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Nitrogen and weed management in transplanted tomato in the Nigerian forest-savanna transition zone

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ABSTRACT

Weed infestation and inherent low soil fertility are among primary reasons for low yields of tomato in Nigeria. Field trials were carried out during the wet season of 2015 and 2016 to evaluate yield response of tomato to nitrogen (N) application and weed control methods in the forest-savanna transition zone of Abeokuta, Nigeria. Positive relationship exists between growth of weed species and increase in N application. Across the years of study, increase in N up to 90 kg/ha increased weed density by 11–25%, however, the increased N gave the transplanted tomato competitive advantage and thus enhanced weed smothering. Pre-transplant application of butachlor (50% w/v) or probaben® (metolachlor 20% w/v + prometryn 20% w/v) each at 2.0 kg a.i/ha followed by supplementary hoe weeding at 6 weeks after transplanting (WAT) significantly reduced weed density by at least 15% and increased fruit yield of tomato by at least 32%, compared to use of the pre-transplant herbicides alone, across both years of study. The greatest tomato fruit yield of 12.2 t/ha was obtained with pre-transplant application of butachlor at 2.0 kg a.i/ha followed by supplementary hoe weeding at 6 WAT, averaged for both years. In general, this study suggests that increased application of N up to 90 kg/ha, and complementary weed control by pre-transplant herbicide and hoe weeding at 6 WAT would improve yield of tomato in the forest-savanna transition zone of Nigeria.

Introduction

Tomato (*Solanum lycopersycum* L.) is a crop of tremendous economic and nutritional importance throughout the world. It is the second most important vegetable crop next to potato in the world [1]. The world production of tomato is estimated at 162 million tonnes from land area of about 4.8 million hectares with China leading with 50 million metric tonnes [2]. 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 tonnes and average yield of 10 tonnes/ha [3]. Unfortunately, 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 tonnes of tomato paste valued at over 16 billion Naira to bridge the deficit gap between demand and supply in the country [4]. Ref. [5] 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 tonnes/ha). Several reasons are responsible for the low yields of tomato among which weed infestation and inherent low soil fertility are primary [6,7]. Tropical soils are generally poor in organic matter and are adversely affected by sub-optimal soil fertility hence, crop productivity decline over time [8]. Similarly, the heavy rainfall and high relative humidity particularly in the forest-savanna transition zone of South Western Nigeria, favour rapid and excessive weed growth which results in high tomato yield losses ranging between 53 and 67% [7].

Attempts to reduce the yield losses caused by weeds for smallholder farmers have been focused on hoe weeding and chemical weed control [9]. 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 [7,10]. 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 [11] and other numerous problems like soil pollution and leaching of herbicide into ground and surface water. A paradigm shift from weed control to weed management is required to effectively address the problems caused by weeds for smallholder farmers. Weed management places greater attention on the reduction of

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weed emergence in a crop and minimizing weed interference with the crop through the integration of techniques, knowledge and management skills [12,13]. Farmers are becoming increasingly interested in more comprehensive weed management systems that would decrease their dependence on herbicides and frequent hoe weeding. Managing for increased competitive ability of crops with weeds is an important means of achieving that goal. Cultural weed management techniques such as adequate fertilizer application have potential to produce a healthy crop with aggressive competition against weeds and therefore reduce the burden of hoe weeding in tomato. There is need, however, to systematically integrate this weed management tactics into the production practice of smallholder farmers to tackle problems caused by weeds in a sustainable manner within the context of Integrated Weed Management [9].

Nitrogen (N) is the major nutrient added to increase crop yield [14], application of optimum N-fertilizer to the soil produces high tomato fruit yield, increases fruit size and improves fruit quality whereas, excessive application leads to luxuriant development of vegetative parts of the plant at the expense of reproductive growth [15]. It is also, not always recognised that soil N levels can affect crop-weed competitive interactions in terms of selective inhibition and promotion [16]. Application of mineral fertilizer especially N can break the dormancy of certain weed species [17] and, thus, increase weed densities and influences the competitive balance between tomato and weeds. At proper rate and time however, weeds can be controlled by reducing extra nutrients, not taken by plants. An early application of N at transplanting of crop, after initial weed control during land preparation, could result in growth and competitive advantage for tomato against later emerging weeds. Delay in weed emergence provided by pre-transplant application of herbicide could further give tomato advantage against weed, subsequently resulting in improved fruit yield. The aim of this study was therefore to elucidate the effects of N levels and weed control methods on weed growth, and growth and yield of tomato in a forest-savanna transition zone of South Western Nigeria.

Materials and methods

Two field trials were conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria (07 15′N 03 25′E) in the Forest-Savanna transition zone of South West Nigeria in 2015 and 2016 wet seasons. In both trials, the land was ploughed and disc harrowed at two-week intervals and later pulverized and leveled manually before marking into various plots. Gross and net plot sizes were (4.5 × 3.0) m^2 and (3.0 × 3.0) m^2, respectively. Surface soil (0–15 cm depth) samples were randomly taken from the experimental sites in 2015 and 2016 with the aid of soil core sampler of 10 cm length and bulked to form composite sample. Composite sample was then taken for laboratory analysis. The soil was air-dried and sieved through 2 mm mesh sieve. Analyses on physical and chemical properties of soil were carried out.

Six weeks old tomato seedlings (Var. Roma VF) were transplanted into the plots at inter and intra-row spacings of 50 cm. The treatments comprised of three nitrogen levels (0, 60 and 90 kg N/ha) which constituted the main plot treatments, while the sub-plot treatments were made up of seven weed control methods (probaben® [metolachlor 20% w/v + prometryn 20% w/v] at 2 kg a.i/ha; probaben® at 2 kg a.i/ha followed by (fb) supplementary hoe weeding (SHW) at 6 weeks after transplanting [WAT]; butachlor [50% w/v] at 2.0 kg a.i/ha; butachlor at 2.0 kg a.i/ha fb SHW at 6 WAT; 2 hoe weedings at 3 and 6 WAT; 3 hoe weedings at 3, 6 and 9 WAT; and weedy check). Probaben® was produced by Jiangsu Fag Chemical Industry co. Ltd Changfenghe road, Nanjiang.

All treatments in different combinations were arranged in a split-plot design with three replications. N fertilizer treatments were applied as urea in two splits at transplanting of tomato and 3 WAT. All herbicides treatments were applied pre-transplant, one day before transplanting with knapsack sprayer (CP 15, Hozelock-Exel, Cedex, France) in a spraying volume of about 250 l/ha using a deflector nozzle at a pressure of 2.1 kg/cm^2. Weed cover score, weed density, weed dry weight, crop vigour score, plant height, number of leaves and branches per plant, number of fruits per plot, fruit length, fruit diameter and fruit yield per hectares were used to evaluate the performance of various treatments. A periodic observation of various growth parameters were taken from five tagged plants at net plot at various stages of crop growth and were subjected to analysis of variance (ANOVA) using GENSTAT (VSN International Ltd, Hempstead, UK) discovery package to determine the level of significance (F value) of the treatments. Treatment means were separated using the least significant difference (LSD at $P \leq 0.05$) where F value was significant.

Table 1
Physicochemical properties of the soil of experimental sites at Abeokuta in 2015 and 2016.

Soil properties	2015	2016
pH	6.7	7.9
Sand (%)	88.0	84.0
Clay (%)	5.4	8.8
Silt (%)	6.6	6.8
Organic carbon	1.2	3.8
Total N (g/kg)	0.1	0.2
Available P	11.5	9.9
Total K	0.49	0.48
Ca (g/kg)	89.0	20.4
Mg (g/kg)	10.8	5.0
Na (g/kg)	6.1	3.5
K (g/kg)	2.1	1.4

Results and discussion

The soil of the experimental sites in 2015 and 2016 were deep freely drained sandy loam with 84–88% sand, 6.6–6.8% silt and 5.4–8.8% clay. Soil pH in 2015 was near neutral (6.7) whereas that of 2016 was slightly alkaline with pH of 7.9. The soils in the experimental site in both years were low in organic carbon and percentage N (Table 1), justifying the need for additional fertilizer input to boost crop yield. There was higher total amount of rainfall during the period of crop growth in 2016 (584.1 mm) than in 2015 (521.9 mm) (Table 2).

The experimental sites were infested with different categories of weeds which included broad leaves, grasses and sedges. Common weed species and their level of occurrence at the experimental sites are presented in Table 3. The higher weed infestation observed in 2016 than in 2015 could be attributed to the higher rainfall in the former than in the later. Higher rainfall usually favours weed species abundance, prevalence, spread and competitiveness within weed and crop communities. This result is in agreement with a report by Ref. [18] who observed that weeds re-emerged more quickly and grew more vigorously because of high humidity, light intensity and rainfall.

Table 2
Rainfall, temperature and relative humidity during the experimental period in 2015 and 2016 at Abeokuta, Nigeria.
Source: Department of Agro Meteorology and Water Resources Management, Federal University of Agriculture, Abeokuta, Nigeria.

Month	Total Rainfall (mm)		Relative Humidity (%)		Temperature (^{0}C)	
	2015	2016	2015	2016	2015	2016
June	53.7	164.9	71.0	70.8	27.2	26.8
July	202.6	65.6	76.2	73.0	25.6	27.2
August	35.2	29.4	71.7	70.3	24.3	26.2
September	136.0	165.1	69.7	71.9	25.6	26.3
October	94.4	159.1	67.2	69.2	27.0	26.3
Total	521.9	584.1				

Table 3
Relative abundance of common weed species found on the experimental sites in 2015 and 2016.

	Weed species	2015	2016
Broad leaved	*Chochorus olitorus (L.)*	**	**
	Euphobia heterophylla (Linn.)	* **	**
	Gomphrena celozoides (mart.)	**	***
	Hyptis sauveolens (Poit)	* **	***
	Spigelia anthelmia (Linn.)	* *	**
	Talinum triangulare (Jacq.) Wild.	**	**
	Tridax procumbens (Linn.)	* **	**
	Amaranthus spinosus (L)	***	***
	Amaranthus viridis (L)	**	**
	Boerhavia diffusa (L)	**	**
	Tithonia diversifolia (Hemsl.)A. Gray	* *	*
	Laportea aestuans	* *	*
	Senna hirsute (Linn) Irwin	* *	*
	Chromolaena odorata (L)	* *	*
Grasses	*Andopogon gayanus* (Kunth var.)	* **	**
	Commelina bengalensis (L.)	* *	*
	Cynodon dactylion (Linn.)	**	**
	Imperata cylindrica (Linn.)	**	-
	Panicum maximum (Jacq.)	* *	*
	Rottbeollia cohinchinesis	* *	*
	Digitaria horizontalis (willd)	* *	*
	Brancharia lata Hubb (Schum)	* *	*
Sedges	*Cyperus rotundus* (Linn)	**	**
	Kylinga squaminata (Thonn)	* **	*
	Mariscus alternifolius (Vahl)	*	*

***High infestation (60–90%).
*Low infestation (1–39%).
**Moderate infestation (40–60%).
-Not noticeable.

Effect of nitrogen level and weed control methods on weed growth in tomato in 2015 and 2016

N level had significant effect on weed cover score and weed density throughout the period of observation in 2015 and 2016 (Table 4). In both years, there was significant increase in weed cover score (4.24–7.64) and weed density (24–37 weeds/m^2) with increase in N level from 0 to 60 and 60–90 kg/ha. This could be attributed to the positive impact of N fertilizer on weed germination, establishment and abundance. Previous studies [16,19,20] similarly documented that higher level of N influenced the response of weed species and significantly increased weed density. On the other hand however, in this study, increase in weed density obtained with increased N level did not result in any significant gain in cumulative weed dry matter production probably because the higher N level increased tomato crop competitiveness for available resources thus, it enhanced better dry matter accumulation at the detriment of competing weed species. [21] also reported a similar result on crop-weed interaction in okra.

All weed control methods significantly reduced weed growth throughout the period of observation (Table 4). At 3 and 6 WAT in both years, pre-transplant application of probaben® and butachlor each at 2.0 kg a.i/ha applied alone or supplemented with hoe weeding at 6 WAT had similar weed cover score with those of hoe weeded plots. At 9 WAT, pre-transplant application of probaben® and butachlor at 2.0 kg a.i/ha each followed by supplementary hoe weeding at 6 WAT caused significant reduction in weed cover score, weed density and cumulative weed dry matter production similar to three hoe weedings than each herbicide applied alone. This implies that pre-transplant herbicides require supplementary hoe weeding to provide season long weed control in tomato. In agreement to this result [22,23] reported that most pre-transplant herbicide treatments gave early weed control of emerging weed seedlings but lost efficacy early thereby allowing late emerging weeds to re-infest plots. Among the weed control methods, pre-transplant application of butachlor at 2.0 kg a.i/ha followed by supplementary hoe weeding provided the greatest reduction in weed density (59.3–59.5%) and cumulative weed dry matter production (62–69%) in both years. The reduction in weed density and weed dry matter may be as a result of high inhibition of weed root and shoot growth provided by the herbicides, coupled with complementary weeding provided by hoeing at 6 WAT. Similar effects were earlier reported by Refs. [24] and [25] who both observed that pre-transplant application of butachlor at 1.0 kg a.i/ha followed by one hand weeding at 45 DAS significantly reduced weed dry weight compared to other weed control treatment in pepper. Furthermore, the mode of action of butachlor clearly indicates that these herbicides are mainly absorbed by germinating shoots, thus inhibiting the germinating seedlings [26].

Effect of nitrogen level and weed control methods on growth and yield of tomato in 2015 and 2016

The growth and yield response of tomato to N application largely followed similar trend in 2015 and 2016 (Tables 5 and 6). N level had significant effect on crop vigour score at 6 and 9 WAT in both years,

Table 4
Effect of Nitrogen level and weed control method on weed cover score, weed density, and weed dry weight in 2015 and 2016 wet season.

Nitrogen level (kg/ha)	Weed cover score						Weed density no/m^2		Cumulative weed dry matter (kg/ha)	
	3 WAT		6 WAT		9 WAT		9 WAT		9 WAT	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
0	4.24	5.48	4.29	5.7	6.05	5.8	24.2	33.2	2160	2748
60	5.57	6.71	5.62	6.8	6.81	6.2	26.0	35.0	2180	3088
90	6.30	7.64	7.00	7.1	7.14	7.3	30.7	36.5	2220	3004
LSD (5%)	0.6	0.7	0.5	0.4	0.2	0.2	0.3	0.4	ns	ns
Weed management										
Probaben® at 2.0 kg a.i/ha	5.89	4.50	4.56	5.2	7.33	5.9	34.3	37.2	2480	2960
Probaben® at 2.0 kg a.i/ha fb SHW at 6 WAT	5.89	4.33	5.44	5.6	5.22	4.2	24.0	31.9	2360	2480
Butachlor at 2.0 kg a.i/ha	4.56	7.22	4.33	5.3	6.11	5.8	28.3	36.9	2400	2788
Butachlor at 2.0 kg a.i/ha fb SHW at 6 WAT	4.67	7.28	4.11	5.0	5.89	5.0	18.7	28.5	1820	2244
2 hoe-weedings at 3 and 6 WAT	4.67	7.78	4.67	4.7	6.33	4.6	26.4	30.4	2200	2248
3 hoe-weedings at 3, 6 and 9 WAT	4.78	7.56	4.89	5.1	5.89	4.7	20.6	30.4	2000	2508
Weedy check	6.44	7.61	8.11	7.6	8.89	8.1	50.2	70.2	2900	3948
LSD (5%)	ns	0.3	0.7	1.4	0.4	1.4	3.4	4.4	198.0	236
Nitrogen level × Weed management	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

a. a.i. = active ingredient; LSD = least significant difference; fb = followed by; WAT = weeks after transplanting; SHW = supplementary hoe weeding, ns = not significant.
b. Weed cover score was by visual observation based on scale 1–10 where 1 represented completely weedy plot and 10 represented the most clean plot.

Table 5
Effect of nitrogen level and weed control method on growth parameters of tomato in 2015 and 2016 wet season.

Nitrogen level (kg/ha)	Crop vigour score				Plant height (cm)				Leaf/plant 9 WAT		Branch/plant 9 WAT	
	6 WAT		9 WAT		6 WAT		9 WAT					
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
0	3.14	6.3	5.8	7.6	34.4	36.5	42.8	39.9	42.8	21.9	4.2	3.3
60	4.76	7.6	7.3	7.8	34.7	38.0	46.5	44.7	45.3	27.5	4.8	3.9
90	5.52	7.9	7.3	8.1	37.8	41.0	48.6	47.0	46.5	29.6	6.1	4.1
LSD (5%)	0.5	0.2	0.3	0.1	ns	ns	1.3	1.8	1.1	3.0	0.3	0.3
Weed management												
Probaben® at 2.0 kg a.i/ha	4.56	6.2	7.1	7.3	35.8	40.2	43.2	44.5	45.9	22.3	4.3	3.3
Probaben® at 2.0 kg a.i/ha fb SHW at 6 WAT	4.89	7.3	7.5	8.6	37.8	39.0	47.8	49.5	48.4	28.0	5.4	3.8
Butachlor at 2.0 kg a.i/ha	4.22	6.7	6.7	7.5	37.2	39.5	44.0	43.4	44.9	21.9	4.2	4.2
Butachlor at 2.0 kg a.i/ha fb SHW at 6 WAT	5.22	7.7	7.7	8.8	30.4	39.8	48.0	48.2	46.4	29.2	5.5	3.8
2 hoe-weedings at 3 and 6 WAT	3.22	6.0	6.7	7.7	35.2	39.0	48.8	47.0	46.7	31.6	4.7	3.7
3 hoe-weedings at 3, 6 and 9 WAT	3.30	6.8	6.7	7.8	37.1	38.0	48.8	49.9	45.9	29.3	4.0	4.0
Weedy check	2.22	5.1	4.3	0.4	35.8	32.1	35.4	37.3	38.9	19.0	2.3	3.3
LSD (5%)	0.2	0.4	0.3	0.4	ns	ns	2.1	3.2	2.4	3.0	1.2	ns
Nitrogen × weed management	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

a. a.i. = active ingredient; LSD = least significant difference; fb = followed by; WAT = weeks after transplanting; SHW = supplementary hoe weeding, ns = not significant.

b. Crop vigour score was by visual observation based on scale 1–10 where 1 represented completely dead tomato and 10 represented the very healthy tomato.

plant height and number of leaves and branches per plant at 9 WAT in both years, number of fruits per plant, fruit length and fruit yield per hectare in both years (Tables 5 and 6). Overall, 60 and 90 kg N/ha produced significantly better crop growth and yield than those without N application. This suggests that N fertilizer application was needed to enhance crop growth and to sustain good yield of tomato. A similar suggestion was earlier reported by Ref. [21] who found that plant height, branches, leaf production and fruit yields of tomato increased significantly as the rate of N fertilizer applied increased from 0 to 60 kg/ha. [27] also reported that yield of tomato was significantly improved by N. In this study, application of 60 and 90 kg N/ha resulted in comparable tomato crop vigour score at 9 WAT in 2015. However, at 6 WAT in both years and 9 WAT in 2016, application of 90 kg N/ha resulted in significant increase in crop vigour score than 0 and 60 kg N/ha application. In both years, there was significant increase in plant height and number of leaves and branches at 9 WAT, number of fruit per plot, and fruit length and fruit yield of tomato per hectare with increase in N level from 0 to 60 and 60–90 kg N/ha. For example, application of N at 90 kg/ha resulted in 57–65 and 28–40% increase in tomato fruit yield compared to 0 and 60 kg/ha N/ha respectively. Application of 60 kg N/ha resulted in 40–42% increase in tomato fruit yield compared to 0 kg N/ha in both years. The results obtained from this study have confirmed the critical role N plays in the nutrition of tomato. Increased fruit yields of tomato at higher N level in this study were likely due to the role of N, an important component of chlorophyll in enhancing photosynthesis and increasing production of assimilates. These results are in harmony with that of [21] who reported 37 and 32% increase in tomato fruit yield with 60 and 30 kg N/ha respectively. Similarly [28], and [29] reported the highest tomato fruit yield at 90 kg N/ha in a study conducted on a savannah soil of Samaru, in Northern Nigeria.

All weed control methods produced significantly higher crop growth compared to the weedy check (Tables 5 and 6). At 6 and 9 WAT in both years, pre-transplant application of probaben® and butachlor each at 2.0 kg a.i/ha followed by supplementary hoe weeding at 6 WAT resulted in significantly higher crop vigour score than hoe weeded plots or each herbicide applied alone. At 9 WAT in both years, pre-transplant application of probaben® and butachlor each at 2.0 kg a.i/ha followed by supplementary hoe weeding at 6 WAT caused significant increase in plant height and number of leaves and branches of tomato similar to two and three hoe weedings but significantly higher than each herbicide applied alone.

Table 6
Effect of nitrogen level and weed control method on yield parameters of tomato in 2015 and 2016 wet season.

Nitrogen level (kg/ha)	No of fruits/ plant		Fruit weight (t/ha)		Fruit length (cm)		Fruit diameter (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016
0	7.5	7.0	5.4	4.0	2.79	7.2	2.4	1.4
60	19.8	15.3	9.0	6.8	3.85	6.1	2.8	1.3
90	26.9	20.2	12.6	11.4	4.09	5.6	2.9	1.4
LSD (5%)	4.5	3.9	2.9	1.7	0.2	0.5	ns	ns
Weed Management								
Probaben® at 2.0 kg a.i/ha	11.4	8.7	7.8	6.5	3.54	6.0	2.4	1.4
Probaben® at 2.0 kg a.i/ha fb SHW at 6 WAT	25.4	19.3	12.0	10.1	3.51	6.0	2.4	1.5
Butachlor at 2.0 kg a.i/ha	16.7	12	7.8	6.2	3.94	5.8	3.1	1.2
Butachlor at 2.0 kg a.i/ha fb SHW at 6 WAT	27.5	21.5	13.2	11.2	3.63	6.6	3.0′	1.4
2 hoe-weedings at 3 and 6 WAT	11.3	11.4	7.8	7.2	3.22	6.2	2.6	1.3
3 hoe-weedings at 3, 6 and 9 WAT	27.4	20.4	9.0	7.9	3.80	6.6	3.0	1.6
Weedy check	6.5	5.5	5.4	2.7	3.38	6.5	2.4	1.1
LSD (5%)	5.9	5.4	4.3	3.4	ns	ns	ns	ns
Nitrogen level x weed management	ns	ns	ns	ns	ns	ns	ns	ns

a.i. = active ingredient; LSD = least significant difference; fb = followed by; WAT = weeks after transplanting; SHW = supplementary hoe weeding, ns = not significant.

Furthermore, herbicide treatments supplemented with hoe weeding at 6 WAT and three hoe weedings resulted in comparable number of fruit per plot and fruit yield per hectare, significantly higher than those obtained with two hoe weedings or each herbicide applied alone. However, in both years, weed control methods had no significant effect on fruit length and diameter. Maximum fruit yield of 13.2 and 11.2 t/ha were obtained with pre-transplant application of butachlor at 2.0 kg a.i/ha followed by supplementary hoe weeding at 6 WAT in 2015 and 2016, respectively. Better growth and yield obtained with application of butachlor and probaben® each at 2.0 kg a.i/ha supplemented by hoe weeding at 6 WAT in both years can be attributed to the initial weed control of provided by each herbicide, as well as control of subsequent emerged weeds by supplementary hoe weeding, thereby ensuring weed control throughout the critical period of tomato growth. The effectiveness of these herbicides in both years is an indication that, they can be used as weed control alternative to two or three hoe weedings, particularly where labour is limiting and land under cultivation is large. This agrees with the findings of [30] that pre-transplant application of pendimethalin at 2.0 kg a.i/ha followed by hoe weeding at 6 WAT gave excellent weed control in tomato in Ghana [30,31] also reported that pre-transplant herbicides such as metolachlor and metolachlor + terbutryn supplemented with hoe weeding increased growth and fruit yield of tomato. This clearly underscores the importance of integrated weed management in enhancing better weed control compared with the use of a single weed control tool. Higher tomato yield obtained in 2015 (13.2 t/ha) than in 2016 (11.2 t/ha) in this study however, can be attributed to the higher weed infestation occasioned by higher total amount of rainfall in the later than in the former. Cumulative weed dry matter production of about 2.9 t/ha and 3.9 t/ha were obtained from the unweeded plots in 2015 and 2016 respectively (Table 4). Unchecked weed growth resulted in 59 and 76% reduction in tomato fruit yield compared to the maximum obtained in 2015 and 2016, respectively.

Conclusion

It can be concluded that for soils in the forest-savanna transition zone with poor N content, 90 kg N/ha and pre-transplant application of butachlor or probaben® each at 2.0 kg a.i/ha followed by supplementary hoe weeding at 6 WAT will significantly improve growth and yield of tomato. The results of this study also suggest that farmers can reduce the burden of hoe weeding and cut down on labour input with the use of pre-transplant herbicides for weed control in tomato production. This study has demonstrated that a relationship exists between growth of weed species and N fertilizer in tomato. Increase in N application could increase weed density, however, the increased N gave tomato competitive advantage and thus enhanced smothering of the weed particularly at the early stage of crop.

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