion in the intercrop was the combined maize and bean yield.

Maize plant height was highly significantly affected by the main effects (component population and maize intercropping dates) and significantly ($p<0.05$) by the interaction of the main effects (Table 4). When maize in component population of 100T:50M was intercropped 15 days after tomato transplanting, the plants attained the tallest height (123.90 cm). On the other hand, maize intercropped on the same day (15 days after tomato transplanting) and with the same population density (with 50% proportion) but in different component population (50%T with 50%M) had about 5.7% less height. When the density of maize in the component decreased to 33%, plant height further reduced (9.3%). The increment of plant height with increased population per unit area may be due to competition for light. Similar result was reported by Adeniyan *et al.* (2007) in that plant height and internodes length increased with increasing plant population because of competition for light.

3.3 Yield and yield components of tomato and maize intercropping

3.3.1 Marketable and non-marketable

Tomato yields were highly significantly affected by component populations, but not by maize intercropping dates and the interaction effects (Table 6). The yield result showed direct proportionality with tomato populations per unit area of land, *i.e.* as tomato population increased from 50% to 67% and then to 100% of component populations, yield increased from 23.804 t/ha to 32.166 t/ha and then to 41.905 t/ha, respectively. This situation may be due to efficient utilization of resources such as light as a result of total ground coverage by higher plant populations per unit area of land. Similar result was reported by Dorais *et al.* (1991) in that the use of high plant density improved the utilization of the high level of Photosynthetic Photon Flux Densities (PPFD) and yields were greater at the high (3.5 plants m^{-2}) densities than at the traditional 2.3 plants m^{-2} for the 100 and 150 µmol m^{-2} s^{-1} PPFD treatments, respectively. The study of Muoneke and Mbah (2007) also agreed with the current result in that more number of plants per unit area produced a greater yield per hectare than under low plant densities.

3.3.2 Maize yield components

Concerning the intercropping dates of maize, cobs of larger weight were harvested from those intercropped 15 days after tomato transplanting and the smallest ones were collected from those intercropped on 15 days before tomato transplanting. The reason here may also be due to complementarities discussed above. Component populations and interaction effects did not show any significant influence on maize stalk weight, but intercropping dates did significantly affect stalk weight. Maize intercropped on 15 days after tomato transplanting produced the heaviest stalk yield (261.61g). Maize intercropped 30 days after tomato transplanting and at the time of tomato transplanting also produced heavy stalks as can be observed from Table 7. The lightest stalks were harvested from those intercropped 15 days before tomato transplanting which weighed about 189.76 g and varied statistically only from those intercropped 15 DATT. Cob yield (t/ha) was significantly ($p<0.05$) influenced by both component population and intercropping dates, even though not affected by their interaction effects. The highest yield (4.63 t/ha) was obtained from 100T:50M combinations, followed by 4.38 t/ha of 50T:50M combination. The lowest cob yield (2.29 t/ha) was harvested from the component populations of 67T:33M. The cob yield appeared to be directly proportional to the number of plants per unit area of land and also may be due to canopy density as it has positive influence in moisture conservation and water use efficiency. In agreement with this result, Wallace *et al.* (1990) reported that the components of evaporation found indicating a large loss of water as direct evaporation from soil, especially early in the season when the canopy cover was low. In an incomplete sole cane canopy Thompson (1976) also found large losses of water as direct soil evaporation, *e.g.* about 50% of total evaporation came from the soil when the canopy cover was 25%.

Maize intercropped 15 DATT produced significantly higher cob yield (4.35 t/ha) than earlier intercropped ones, with the lowest yield (3.10 t/ha) recorded from maize intercropped 30 days before tomato transplanting. Stalk yields also showed similar trends to that of cob yields, *i.e.* the component population that gave higher cob yield, as mentioned above, also returned higher stalk yields as presented in Table 7. On the other hand, intercropped cob yields of maize crops were highly significantly ($p<0.05$) lower than cob yield weights of sole cropping. Similar yield trend was observed in the maize stalk yield where it was significantly lower in intercropped stand than in sole cropped maize. This is confirmed by the findings of Adeniyan *et al.* (2007) in that the effect of cropping systems on maize grain yield where the order of maize cob yield followed that the sole maize > maize/African yam bean (AYB) intercrop > maize/kenaf intercrop > maize/kenaf/AYB intercrop. The better performance of sole crops than in their association crops is in agreement with results of Emuh *et al.* (2006), who observed higher yield of sole crops than in their corresponding crop mixture. Yield reductions involving one or all components in intercropping have been also reported by other researchers (Adeniyan *et al.*, 2007). They attributed such depressant effects to inter-specific competition for nutrients, moisture and/or space. However, such practices are done with purpose of creating a system with higher combined yield that could benefit the farmers. This will also enhance crop diversity as well as reduce total crop failure due to pest, disease and unusual weather conditions.

4. Summary and Conclusion

Tomato/maize intercropping experiment was conducted under the lowland tropical climate of Humbo, Southern

Ethiopia to improve yield per unit area though evaluation of productivity and profitability level of tomato/maize intercropping and to determine the best compatible combination and right intercropping time of maize for sustainable production of the crops in the area. Factorial combinations of three mixtures of tomato: maize crop components and five intercropping dates of maize accompanied with sole crops of tomato and maize.

Accordingly, growth and yield parameters of tomato/maize intercropping system were assessed. Phenological investigations indicated significant differences due to the main effects of component population.

Similarly, data analysis on growth parameters of component crops indicated that the effect on number of branches per plant was significant only due to component populations. In general, almost all tomato growth parameters were not affected by intercropping system, which can be concluded that maize did not show significant influence on the intercropped tomato.

Generally, neither of the sole cropped tomato growth parameters was significantly different from their respective intercropped ones. Similarly, significant difference was not observed between sole and intercropping tomato crop regarding the yield and yield components. Unlike the growth parameters of intercropped tomato, both the main effects of component populations of the two crops and its different intercropping dates did significantly affect growth parameters of intercropped maize such as number of leaves per plant, leaf area per plant, leaf area index and plant height. It could be concluded that maize was significantly affected by the tomato/maize intercropping system than the component crop (tomato).

With respect to yield and yield components of intercropped maize, both the main effects of component populations of tomato and maize and its intercropping dates highly significantly influenced cob yields (4.63 t/ha). Maize stalk yield (5.71 t/ha) was also influenced highly significantly by component populations and significantly at 0.05 levels by the intercropping dates but the interaction effect was not significant. Sole cropped cob yield (7.89 t/ha) was highly significantly higher than intercropped cob yield (3.77 t/ha), whereas sole cropped stalk yield (10.04 t/ha) was only significantly superior to intercropped stalk yields (4.64 t/ha). This indicates that tomato was better competent for growth requirements than maize as it was weak relatively. That was the reason for the non-significant difference between the yield and yield components of sole and intercropped tomato, but significant difference occurred between that of maize yields.

As a general conclusion, farmers can achieve the full production of the main crop (tomato) and also an additional yield (bonus) associated with an increased plant population of the maize component through intercropping. Hence, tomato/maize intercropping will increase incomes obtained by smallholder farmers in hot low land tropics, like Humbo area of Southern Ethiopia, through reduction of economic risk and market fluctuation resulting from growing a single crop which is more prone to natural hazards and helping the farmers in better utilization of land by having more than one crop produced per unit area. Though all intercrops produced higher productivity, the farmers could better use the 100% tomato population with 50% maize by intercropping it into tomato 15 days after transplanting of tomato in order to maximize yield of both crops as well as total productivity, but growing of sole tomato is more productive in the absence of risk at the study area.

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Table 2. Effect of component populations, maize intercropping dates and cropping systems on phenology of tomato and maize

Treatments	Tomato days to 50%		Maize days to 50%		
	Flowering	Maturity	Tasseling	Silking	Dough formation
*Component Populations**					
100T:50M	33.40	75.67	45.33	49.33	78.20
67T:33M	37.87	79.60	45.60	50.07	79.40
50T:50M	39.33	81.80	44.93	49.00	78.13
LSD (0.05)	2.86	2.93	0.50	0.56	0.61
*Maize intercropping dates***					
30DBTT	35.78	77.89	45.22	49.44	78.56
15DBTT	36.56	78.67	45.33	49.55	78.67
ATT	36.67	78.56	45.22	49.11	78.33
15DATT	38.78	82.11	45.22	49.67	78.67
30DATT	36.56	77.89	45.44	49.56	78.67
LSD (0.05)	NS	NS	NS	NS	NS
CV (%)	10.38	4.96	1.48	1.50	1.04
Cropping Systems					
Intercropping	36.87	79.02	45.29	49.47	78.58
Sole cropping	38.67	81.00	45.00	49.00	80.00
LSD (0.05)	NS	NS	0.09	NS	0.51
CV (%)	7.17	3.59	0.06	0.29	0.18

NS= non significant

*100T:50M = 100% tomato: 50% maize, 67T:33M = 67% tomato: 33%maize, and 50T:50M= 50% tomato: 50% maize.

**30DBTT= time of intercropping maize 30-days before tomato transplanting, 15DBTT= time of intercropping maize 15-days before tomato transplanting, ATT= time of intercropping maize at tomato transplanting, 15DATT= time of intercropping maize 15-days after tomato transplanting and 30DATT= time of intercropping maize 30-days after tomato transplanting.

Table 3. Effect of component populations, maize intercropping dates and cropping systems on tomato growth parameters

Treatments	Tomato growth parameters		
	No. of primary branches per plant	No. of leaves per plant	Plant height (cm)
Component Populations			
100T:50M	11.09	117.08	47.11
67T:33M	12.42	128.21	45.46
50T:50M	10.62	117.93	43.66
LSD (0.05)	1.42	NS	NS
Maize intercropping dates			
30DBTT	11.11	124.50	46.76
15DBTT	11.07	109.39	45.82
ATT	11.43	124.99	43.88
15DATT	11.71	125.10	46.02
30DATT	11.57	121.40	44.58
LSD (0.05)	NS	NS	NS
CV (%)	16.68	19.43	8.44
Cropping Systems			
Intercropping	11.38	121.08	45.41
Sole cropping	10.20	117.07	45.07
LSD (0.05)	NS	NS	NS
CV (%)	6.06	8.88	2.17

NS= non significant

Table 4. Effect of component populations, maize intercropping dates and cropping systems on maize growth parameters

Treatments	Maize growth parameters			
	No. of leaf per plant	Leaf area (cm^2)/plant	Leaf area index/plant	Plant height (cm)
Component Populations				
100T:50M	10.25	2401.30	1.07	111.92
67T:33M	9.82	2165.90	0.96	100.70
50T:50M	9.80	1976.40	0.88	104.75
LSD (0.05)	0.38	297.19	0.13	4.62
Maize intercropping dates				
30DBTT	9.41	1899.80	0.84	95.22
15DBTT	9.79	2234.90	0.99	100.89
ATT	9.96	2261.40	1.01	109.81
15DATT	10.14	2506.60	1.11	117.70
30DATT	10.49	2003.40	0.89	105.33
LSD (0.05)	0.49	383.67	0.17	5.96
CV (%)	5.07	18.22	18.22	5.84
Cropping Systems				
Intercropping	9.96	2181.21	0.97	105.79
Sole cropping	10.27	2265.81	1.01	113.17
LSD (0.05)	NS	NS	NS	NS
CV (%)	1.37	3.84	3.83	6.29

NS= non significant

Table 5. Height of maize as affected by the interaction effect of component populations and cropping systems with maize intercropping dates

Component Populations	Maize intercropping dates					Means
	30DBTT	15DBTT	ATT	15DATT	30DATT	
100T:50M	101.67	107.87	121.95	123.90	104.20	111.92
67T:33M	95.20	97.60	95.89	112.43	102.38	100.70
50T:50M	8.80	97.20	111.58	116.77	109.42	104.75
Intercropping	95.22	100.89	109.81	117.70	105.33	105.79
Sole	-	-	113.80	-	-	113.80
		CS		CP x MID		
LSD (0.05)		NS		10.33		
CV (%)		6.29		5.84		

Where CS= cropping system, MID= maize intercropping dates, CP=component population
NS= non significant

Table 6. Tomato yield components as affected by component populations, maize intercropping dates and cropping systems

Treatments	Tomato yield components					
	No. of fruit clusters/ plant	No. of fruits/ cluster	Weight/ fruit (g)	Volume/ fruit (ml)	Longitudinal size/fruit (cm)	Cross-sectional size/fruit (cm)
Component Populations						
100T:50M	32.61	3.09	53.27	55.83	16.10	12.33
67T:33M	33.07	3.12	56.00	58.87	16.17	12.52
50T:50M	31.85	2.98	50.73	52.06	16.45	12.65
LSD (0.05)	NS	NS	NS	NS	NS	NS
Maize intercropping dates						
30DBTT	33.07	3.11	56.78	61.67	16.40	12.48
15DBTT	31.39	3.10	52.67	53.99	15.45	12.10
ATT	33.57	3.00	51.00	51.83	16.25	12.63
15DATT	31.41	3.06	53.56	54.67	16.29	12.44
30DATT	33.10	2.04	52.67	55.78	16.82	12.86
LSD (0.05)	NS	NS	NS	NS	0.86	NS
CV (%)	18.41	13.81	11.12	13.55	5.47	5.45
Cropping Systems						
Intercropping	32.51	3.06	53.33	55.59	16.24	12.50
Sole cropping	31.93	2.96	56.67	61.67	16.37	13.15
LSD (0.05)	NS	NS	NS	NS	NS	NS
CV (%)	3.87	7.17	9.29	4.25	5.49	4.36

NS= non significant

Table 7. Effect of component populations, maize intercropping dates and cropping systems on tomato fruit yields

Treatments	Tomato yields	
	Marketable yields (t/ha)	Non-marketable yield (t/ha)
Component Populations		
100T:50M	41.90	8.90
67T:33M	32.17	9.13
50T:50M	23.80	9.33
LSD (0.05)	3.55	NS
Maize intercropping dates		
30DBTT	32.43	9.77
15DBTT	33.73	9.08
ATT	30.58	8.45
15DATT	34.26	9.34
30DATT	32.12	8.96
LSD (0.05)	NS	NS
CV (%)	14.57	10.56
Cropping Systems		
Intercropping	32.62	9.12
Sole cropping	48.18	9.34
LSD (0.05)	NS	NS
CV (%)	19.11	4.86

NS= non significant

Table 8. Maize yield and yield components as affected by component populations, its intercropping dates and cropping systems

Treatments	Maize yield and yield components				
	No. of cobs/plant	Cob weight (g)	Stalk weight (g)	Cob yield (t/ha)	Stalk yield (t/ha)
Component Populations					
100T:50M	1.16	217.20	223.81	4.63	5.71
67T:33M	1.12	190.27	217.82	2.29	2.75
50T:50M	1.13	200.07	217.43	4.37	5.44
LSD (0.05)	NS	20.70	NS	0.48	0.75
Maize intercropping dates					
30DBTT	1.12	197.33	204.09	3.10	4.13
15DBTT	1.16	180.00	189.76	3.68	4.03
ATT	1.11	202.78	219.61	3.56	4.68
15DATT	1.17	539.32	261.61	4.35	5.39
30DATT	1.13	194.67	223.38	4.14	4.96
LSD (0.05)	NS	26.73	46.15	0.61	0.97
CV (%)	16.04	13.67	21.75	16.96	21.62
Cropping Systems					
Intercropping	1.14	202.51	219.69	3.77	4.64
Sole cropping	1.00	198.33	225.12	7.89	10.04
LSD (0.05)	0.09	NS	NS	1.70	2.60
CV (%)	2.43	1.68	5.88	8.28	10.06

NS= non significant