Effect of Row Spacing and Weed Management Practices on Growth and Yield Components of Tomato (Solanum Lycopersicum L.) in Yola, North-Eastern Nigeria

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ABSTRACT

Field trial was conducted during 2020 and 2021 dry seasons at experimental farm site of the Department of Crop Production and Horticulture, Modibbo Adama University, Yola to study the Effect of row spacing and some weed management practices on growth and yield components of Tomato (Solanum lycopersicum L) in Yola north-eastern Nigeria. The experiment was layout in a split plot arrangement of a Randomize Complete Block Design (RCBD) with (5) treatments Zero weeding (Control), Weedy check (Weeding at 2 and 4 Weeks After Transplanting), Maize straw at 1.0 kg m^{-1}, S-metolachlor at 1.5 kg ha^{-1} and Pendimethalin at 1.44 kg ha^{-1}) replicated three (3) times. Row spacing of 40x40cm, 60x60cm and 80x80cm was assigned to main plot while the different weed management treatments were assigned to sub-plot. The parameters measured on the crop include tomato plant height, number of branches per tomato plant, number of tomato fruits per plant. And weed parameters measured were number of broadleaf weeds/m^2, grasses/m^2, sedges/m^2, total weed density/m^2, weeds dry weight/m^2, weed control efficiency (%) and weed index at harvest. The data collected were analyzed statistically using analysis of variance (ANOVA) and Duncan's Multiple Range Test to separate the means at 5% level of probability. The results shows significant differences on plant height of tomato. Weedy check and 40cm row spacing recorded the tallest tomato plant heights of (18.54) at 2 WAT in 2020 while the tallest plant, was recorded at the interaction between weedy check and 60 cm row spacing of (22.58 cm) in 2021. The highest number of branches for the two experimental years of 2020 and 2021, were recorded at the interaction between 40 cm row spacing and weedy check treatment of (7.17) and (11.50), compared with Pendimethalin that recorded the lowest tomato plant heights, number of branches of (1.00) and (2.00) at 4 & 5 WAT. Similarly, the result for weed parameters also indicated that weedy check and 40cm row spacing has the lowest weed density m^{-2} of (1.84) at 30 days after application in 2020 and (1.77) in 2021 compared to Zero weeding plot and 80cm row spacing that recorded with the highest weed density of (7.04) & (7.16) for both 2020 and 2021 experimental years, also the percentage of weed dry matter. Weedy check also recorded highest weed control efficiency and weed index compared with remaining treatments. Therefore, the finding of this work said "weedy check treatment and 40 cm x 40cm row spacing were the best among weed management practice and row spacing" and are recommended for use as an alternative to the use of herbicide and 60 cm x 60 cm row spacing for effective weed control and maximum yield output of the tomato production in Yola, Nigerian.

Keywords: Row Spacing, Tomato, Weed, Growth and Yield, Management Practices

INTRODUCTION

Tomato (Lycopersicum esculentum) is a major vegetable crop produce worldwide. It is usually grown outdoors to be used fresh or processed (Lucier et al. 2000). It is a popular and nutritive vegetable crop ranking next to potato in world's vegetable production. It is warm season crop reasonable resistance to heat, drought and grows on wide range of soil and climatic conditions. Nigeria is the fourth largest producing country of tomato in Africa and largest in West Africa sub region with an estimated output of 1.8 million metric tons and average

yield of 10 tons/ha (FAO, 2012). Nigeria is unable to meet its growing requirement of tomato and tomato products. Consequently, the country reverted to importation of tomato products which resulted in unnecessary pressure on foreign reserve. Between 2009 and 2010, Nigeria imported a total of 105,000 metric tons of tomato paste valued at over 16 billion Naira to bridge the deficit gap between demand and supply in the country (FAO, 2012). Kalu (2013) attributed this situation to the low yield obtained from farmers' field in Nigeria. Average yields of tomato in Nigeria are only about half of those in world leading countries like China (25.3 tons/ha). Several reasons are responsible for the low yields of tomato among which weed infestation and spacing are primary (Adigun, 2005). Adigun (2002) reported that unrestricted weed growth throughout the crop life cycle resulted in 92 to 95% reduction in tomato fruit yield.

Weeds is the major constraint that limiting the crop production and most deleterious effect and ultimately causing the yield reduction of tomato by 53 to 67%. Present study was undertaken with a view to reduce the losses of economic production through effective weed control and solve the scarcity of labors to some extent. weed reduce yields by competing for space, light, water and nutrients, weakening crop stand and reduce harvest efficiency (Abbasi, et al. 2013). However, the yield loss in agricultural production is becoming increasingly important because of decrease in agricultural lands as well as the population growth. The most important part of losses in plant production is caused by weeds. Herbicides are commonly used in order to control the weeds. However, common use of herbicides negatively affects human health and environment, and chemical residues are left in the soil, water, air and products. Furthermore, one hand weeding in addition to herbicide application significantly increased yield.

Mulching is a recent and important non-chemical weed control method. It is necessary to cover the soil surface with different materials to obtain high biological activity, retain soil moisture and to achieve a good control of weeds. Row spacing affects light interception and also influences the space available for weeds to grow. Row spacing can also affect the plant canopy (tomato) shape and branching, thereby influencing flowering and fruiting as well as crop competitiveness with weeds. Row spacing is often determined by the type of planting and harvesting equipment available, and will result in different crop yields and can influence overall economic return.

Attempts to reduce the yield losses caused by weeds for smallholder farmers have been focused on hoe weeding and chemical weed control (Mashingaidze and Chivinge, 2005). Apart from the high cost of hoe weeding, severe labour bottlenecks are common during peak weeding, resulting in delayed weeding in large portions of the planted crops, well after they have suffered significant damage from weeds (Adigun and Lagoke, 2003) Most available herbicide, on the other hand does not give a season long weed control effect. Moreover, the sole dependence on herbicides may lead to development of herbicide resistant weeds (Osipitan and Dille, 2017). Weed control places greater attention on the reduction of weed emergence in a crop and minimizing weed interference with the crop through the integration of techniques, knowledge and control skills.

The strategic weed control practices such as mulching and row spacing has potential to produce a healthy crop with aggressive competition against weeds and therefore reduce the burden of hoe weeding and chemical herbicide in tomato. There is need, however, to systematically integrate this weed control tactics into the production practice of smallholder farmers to tackle problems caused by weeds in a sustainable manner within the context of Weed Control. High cost of chemical herbicide to provide the much needed weed control for plant growth means that alternatives and possible new control practices have to be explored. At proper rate and time however, weeds can be controlled by reducing chemical herbicide and introducing mulches material. Delay in weed emergence provided by application of mulching materials could further give tomato advantage against weed, subsequently resulting in improved fruit yield.

The study is designed to investigate the feasibility of using mulch materials and herbicides as a weed control approach and varying row spacing for controlling weeds in tomato in Yola Adamawa State. Therefore, the aim of the research is to investigate the feasibility of using mulch materials and herbicides as weeds control approach and varying row spacing for controlling weeds in tomato. The objectives are, to evaluate effects of different spacing on growth and yield component of tomato, to evaluate the effect of growth, and yield components and different weed management practice on tomato.

MATERIAL AND METHODS

The experiment was conducted at the Teaching and Research Farm of Crop Production and Horticulture Department, Modibbo Adama University, Yola during 2020 and 2021 dry seasons. The experimental site lies between latitude $9^0 35^{!}$ 38" and longitude $12^0 50'45.3"$ and materials used consists of tomato seed "Roma" and the treatments used were T_1 = Zero weeding (Control), T_2 = Weed free check, T_3 = Maize straw at 1.0 kg m^{-1}, T_4 = S-metolachlor at 1.5 kg ha^{-1} and T_5 = Pendimethalin at 1.44 kg ha^{-1}. Laid out on a Randomized Complete Block Design (RCBD) with a split plot arrangement having (5) treatments, replicated three (3) times. Row spacing of 40 cm, 60 cm and 80 cm was assigned to main plot while treatments was assigned to sub-plot, each replication consists of (15) sub-plots, and was measured 140 cm, 190 cm and 250 cm by 150 cm per sub-plot, a boundary of 15 cm was maintain within sub-plot and a part way of 75 cm between main plot and replication having 4.8 m x 4.5 m experimental side. A sunken seed bed was prepared as nursery to raise the seedling for 28 days, transplanted on ridges using the spacing 40 cm x 40 cm, 60 cm x 60 cm and 80cm x 80cm between plants. The application of treatments (herbicides and mulch material) was done (3) days after transplanting. The parameters measured for growth and yield were tomato plant height, number of branches per tomato plant, number of tomato fruits per plant. And weed parameters measured were number of broadleaf weeds/m^2, grasses/m^2, sedges/m^2, total weed density/m^2, weeds dry weight/m^2, weed control efficiency (%) and weed index at harvest. Watering was maintained as required throughout the experiment. The data collected were analyzed statistically using analysis of variance (ANOVA) and Duncan's Multiple Range Test to separate the means at 5% level of probability.

RESULTS AND DISCUSSIONS

Effect of Row Spacing and Some Weed Management on Plant Height of Tomato

The effect of row spacing and some weed management on plant height of tomato were presented in table 1. Show significantly different on plant height of tomato at 4 WAT in 2020 and highly significant different at 2 WAT in 2021 (Table 1). At 4WAT 60 cm row spacing recorded the tallest tomato plant of 31.67 cm compared with 80 cm row spacing that recorded the shortest tomato plant of 27.69 cm gave significant different when compared, this as a result of competition of nutrient and sunlight in a close spacing that shows tomato plant height becomes taller in close spacing than in wide spacing. The result is in line with Mishra, (2000) research on crop weed competition, that reported plant become higher in small rows, interaction competition including quest for reaching sunlight is high, this is established in high populations, the plant height is always higher compared to thin population as in dense population where the plants are trying to reach and harvest maximum of the sunlight, therefore became taller. While in the 2021, the highly significant different was observed at 2 WAT. 60 cm row spacing recorded the tallest tomato plant height of 16.90 cm compared with 40cm that recorded the shortest tomato plant of 13.74 cm, This result agreed with the findings of (Olaniyi and Fagbayide, 2009), who found that the plant showed growth in height beginning rather slowly, increasing to a maximum then slow down again so that the graph obtained by plotting height against time is like an oblique 'S' in shape.

However, the significant different among the different weed management treatments were highly significant in 2020 and 2021 (Table 1). The weed-free check treatments recorded with tallest plant height, that shows significant different compared with the remaining treatments, S-metolachlor at 1.5 kgha^{-1} recorded with the shortest tomato plant height throughout the two (2) experimental years that shows significant different to all the remaining treatments. This shows the reaction of the herbicide that shows slow growing phrase on the tomato plant. In weed-free check inter-specific competition plant become taller in such environments (Tamana. B. & Ijaz A. K., 2014). The superiority of weed-free check to produce taller plants and more number of branches may be due to the fact that weed-free check provides better weed free condition from the very beginning of crop emergence and later by maize straw and zero weeding then followed by the herbicide thus weeds are managed during critical period of crop weed competition.

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Table 1: Effect of Row Spacing and Weed Management on Plant Height of Tomato.

Plant Height (WAT)

Treatments		2020			2021		
Row Spacing (cm)		2	4	6	2	4	6
40 X 40		13.08b	31.24a	53.81a	13.74b	28.55a	60.81a
60 X 60		13.92b	31.67a	53.56a	16.90a	33.44a	63.57a
80 X 80		12.41b	27.69ba	48.53a	15.12a	32.48a	64.31a
LSD		1.62	3.59	7.73	1.71	4.97	10.51
Diff. weed managements							
Zero weeding (control)		13.21bc	31.44b	53.05c	14.20c	31.65c	61.98c
Weed-free check		15.39a	40.37a	65.58a	20.37a	41.87a	78.75a
Maize straw at 1.0kgm^{-1}		14.73b	32.72b	59.78b	16.65b	37.22b	68.42b
S-metolachlor at 1.5kg ha^{-1}		10.73d	19.71d	37.19d	11.66d	19.94e	46.86e
Pendimethalin at 1.44kg ha^{-1}		11.62c	26.74c	44.23e	13.36c	26.77d	58.48d
LSD		1.67	4.35	5.55	1.32	2.84	4.46
(RS x DWM)	LSD	2.83	7.2	10.37	2.4	5.86	11.06

Weed-free check= (weeding to two weeks' intervals), WAT= Weeks After Transplanting, NS= Not Significant ** = Significantly Different behalf

Means follows by the same latter(s) within the same treatment group are not significantly different at 5% level of probability according to LSD

Effect of Row Spacing and Weed Management on Number of Branches for Tomato Plant

The result on effect of row spacing and different weed management on number of branches of tomato plant shows that, the row spacing recorded significant different only at 4WAT in 2020 but no significant different in 2021. During the 2020 at 4WAT 40cm row spacing shows significant different as it recorded the highest number of branches of 3.89 compare with 80cm row spacing that recorded with the least number of branches of 3.10 (Table 2). This can be attributed to the competition of sunlight that produce more number of branches to harvest maximum sunshine. This finding is in agreement with Mishra, (2000) who reported crop competition become higher in small rows which compete in search for reaching sunlight. In 2021 the number of branches on has no significant different at 40cm, 60cm and 80cm respectively. Among weed management treatments, the result showed significant differences during the two experimental years. In all cases weed-free check recorded the highest number of branches compared with S-metolachor at 1.5kg ha^{-1} that recorded the least number of branches. However, the highest values of all growth parameters were recorded under the weed-free check up to harvest due to reduced tomato-weed competition and better utilization of resources by the tomato plant. The results corroborate the findings of Nath and Sharma (2000). The minimum values of all yield

attributes, however, were registered under the weed-free plots till harvest due to season long crop-weed competition.

Table 2: Effect of Row Spacing and Different Weed Management on Number of Branches on Tomato.

Number of Branches (WAT)

Treatment	2020					2021				
Row spacing (cm)	2	3	4	5	6	2	3	4	5	6
40 X 40	0.40^{a}	2.15^{a}	3.89^{a}	6.03^{a}	6.70^{a}	1.17^{a}	2.32^{a}	3.48^{a}	5.61^{a}	7.46^{a}
60 X 60	0.40^{a}	1.89^{a}	3.16^{b}	4.92^{a}	5.53^{a}	1.36^{a}	3.06^{a}	3.68^{a}	5.62^{a}	7.67^{a}
80 X 80	0.96^{a}	2.10^{a}	3.10^{b}	5.21^{a}	6.45^{a}	1.63^{a}	2.65^{a}	3.61^{a}	5.23^{a}	7.27^{a}
LSD	1.08	0.75	0.64	1.82	2.05	1.18	1.51	1.54	1.94	3.94
Diff. Weed management										
Zero weeding (control)	0.37^{bc}	1.58^{c}	2.69^{c}	4.13^{c}	4.67^{c}	1.30^{bc}	2.71^{b}	3.63^{bc}	4.73^{c}	6.12^{c}
Weed-free check	1.22^{a}	3.61^{a}	6.01^{a}	9.53^{a}	10.92^{a}	2.05^{a}	3.60^{a}	4.63^{a}	8.12^{a}	11.21^{a}
Maize straw at 1.0kgm^{-1}	0.72^{b}	2.51^{a}	4.44^{b}	6.97^{b}	7.86^{b}	1.70^{ab}	3.11^{ab}	4.02^{b}	6.70^{b}	9.51^{b}
S-metolachlor at 1.5kgha^{-1}	0.17^{c}	1.31^{cd}	1.69^{c}	2.75^{c}	3.47^{c}	0.72^{c}	1.77^{d}	2.37^{d}	3.27^{d}	4.57^{d}
Pendimethalin at 1.44kg ha^{-1}	0.44^{bc}	1.41^{cd}	2.09^{c}	3.56^{c}	4.22^{c}	1.16^{c}	2.21^{bd}	3.29^{c}	4.61^{c}	5.93^{c}
LSD	0.52	0.63	0.87	1.42	1.65	0.42	0.54	0.48	0.75	0.93
(RS x DWM)										
LSD	1.18	1.12	1.42	2.58	2.97	1.20	1.53	1.53	1.99	3.86

Weed-free check= (weeding to two weeks' intervals), WAT= Weeks After Transplanting, NS= Not Significant ** = Significantly Different

Means follows by the same latter(s) within the same treatment group are not significantly different at 5% level of probability according to LSD

Effect of Row Spacing and Weed Management on Fruit Yield of Tomato Plant

The effect of row spacing on fruit yield of tomato shows no significant different effect on number of fruit yield of tomato in 2020 and 2021 experimental years (Table 3). The significant different was observed at different weed management treatment in 2020 and 2021 experimental years. The result showed significant difference at 40 DAT and highly significant difference at 50 and 60 DAT for the two experimental years. Weed-free check treatment recorded the maximum number of fruits compared with S-metolachor at 1.5 kg ha^{-1} that recorded the least number of fruits throughout the research work. The number of fruits per plant increases weed free environment and decreases in weed-free plots, the highest values of yield attribute were recorded under the weed-free check up to harvest due to reduced tomato-weed competition and better utilization of resources by

the tomato plant. The results corroborate the findings of Nath and Sharma (2000). The minimum values of all yield attributes, however, were registered under the weed-free plots till harvest due to season long crop-weed competition. The significant difference recorded on number of tomato fruits may be due to the fact that weed-free check provide better weed free condition from the very beginning of the tomato emergence and during critical period of the crop weed competition. Chaudhari et al., (2018) reported that weed free environment significantly influenced the growth characters like plant height, number of branches per plant and number of fruit yield in tomato. Bangis et al., (2014) also noted that significantly highest number of fruits was recorded under weed free treatment in brinjal crop. Singh et al., (2016) also reported that significantly the highest average bulb weight, marketable sign and total number of fruit yield were noted in weed free check. Ved and Srivastava (2006) also reported that the significant highest tomato fruit yield was noted in weed-free check, which was at par with Pendimethalin and hand weeding at 40 days after transplanting.

Weed Flora of Tomato Experimental site for 2020 and 2021

The most predominant weeds observed in the experimental site during the two research period include; Acanthospermum hispidum, Agratum conyzoides lynn., Vernonia anbigua kotchy & peyr, Tridax procumbens L., Polycarpea corymbosa L., Cleomeviscosa L., Commelina benghalensis L., Ipomoea eriocarpa R. Br., Euphorbia hirta L., Hyptis suavolens (L.) Poit, Leucas martinicensis R., Senna obtusifolia, Crotalaria macrocalyx Benth. Desmodium scorpiurus (Sw.)

Table 3: Effect of Row Spacing and Weed Management on Number of Fruits of Tomato.

Number of Fruits (DAT)

Treatments		2020			2021		
Row Spacing (cm)		40	50	60	40	50	60
40 X 40		4.38a	10.77a	24.13a	4.43a	11.29a	24.75a
60 X 60		5.09a	13.10a	26.46a	5.36a	13.67a	27.55a
80 X 80		4.46a	14.93a	28.29a	4.93a	14.57a	27.85a
LSD		2.19	7.55	7.55	2.12	4.13	8.27
Weed management treatments							
Zero weeding (control)		4.27c	12.02b	25.38b	4.48b	11.82c	25.91c
Weed-free check		5.64a	17.73a	31.09a	5.99a	17.78a	32.01a
Maize straw at 1.0kgm^{-1}		4.91b	12.42b	25.78b	5.25ab	14.84b	28.27b
S-metolachlor at 1.5kg ha^{-1}		4.07d	10.67b	24.03b	3.93b	9.47d	22.97d
Pendimethalin at 1.44kg ha^{-1}		4.31c	11.84b	25.20b	4.89b	11.96c	24.43cd
LSD		1.45	2.31	2.31	1.04	1.79	1.86
(RS x DWM)	LSD	2.79	7.49	7.49	2.34	4.37	8.08

Weed-free check= (weeding to two weeks' intervals), DAT= Days After Transplanting, NS= Not Significant ** = Significantly Different

Means follows by the same latter(s) within the same treatment group are not significantly different at 5% level of probability according to LDS

Desv., Sida acuta, Corchorus tridens linn., Mitracarpus villosus (SW.) DC., Salvinia molesta Michel, Dactyloctenium aegyptum (L.) Willd, Eleusine indica (L) Gaertner, Phalaris minor RetZ, Pennisetum pedicellatum Trin., Eragrostis triemula Hochst.es Steud, Setaria pumila (Poir.), Cyperus esculentus, Cyperus rotundus L. and Cyperus tuberosus. The weeds flora of the site composed of twenty-seven species that belong to fourteen families and the number and proportions of the families were Poaceae 6(22.2%), Astraceae 4(14.8%), Cyperaceae 3(11.1%), Leguminoceae 3(11.1%), Laminaceae 2(7.4%), Caryophyllaceae 1(3.7%), Cleomaceaea 1(3.7%), Convovulaceae 1(3.7%), Euporbiaceae 1(3.7%), Malvaceae 1(3.7%), Tiliaceae 1(3.7%), Rubiceae 1(3.7%), and Salviniaceae 1 (3.7%) respectively (Table 4). Similarly, the weed species grouped based on their morphology into broadleaves, grasses and sedges, had numbers and proportions of 18(66.67%) broadleaves, 6(22.22%) grasses and 3(11.11%) of sedges. This is indicating that the experimental site was dominated by broadleaf weeds and shows that broadleaves exhibit higher competitive ability than other weeds; this is attributed to the fact that broadleaves weed can grow rapidly at high temperatures and high light intensity to tolerate drought, and compete aggressively with the crop for light, moisture, and nutrients (Shrestha & Swanton, 2007).

The weed parameters studied included number of broadleaf weeds, grasses, sedges, weed dry weight, weed control efficiency, weed index and total density m^{-2} at 30 days after transplanting among these parameters, the effect of row spacing and weed control management treatment was significant and highly significant, respectively; however, on the interaction also the weed parameters shows significantly deferent on weed density and weeds biomass at 80 days after transplanting as the weed increases with increases in row spacing. Whereas the weed dry weight, weed control efficiency and weed index parameters shows no effect on the treatments during the research period.

Effect of Row Spacing and Weed Management on Weed Density of Tomato at 30days after transplanting.

The effect of row spacing and weed management treatments on weed density m^{-2} at 30 days after transplanting in tomato show significant different in 2020 and 2021 experimental years. The effect of row spacing was significantly difference at 60 cm and 80 cm row spacing with (4.27, 4.54) (4.23, 4.57) in 2020 and 2021 experimental years table 5, this was as a result of increase in spacing. Tamana B. and Ijaz A. K (2014). Observed an increase row spacing increase weed density with increase in row spacing from 40 cm, 60 cm and 80 cm respectively.

Table 4: Weeds Flora Found in the Experimental Site

S/No	Botanical name	Common name	Family
	Broad leaf weeds		
1	Acanthospermum hispidum	Bristly starbur	ASTRACEAE
2	Agratum conyzoides lynn.	Goat weed	ASTRACEAE
3	Vernonia anbigua kotchy & peyr	Iron weed	ASTRACEAE
4	Tridax procumbens L.	Tridax or coat button	ASTRACEAE
5	Polycarpea corymbosa L.	Old man's cap	CARYOPHYLLACEAE
6	Cleomeviscosa L.	Spider plant or consumption weed	CLEOMACEAE
7	Commelina benghalensis L.	Wandering jew, tropical	COMMELINACEAE

		spiderwort	
8	Ipomoea eriocarpa R. Br.	Tiny morning glory	CONVOLULACEAE
9	Euphorbia hirta L.	Snake weed or Asthma herb	EUPORBIACEAE
10	Hyptis suavolens (L.) Poit.	Pignut	LAMIACEAE
11	Leucas martinicensis R.	Whitewort	LAMIACEAE
12	Senna obtusifolia	Java bean or sickle pod	LEGUMINOCEAE;
13	Crotalaria macrocalyx Benth.	Rattle pod	LEGUMINOSAE
14	Desmodium scorpiurus (Sw.) Desv.	Scorpion ticktrefoil	LEGUMINOSAE
15	Sida acuta	Common wire weed	MALVACEAE
16	Corchorus tridens linn.	Wild jute	TILIACEAE
17	Mitracarpus villosus (SW.) DC.	Tropical girdlepod	RUBIACEAE
18	Salvinia molesta Michel	Water fern	SALVINIACEAE
	Grasses		
1	Dactyloctenium aegyptum (L.) Willd	Crowfoot-grass	POACEAE
2	Eleusine indica (L) Gaertner	Goose grass	POACEAE
3	Phalaris minor RetZ	Little kernel canary grass	POACEAE
4	Pennisetum pedicellatum Trin.	Deenanath grass or Feather pennisetum	POACEAE
5	Eragrostis triemula Hochst.es Steud	Love grass	POACEAE
6	Setaria pumila (poir.)	Yellow Foxtail	POACEAE
	Sedges		
1	Cyperus esculentus	Yellow nudsedge	CYPERCEAE
2	Cyperus rotundus L.	Purple nudsedge	CYPERCEAE
3	Cyperus tuberosus	Nutgrass	CYPERCEAE

*Sedges = 11.11%

**Grasses = 22.22%

***Broadleaves = 66.67%

The weed density at 30DAT has recorded significant different across the difference weed management in 2020 and 2021 also. Control treatment recorded with the highest weed density level of (6.16) and (6.19) in 2020 and 2021 experimental years compared with weed-free check treatment that recorded with best weed density level. This result is in line with those reported by Monks et al., (1997) and Tamana B. & Ijaz A. K (2014) who concluded that weed-free check and some mulches provide satisfactory weed control. Zafar et al., (2010) also reported that there was an increase in weed-crop competition period. Similarly, maximum number of weed

density was observed in plot where weeds were allowed to compete with crop for full growing season whereas the minimum was observed in weed free plot (Tesfaye et al., 2015).

Table 5: Weed Density at 30 Days after application of Treatments in Tomato

Treatments		2020		2021	
Row Spacing (cm)		Weed Density		Weed Density	
40 X 40		3.51b		3.51b	
60 X 60		4.27a		4.23a	
80 X 80		4.54a		4.57a	
LSD		0.3		0.36	
Diff. Weed management					
Zero weeding (control)		6.16a		6.19a	
Weed-free check		2.29d		2.30d	
Maize straw at 1.0kgm^{-1}		3.90c		3.71c	
S-metolachlor at 1.5kg ha^{-1}		4.05bc		4.16b	
Pendimethalin at 1.44kg ha^{-1}		4.19b		4.14b	
LSD		0.21		0.27	
(RS x DWM)	LSD	0.39		0.49	

Means follows by the same latter(s) within the same treatment group are not significantly different at 5% level of probability according to LSD

Effect of Row Spacing and Weed Management on Weed Biomass of Tomato.

Effect of different row spacing and weed managements on weed biomass of a tomato showed significant different on row spacing and weed management in 2020 and 2021 experimental years (Table 6). The effect on row spacing shows significant difference as 80 cm row spacing recorded with the maximum weeds biomass for the two research years that shows significantly different compared with the 40 cm and 60 cm row spacing.

The different weed management treatment was also significantly different for two experimental years as (Zero weeding) control treatment shows significant different compared with Weed-free check treatment that have least weed biomass. This result is agreed with the work of Gosheh, et al., (2010). Who reported that weed biomass was much higher in weed-free plots. Similarly, Tesfaye, et al. (2015) observed that the effect of different weed crop completion period on weed dry weight was significant as weed-free plot produced highest weed dry weight (1093.20) whereas the minimum was recorded from weed free plot up to harvest (0.0) this indicated that increment of weed free period was increased; there was significant reduction in weed biomass. This may be due to lowest weed density and influenced markedly due to different durations of crop-weed competition. Weed dry weight decreased with increase in duration of weed-free condition, whereas the weed dry matter accumulation increased with increase in weed-free duration. Ved and Srivastva (2006) reported that the lowest weed dry weight was noted in the plots kept weed-free up to harvest and was similar to that plots

kept weed-free up to 75, 60, 45 OAT and weed-free till 15 OAT. This was attributed to repeat weeding. Weed dry weight increased progressively when the weed-free period extended from 15 to 45 OAT due to continued dry matter accumulation in weeds. Weed-free condition beyond 45 DAT till harvest produced less weed dry weight significantly.

Table 6: Fresh and Dry Weed Biomass recoded as Dry Matter

Treatments		2020			2021	
Row Spacing (cm)		Fresh	Dry		Fresh	Dry
40 X 40		130.39b	33.35c		132.00c	31.20b
60 X 60		174.65a	36.71b		173.00a	36.60ab
80 X 80		174.47a	39.89a		168.00b	38.50a
LSD		38.84	3.68		59.5	6.38
Diff. Weed management						
Zero weeding (control)		203.10a	66.52a		316.00a	66.50a
Weed-free check		63.29e	16.49c		59.00e	16.30c
Maize straw at 1.0kgm^{-1}		108.59d	36.56b		108.00d	30.50b
S-metolachlor at 1.5kg ha^{-1}		135.98c	28.37b		135.00c	28.40b
Pendimethalin at 1.44kg ha^{-1}		168.83b	35.32b		169.00b	35.30b
LSD		45.29	10.05		65.7	10.55
(RS x DWM)	LSD	75.31	15.77		110.2	16.92

Means follows by the same latter(s) within the same treatment group are not significantly different at 5% level of probability according to LSD

Effect of Row Spacing and Weed Management on Weed Control Efficiency of Tomato.

There was no significant difference of row spacing on weed control efficiency of tomato in 2020 and 2021 experimental years, whereas the different weed management treatments recorded significant different on weed control efficiency of tomato in 2020 and 2021 experimental year (Table 7). The weed-free check treatment recorded the highest weed control efficiency of 81.01% compared with Pendimethalin at 1.44 kgha^{-1} that recorded the lowest weed control efficiency of 49.96% in 2020. In 2021, the effect on different weed management treatments observed significantly different on weed control efficiency. The weed-free check treatment also shows significantly different that recorded highest WCE of 78.00% compared with Pendimethalin at 1.44 kgha^{-1} that recorded 47.40%. Chauhan, 2012 that states that a single or double hand weeding application would control weeds at the early stage of the crop and reduces the need for future weed management.

Table 7: Weed Control Efficiency (%) up to Harvest

Treatments		2020		2021	
Row Spacing (cm)		WCE%		WCE%	
40 X 40		53.47a		50.70a	

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60 X 60		50.81a		51.70a	
80 X 80		48.92a		49.30a	
LSD		11.07		23.99	
Diff. Weed management					
Zero weeding (control)		0		0	
Weed-free check		81.01a		78.00a	
Maize straw at 1.0kgm^{-1}		71.26b		70.00a	
S-metolachlor at 1.5kg ha^{-1}		56.12c		57.50b	
Pendimethalin at 1.44kg ha^{-1}		49.96c		47.40b	
LSD		14.29		12.24	
(RS x DWM)	LSD	24.74		26.89	

Means follows by the same latter(s) within the same treatment group are not significantly different at 5% level of probability according to LSD

Effect of Row Spacing and Weed Management on Weed Index of Tomato.

The weed index of tomato shows no significant difference on the row spacing and weed management treatments for control of weed in tomato during 2020 and 2021 experimental years.

For different weed management treatments significant different was observed in 2020 and 2021 experimental year. The different weed management treatments in the sub-plot shows significantly different on weed index (%). As weed-free check treatment was used to calculate the percentage, S-metolachlor at 1.5kgha^{-1} recorded the weed index % of 22.22% compared with Zero weeding that recorded the least weed index of 17.34% in 2020. While in 2021 the result recorded significant different as S-metolachlor at 1.5kgha^{-1} also recorded the higher weed index % of 22.22% compared with Zero weeding that recorded the least weed index of 17.21%.

Table 8: Weed Index (%) up to Harvest

Treatments		2020		2021	
Row Spacing (cm)		Weed Index (%)		Weed Index (%)	
40 X 40		15.45a		15.53a	
60 X 60		17.81a		17.20a	
80 X 80		13.43a		13.45a	
LSD		7.14		12.18	
Diff. Weed management					

Zero weeding (control)		17.34a		17.21a	
Weed-free check		0		0	
Maize straw at 1.0kgm^{-1}		17.44a		17.56a	
S-metolachlor at 1.5kg ha^{-1}		22.22a		22.22a	
Pendimethalin at 1.44kg ha^{-1}		20.08a		19.97a	
LSD		9.22		6.47	
(RS x DWM)	LSD	15.96		13.89	

Means follows by the same latter(s) within the same treatment group are not significantly different at 5% level of probability according to LSD

CONCLUSION

Based on the findings in this study, it can be concluded that weed free check and 40 cm x 40 cm spacing give the tallest plant, highest number of branches and number of fruits. Weed-free check plot was also noted with highest weed control efficiency and weed index, likewise the lowest weed density m^{-2} and weed dry matter was recorded in weed-free check treated plot for the both experimental years of 2020 and 2021.

For the effect of some weed management practices on growth and yield components of tomato, weed-free check secured effective weed control with tallest plant heights, highest number of branches and maximum number of tomato fruits, as well as weed control efficiency and weed index.
The row spacing 40 cm x 40 cm were the best spacing for effective maximum growth and yield of tomato as it produce the maximum number of fruits and have weed control efficiency effectively.

RECOMMENDATIONS

From this research, it can be recommended that weed-free check and 40 cm x 40 cm row spacing were the best among weed management practice and row spacing, this are recommended to be used as an alternative to the use of herbicide for effective weed control and maximum yield output of the tomato production in Yola, Nigeria.

Special attention should also be paid on testing the efficacy of weed-free check and 40 cm x 40 cm row spacing in different environments.

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