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Effects of weeding frequency and plant spacing on the infestation and damage of the major insect pests of tomato (*Solanum lycopersicum* l.)

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ABSTRACT

Tomato insect pests are major constraint in tomato production in Gombe State. Therefore field studies were conducted at the Leventis Foundation/Gombe State Agricultural School, Tumu, Gombe State, Nigeria during 2015 and 2016 cropping seasons to assess the effects of planting space and weeding frequency on the infestation and damage of the major insect pests of tomato. The experiment was a 4 x 3 factorial arrangement laid out in Randomized Complete Block Design (RCBD) with three replications. The tomato planting spaces were (60 x 60 cm; 50 x 50 cm; 40 x 40 cm and 30 x 30 cm) as the first factor (A) and weeding frequencies (0, 1 and 2) was the second factor (B). Data were collected on: number of insect pests, plants' height, number of fruits/plant, number damaged fruits, number of undamaged fruits, fruit weight and fruit yield. The spacing of 50 x 50 cm was the optimum for the reduction of the insect pests, increased growth performance and increased fruit yield. Two weeding frequencies of tomato at 3 and 6 weeks after transplanting (WAT) was also found to be good for the insect pest reduction, improved plant growth, increased fruit weight and fruit yield. This combined cultural control methods of insect pests is an ample potential to improve tomato production in the study area.

Keywords: Cropping seasons, major insect pests, plant spacing, Tomato, weeding frequency

INTRODUCTION

Tomato *(Solanum lycopersicum* L.) is a vegetable crop which belongs to the family Solanaceae and is widely grown for its fruits (FAO, 2004). It is the second most popular vegetable crop cultivated throughout the humid and sub tropics (Nicola, *et al.*, 2015). Tomato is one of the most important vegetable widely cultivated in northern Nigeria and all other parts of the country mostly by subsistence farmer (Mohammed and Singha, 2007). It constitutes 18% of the total vegetable consumed in most Nigerian homes (Aja, 2012). Tomato is an important source of vitamins, minerals and can be used as fresh vegetable or processed as canned paste, juice and sauce. Tomato production in Nigeria is gaining popularity due to high demand and high revenue return (FAO, 2009). It is making an incursion into the eating habit of the populace, considering the benefits of tomato in human's health and life. Despite its importance, tomato farmers face several adverse conditions in growing the crop throughout Nigeria. Yield of tomato in Nigeria is low (7.0t/ha) compared with average yields recorded in other countries which, are about 9.9 t ha^{-1} in

Thailand, 8.8 t ha^{-1} in Phillippines, 15.6 t ha^{-1} in India, 25.3 t ha^{-1} in China, 52.8 t ha^{-1} in Japan and 63.6 t ha^{-1} in USA. In Africa, highest yield was obtained in South Africa (76.25 t ha^{-1}) and the least was from Angola (3.7 t ha^{-1}) (FAOSTAT, 2005, Mohammed and Sighn, 2007 and FAO, 2005). The low yield is attributed to complex of insect pests attack mainly to fruits and flowers (Lawan *et al.*, 2016). Among the insect pests attacking tomato,fruit bollwarm (*Helicoverpa armigera* Hubner);whitefly (*Bemisia tabaci* Gen.); Aphids Sp. *(Myzus persicae)*; flower thrips (*Thrips tabaci)*; root-knot, nematode (*Meloidogyne* sp.) (Mailafiya *et al.*, 2014; Oladokun *et al.*, 2017). Of all these insect pests, *Helicoverpa armigera*; *B. tabaci* and *M. Persicae* are the major insect pests of tomato in northern Nigeria (Degri and Mailafiya, 2013, Silas *et al.*, 2011.) The damage is caused by the larvae of the fruit borer which bore into fruits causing direct damage and indirect damage by predispose infested fruits to the entry of fungal and bacterial pathogens which reduce the fruits to a smelly liquid mass (Umeh *et al.*,2002).

The pests affect tomato by reducing yields, lowering crops market value. Tomato aphids (*M. persicae*) (Umeh *et al.*, 2002) and whitefly *(B. tabaci*) affects tomato indirectly through piercing and sucking of the plants sap thereby removing sap from the plant by their piercing, sucking mouth parts. Aphids and whiteflies are the most common polyphagous insect pests. These pests affects almost all the aerial parts of tomato plant from the early growth stages till the fruit maturation stage thereby resulting in stunting, curling or yellowing of plant foliage (Mailafiya *et al.*, 2014). These piercing and sucking insect pests attack the lamina of the tomato foliage which results in reduction of the photosynthetic ability of the crop yield (Hill and Walker, 1998). Aphids and whiteflies are also responsible for transmission of tomato mosaic virus (TMV), this infection could result in 30-50% yield production.

Tomato yield could be substantially increased through the use of cultural practices .Some of the practices that may increase tomato yields are spacing and weeding. The current spacing of 60X60cm giving 27,778 plants/ha is too low (Adigun *et al.*, 1994). Optimum weeding of tomato can significantly improve tomato growth and yield per hectare. This study therefore, was done to assess the effect of weeding frequency and spacing on the infestation and damage caused by the major insect pests of tomato.

MATERIALS AND METHODS

Experimental Sites

The field experiments were conducted at the Leventis Foundation/Gombe State Agricultural School, Tumu located in Akko Local Government Area of Gombe State during 2016 and 2017 cropping seasons .Gombe is in the Sudan savannah agro-ecology on latitude 10^0 14'N and latitude 10^0 14'E at altitude 148.5 above sea level. It has a mean annual rainfall of 860 mm and the temperature range from 15-38^0 C.

Experimental Design

The field experiments were laid out in factorial set up fitted into a randomized complete block design (RCBD) and replicated three times. The treatments consisted of four planting spacing (60X60cm; 50X50cm; 40X40 and 30X30cm) as the first factor (A) and weeding frequency of (no weeding, one weeding and two weeding) as the second factor (B). The plot size was 4.0m X3.0m and the variety used for the study was Roma VFN which is resistant to viruses, fungi and

nematode purchased from a reputable farm input retailers in Gombe main market.

Agronomic Practices

The site for raising seedlings was cleared of debris and weeds burnt, tilled and leveled. The nursery bed was watered to field capacity using watering can once daily in the evening for 14 days. Tomato seeds were sown by drilling and then watered daily .Weeds was handpicked from the nursery bed until when the seedlings were ready for transplant at 5-6 leaves old. Seedlings were transplanted to the experimental field when they attained 3-4 leaves by carefully uprooting them from nursery beds gently with a ball of earth to minimize transplanting shock and root destruction. One day before transplanting the nursery beds were irrigated to ease uprooting of seedlings. During transplanting, healthy, vigorous and uniform seedlings were transplanted late in the evening. The seedlings were transplanted according to planting spacing designed for the study and were watered to field capacity immediately after transplanting. Gap filling was made within a week after transplanting (WAT) to maintain the desired plant population per plot.

A compound fertilizer N.P.K 15:15:15 was applied to the seedlings at the rate of 70kg/ha as basal application, because of the poor soils in the Sudan Savannah Agro-ecological zone. The plots were weeded according to the weeding frequencies of the study with the help of hand held hoe and hand pulling. Harvesting was done when tomato plants attained physiological maturity.

Data Collection

The data generated during the study were collected on the number of fruit holes per plant at harvest, population's density of aphids, and population density of whitefly at the vegetative and reproductive stages. Yield and yield component data such as number of damaged fruits, number of undamaged fruits, fruit weights, fruit yield, number of fruits/plant at harvest

Analysis of Data

The data collected were analyzed using analysis of variance (ANOVA). Means of treatments that varied significantly were separated by using the least significant difference (LSD) at probability level of $P \leq 0.05$.

RESULTS

Result in table 1 shows the effect of plant spacing and weeding frequency on the number of major insect pests of tomato in 2016 and 2017 cropping seasons. The wider spaced tomato had significantly lower *H. armigera* while the closely spaced tomato had higher *H. armigera* aphids and whiteflies were found to be lower on widely spaced tomato during the 2016 and 2017 cropping seasons. Tomato plants that were weeded twice had low insect pests while zero and one weeding had higher insect pests during 2016 and 2017 weeding seasons.

Table 1: Effects of weeding frequency and plant spacing on mean number of per plant insect pest

Factor	2016	201	2016	2017	2016	2017
A (PS)	*B. tabaci*		*H. armigera*		*M. persicae*	
60 x 60 cm	1.32	1.31	1.38	1.39	2.67	2.94
50 x 50 cm	1.28	1.29	1.26	1.27	2.68	1.63
40 x 40 cm	2.23	2.23	2.11	1.97	2.74	2.76
30 x 30 cm	1.26	1.27	3.14	3.10	2.86	2.83
LSD (0.05)	0.42	0.37	0.92	0.79	0.36	0.38
B (WF)						
0	2.31	2.29	3.28	3.41	3.69	3.72
1	1.26	1.28	1.78	1.93	3.35	3.31
2	1.22	1.23	1.20	1.17	2.08	1.68
LSD (0.05)	0.29	0.16	0.32	0.31	0.09	0.12
Ax B	NS	NS	NS	NS	NS	NS

PS = plant spacing, WF = weeding frequency, Ax B = Interaction, NS = not significant at 5% level of probability

Results presented in table 2 shows that tomato spaced wider (60 x 60 cm and 50 x 50 cm) had taller plant height while closer spacing had shorter (40 x 40 cm and 30 x 30 cm) plant height. The number of fruits produced were more on wider (60 x 60 cm and 50 x 50 cm) spacing than closer spacing (40 x 40 cm and 30 x 30 cm). However, the number of damaged fruits was higher for closer spacing than wider spacing. The number of undamaged tomato fruits were highest on tomato plot spaced 50 x 50 cm followed by 60 x 60 cm while 30 x 30 cm had the lowest undamaged fruits.

Significantly higher plants height, number of fruits and undamaged fruits were recorded on tomato plot weeded twice followed by plot weeded once while plots that were not weeded had the shortest plant height, the least number of fruits, and lowest undamaged fruits .The number of bored tomato fruits were equally the lowest on tomato plot needed twice (5.3 and 5.18) for the two cropping seasons.

Table 2: Effect of weeding frequency and plant spacing on yield parameters of tomato

Factor	Plant height at harvest (cm)		No. of fruits/plant		No. of damaged fruits/plant		No. of undamaged fruits/plant	
A(PS)	2016	2017	2016	2017	2016	2017	2016	2017
60 x 60 cm	37.81	38.11	55.42	54.92	11.41	10.97	44.06	43.95
50 x 50 cm	35.68	35.72	59.53	59.46	10.43	10.61	49.10	48.85
40 x 40 cm	35.61	35.66	50.23	49.26	13.81	14.01	36.42	35.42
30 x 30 cm	33.53	33.00	23.24	24.01	16.84	16.67	27.70	27.50
LSD (0.05)	2.42	2.33	17.57	15.21	8.46	6.85	4.68	4.69
B (WF)								
0	32.17	31.77	22.24	21.73	36.85	36.82	15.66	14.91
1	35.70	35.67	45.49	46.11	14.11	14.09	31.38	32.02
2	38.11	37.98	61.33	59.97	5.38	5.14	54.95	52.83
LSD (0.05)	2.91	2.77	15.04	13.40	20.90	21.01	9.38	9.34
Ax B	NS	NS	NS	NS	NS	NS	NS	NS

PS = plant spacing, WF = weeding frequency, Ax B = Interaction, NS = not significant at 5% level of probability.

Result in (Table 3) showed the fruit weight and fruit yield recorded during the study period . The tomato plots spaced at 50X50cm had significantly higher fruit weight/plant and fruit yield followed by 60X60cm while 30X30cm spacing gave the lowest fruit weight and yield. The result further showed that tomato plot weeded two times produced significantly higher fruit weight and yield in 2016 and 2017 cropping seasons

Table 3: Effects of weeding frequency and plant spacing of tomato fruit yield

Factor	Fruit weight /plant		Fruit yield(t/ha)	
	2016	2017	2016	2017
A(PS)				
60 x 60 cm	32.87	32.89	26.79	27.11
50 x 50 cm	34.91	34.87	29.33	28.58
40 x 40 cm	32.09	31.98	26.03	26.35
30 x 30 cm	24.81	23.88	20.65	21.19
LSD (0.05)	9.72	9.41	5.13	6.83
B (WF)				
0	14.11	15.01	16.19	15.62
1	29.31	29.27	23.22	22.96
2	35.12	34.96	30.92	30.90
LSD (0.05)	2.10	3.41	35.64	34.56
Ax B	NS	NS	NS	NS

PS = plant spacing, WF = weeding frequency, Ax B = Interaction, NS = not significant at 5% level of probability.

DISCUSSION

Tomato spacing and weeding frequency have been found to be effective in reducing the infestation of major insect pests of tomato in this study during 2016 and 2017 cropping seasons .This studies shows that spacing of tomato has direct effect on the population of tomato fruit worm ,aphids and whitefly and improved fruits weight and fruit yield. The closer the spacing the more the buildup of those insect pests ,the reduction in plant height ,number of fruits, damaged fruits and less undamaged fruits .The wider the spacing, the lower the pest infestation, the more the plant height ,number of fruits and lower damaged fruits. This is in agreement with the earlier report by (Nguyen and Nguyen, 2015; Lawan *et al.,* 2016) that spacing of tomato has direct effect on the number of fruit weight and yield of tomato. They further reported that the closer the spacing the higher the number of fruit yield and conversely, the wider the spacing the lower the number of fruit yield per unit area. The results indicate that plant spacing has significant effect on plant height, number of fruit weight and yield. Weeding frequency has significant effect on number of fruit weight, plant height, fruit damage and fruit yield. This is in agreement with the findings of Mohammed and Singha (2007), Seid *et al* (2013); Nguyen and Nguyen (2015) who reported that wider spacing minimizes competition from nutrients, water and solar radiation. They noted that wider spacing allows greater circulation of air and interception of light by plants resulting in lower incidence of pests and diseases at wider spacing.

The tomato plant grown in 50X50cm spacing reduced the number of the major insect pests of tomato more than plant grown in 60X60cm and 40X40 while plant grown in 30X30cm spacing had more insect pests of tomato. This is also in agreement with the report of Lawan *et al* (2016) that farmer practices of spacing tomato wider and closer increase insect pests build up either due to enough space to locate appropriate feeding sites on their host or limited space to hinder the pest from locating the appropriate feeding sites on their hosts .Umeh *et al* (2002) reported that increasing plant density by planting them closer increased the canopy and shading effects of the plant thereby providing the insect pests conducive environment for attacking their host.

Weeding frequency was also found to affect insect pests infestations and damage .This is because weeds provide a favourable environment for the insects (Altieri *et al.*,1981; Kanteh *et al.*,2014; Takim and Uddin ,2010; Yusuf *et al.* ,2015).Tillage practices that gives poorer weed control increase the density and diversity of insect pests population within the habitat (Alteiri *et al.*,1981;Shelton and Edwards ,1983).Weeding and plant spacing have shown to have great influence on the population of the tomato insect pests and yield: The results of this study showed that weeding frequency and spacing are two most important components of cultural method of controlling weeds and insect pests. Weed competition in tomato can lead to two important consequences. The first is weed competition with tomato in harboring insect pest by weed species and these insect pests feed on both vegetative and reproductive plant parts causing economic damage to the crops (Takim and Uddin ,2010;Yusuf *et al.* ,2015).In this study *Helicoverpa armigera, Myzus persicae* and *Bemisia tabaci* populations ,plant height ,number of fruits and number of undamaged

fruits were higher in plants weeded twice than non-weeded and one weeded plants. The plants that were not weeded twice had higher insect population, low plant height, less number of fruits and higher number of bored (damaged) fruits. This implies that the presence of weed provided shelter and conducive environment for the insect pests in tomato field that were not weeded or not properly or regularly weeded hence the high fruit damage and low fruit yield (Altieri *et al.* ,1981;Takim and Uddin ,2010;Yusuf *et al.* ,2015). Weed removal improved the growth performance of tomato because competitive ability of weed species and harboring of the three pest species were reduced in the regularly weeded plants (Shelton and Edwards, 1983). The frequent removal of weeds could have effectively reduced insect pest infestations and effectively reduce competition between the weeds and the tomato crops and ,made more assimilate available to support tomato growth and development and consequently its high fruits weight and yield. This is in agreement with the report of Altieri *et al.* ,1981; Pramanik *et al.*,2014; Pramanik *et al.*,2015;Uddin *et al.* ,2018). They reported that regular crop weeding had higher yield compared to none weeded and that safer insect pests control could be achieved and crop productivity improved through the simple manipulation of weeding regimes and appropriate plant spacing.

CONCLUSION

This study showed that tomato spacing and weeding have direct effect on the reduction of tomato insect pests and improving growth and yield performance. Tomato plants sown at 50X50cm gave good reduction of tomato fruit worm *(Helicoverpa armigera*),aphids *(Myzus persicae*) and whitefly *(Bemisia tabaci)* infestation and damaged fruits. It improved the growth of tomato plants, the number of fruits/plants and number of undamaged fruits. It also showed that weeding tomato twice (3 and 6 WAT) was found to be more effective in reducing weed competition. , reducing insect pest infestations and fruit damage while increasing plant growth, fruit weight and fruit yield. Therefore, it can be concluded that with these cultural practices used in this study for controlling insect pests, there is an ample potential to improve tomato productivity in the study areas.

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