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Effects of Varying Tillage Passes and 15-15-15 NPK Fertilizer on Some Agronomic Parameters, Nitrogen, Phosphorous and Potassium Uptake by *Amaranthus viridis* in Derived Savannah of Southwest Nigeria

Babatunde KM[1*], **Adekanmbi OA**[1], **Adeyolanu AS**[2] **and Salau MA**[1]

[1]*Department of Agricultural Technology, The Oke-ogun Polytechnic, Saki, Oyo State, Nigeria*

[2]*Department of Agricultural Engineering, The Oke-ogun Polytechnic, Saki, Oyo State, Nigeria*

***Corresponding author:** Babatunde KM, Department of Agricultural Technology, The Oke-ogun Polytechnic, Saki, Oyo State, Nigeria, Tel: 08051279769; E-mail: mbabatundekayode@gmail.com

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Abstract

Experiment was conducted to obtain information on seperate and interaction effects of tillage passes and 15-15-15 NPK fertilizer application rates on some growth parameters, N, P and K uptake by *Amaranthus viridis*, hence the use of a tractor implement with specified specification on sandy clay soil planted with *Amaranthus viridis*. The research was conducted at vegetable research plot, Department of Agricultural Technology, The Oke-Ogun Polytechnic, Saki, between 2nd July and 30th September, 2015. Soil treatments consisting of three levels of tillage passes (0, 3 and 6) equivalent to 1.7, 1.3 and 1.5 g/cm^3 soil bulk density respectively, four levels of 15-15-15 NPK fertilizer rates (0, 100, 150 and 200 kg/ha) and replicated three times in a completely randomized design. The results showed that no-tillage pass had significant effect on bulk density, zero tillage reduced the percent uptake of N (0.58-0.46), P (0.002-0.0005) and K (0.13-0.04), however, statistically, the reduced effects were more pronounced on Nitrogen and Potassium. Fertilizer rates significantly improved percent uptake of N (0.11-0.58), P (0.0004-0.005) and K (0.04-0.07). Interactions (tillage passes × fertilizer rates) effects were observed on plant height, stem girth, fresh weight, root length and percent N, P and K uptake, but T2F2 (6 passes × 150 kg/ha) significantly increased plant height and improved uptake of Phosphorous, therefore, 6 passes and 150 kg/ha 15-15-15 could be more suitable for optimum production for *Amaranthus viridis* on a sandy clay soil.

Keywords: Bulk density; Traffic intensity; Vegetable production; Compaction; Mass flow

Introduction

Amaranthus viridis (Vernacular names: Green amaranth, local tete 'Tete abalaye', African spinach (En), Amarante verte, épinard vert, épinard du Congo (Fr), Amaranto (Po), Mchicha (Sw) is an annual herb which grows from 6 to 100 cm high. It propagates by seed and flowers all year in subtropical and tropical climates. The plant flowered with sowing in any month [1]. High soil moisture (85%) delays seed germination. There was no change in the germination of seeds which were buried 2.5 cm below the surface and deeper for up to a year, indicating a survival technique used by this species [2]. *Amaranthus viridis* is grown and utilized in many areas of the world as both a wild and cultivated pot herb [3]. The plant is rich in calcium and iron and is a good source of vitamins B and C [4]. A decoction of the entire plant is used to stop dysentery and inflammation [5]. The plant is antidiabetic, antihyperlipidemic and antioxidant [6]. The plant has antiproliferative and antifungal lectin [7]. The plant is emollient and vermifuge [5,8]. The root juice is used to treat inflammation during urination and constipation [9]. The seeds can survive in the digestive tract of chickens [10]. It is good cattle fodder, and is used medicinally and for making soap [11], but is poisonous to pigs [12]. Of all vegetables; *Talinum triangulare*, *Telfaria occidentalis*, *Corchorus olitorius*, *Vernonia amygdalina*, and *Amaranthus* species such as *A. hybridus*, *A. cruentus*, *A. caudatus*, and *A. deflexus* are mostly consumed. The genus; *Amaranthus* belongs to a relatively large family of dicotyledonous flowering plants family; *Amaranthaceae* which has about 65 genera and 900 species [13]. Within the genus *Amaranthus*, approximately 70 species have been recognized, of which *Amaranthus viridis* is one of the least studied. The production and nutritional values of these vegetables are limited due to the low fertility of native soils in most parts of Nigeria [14].

Soil high bulk density is a common problem in vegetable production systems, because farm operations often must be conducted within narrow time windows that do not allow for adequate soil drying before entering the field. Tillage has been used for crop production, however, excessive tillage destroys soil structure, breaks up the soil pores, and reduces the amount of residue on the soil surface [15-17]. Tillage management influences soil quality and plant growth as a result of altering physical, chemical and biological properties [15,18-20]. Tillage operations generally loosen the soil, decrease soil bulk density and penetration resistance by increasing soil macro porosity [21-23]. Conversely, frequent tillage operations can increase soil compaction and bulk density due to the greater traffic intensity [15,24].

A plant receives its nutrients at its roots by a combination of root interception, mass flow, and diffusion. The process of diffusion supplies most of the phosphorous and potassium to the root. Nitrogen, on the other hand, is supplied by mass flow. Soil high bulk density reduces mass flow through large pores, which could reduce nitrate flow to the plant roots. Phosphate and potassium availability could be affected by the reduction in root extension caused by high bulk density, which results in a smaller soil volume explored by roots. Decreases in the concentration of nutrients in a crop due to reductions of the rooting zone because of compaction were reported by several authors [25,26]. However, the uptake of phosphorous and potassium, expressed as units per root length unit, increased in corn, wheat, cotton, and groundnut roots with increasing resistance [27]. In artificial soil conditions, consisting of a bed of glass beads, the effect of compaction on nutrient uptake was studied [28]. As pressure on the glass beads was applied, the concentration of nitrogen and calcium in the roots and shoots decreased. The largest effect was on calcium uptake. Compacted conditions had little effect on the uptake of potassium and sulphur. Lower nutrient uptake on compacted soil may be compensated by higher absorption by roots outside the compacted area in favourable conditions and thus total nutrients need not be decreased. It also has been suggested that the shorter, wider root cells resulting from compaction induced root growth would have greater adsorptive surface area and this would help in overcoming nutrient stress when roots are grown in compacted conditions [29]. The influence of high bulk density on ion uptake depends on the nutritional level of the soil. In soils of low fertility, a slight reduction in root elongation can reduce uptake of immobile nutrients [30]. In a study by Veen and Boone [31], with a high phosphate supply in sandy loam, the uptake of N, P, and K per unit of root length of maize was independent of mechanical resistance, suggesting that the rate of ion uptake is related to root length. Other papers suggest that soil compaction increases the movement of ions towards the root by diffusion [32,33], but decrease the amounts of nutrients mineralized from soil organic matter. This reaction depends on the kind of elements and the way in which they are absorbed.

The objective of this study was to determine the seperate and interaction effects of varying tillage passes and different levels of 15-15-15 NPK fertilizer application rate on some growth parameters, N, P and K uptake by *Amaranthus viridis.*

Materials and Methods

Site

The study was carried out at the Vegetable Research Farm, The Oke-Ogun Polytechnic, Saki; located within latitude 8.33°N and longitude 3.40°E in the derived savannah zone, South western Nigeria, with 1.6 liters of rainfall, average humidity, temperature and soil moisture of 76%, 27°C and 11.3% respectively between 2nd July and 30th September, 2015 (The Oke-Ogun Polytechnic WatchDogweather station). The experiment was sited within 0.5 hectare Agricultural field that has been cleared manually and mechanically tilled and cropped with different indigenous vegetables sponsored by NI-CAN VEG (Nigeria-Canada Vegetable) Research project in the previous year; 2014.

Treatment

Treatment was a 3 × 4 factorial experiment of tillage types (0, 3 and 6 passes as T0, T1 and T2 respectively) and inorganic 15-15-15 NPK fertilizer application levels (0, 100, 150, 200 kg/ha as F0, F1, F2 and F3 respectively), arranged in a split-plot design in completely randomized block designed (CRBD), replicated three times, the entire experimental plots was thirty-six (36). The tillage types represented the main plot and the inorganic fertilizer application levels as the sub-plot. The main plot (2 m × 3.4 m) was sub divided into three sub-plots (2 m × 0.8 m) with 0.5 m distance within the subplot and 10 m apart as head-land between the main plots to allow for the turning of the tractor and its implement. The tillage methods were, manual clearing (0-pass), and mechanized tillage involving the tractor with its plough passing on the same plot three times (3-passes) and another plot six times (6-passes) at the depth of 15 cm. These tillage passes were accomplished using a 65 hp, 2.4 tons tractor (Table 3). Manual clearing (0-pass) treatment consisted of a seedbed which was manually cleared of the existing vegetation using cutlass and hoe. The tillage treatments were amended with 15-15-15 NPK fertilizer application levels according to the design. Seeds of *Amaranthus viridis* which was supplied by NI-CAN VEG Research project was sown at 25.78 kg/ha [34] in three drills. The fertilizer treatments were applied in two split doses, the first application was side dressed immediately after seeding and the second dose was applied three weeks after planting. The plots were immediately watered after each fertilizer application as there was no rainfall at the time of planting.

Soil and plant analysis

Three core samples were taken randomly at selected locations for each subplot at depth of 15 cm for routine physical and chemical analysis. The soil samples were air dried, crushed and sieved to pass through 2 mm sieve, and analyzed. The particle size distribution was carried out using the hydrometer method described by Bouyoucos [35] as presented by Gee and Or [36] using 0.2 M sodium hydroxide as dispersing agent. Undisturbed soil cores were collected by driving with a rubber hammer 5 cm diameter metal cylinder into the soil to the depth specified for each trial. Bulk densities were calculated based on the volumes, calculated from the length and diameter of the section and dry weights of the soil samples [37]. The pH was determined using a glass electrode pH meter, that is; Soil-water suspension (1:1); organic carbon was determined by the chromic acid digestion method [38]. The total Nitrogen concentration was determined by macro-Kjeldahl method [39], and the available P was extracted by Bray-1 method [40] and determined using spectrometer. Exchangeable K, Ca, Na, and Mg were extracted with neutral (pH=7) solution of 1N NH_4OAc, K, Ca and Na were determined using the flame photometer and Mg by the atomic absorption spectrophotometer.

Growth parameters of *Amaranthus viridis* were measured from the subplots; plant height (cm), stem girth (cm) and leaf area (cm^2), weekly, fourth week after planting up to the sixth week and fresh weight (g/plot) and root length (cm) were determined at the end of the experiment (6 weeks). The plant material were wet digested by weighing 0.2 g of each materials into a separate 50 ml digesting tube and adding 30 ml of hydrogen peroxide under fume sulphuric acid and 20 ml of hydrogen peroxide under fume cupboard.

The bottles were set up on heating mantle, digests were cooled and each transferred to separate 100 ml volumetric flask and made up to mark distilled water and then nitrogen was determined using a Technicon-Auto-Analyzer. The plant materials (0.2 g) were weighed into labeled crucibles, ashes into 100 ml conical flasks and analyzed for phosphorus using Vanado-Molybdate method calorimetrically; potassium by flame photometer.

Statistical analysis

Data collected from the field and laboratory were subjected to mean separation as necessary and t-test of SPSS 17.0 Statistical package to determine the separate and interaction effects of the main plot and subplot treatments on the growth parameters, N, P and K uptake by *Amaranthus viridis.*

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Results and Discussion

The properties of the soil used for the experiment (Table 1) indicated a sandy clay (sand 69%, silt 6% and clay 25%) and pH of 6.0. The acidity nature of the soil could be as a result of high rainfall in the area which made the soil fragile and susceptible to erosion and leaching [41].

Properties	Values
Particle size distribution	
(a) Sand (%)	69
(b) Silt (%)	6
(c) Clay (%)	25
Chemical	
(a) Soil pH - (1:1 water)	6.0
(b) Soil organic matter (%)	1.5
(c) Organic carbon (%)	0.9
(d) Nitrogen (%)	0.2
(e) Phosphorous (ppm)	0.3
(f) Exchangeable cations (Cmol(+)/kg)	
(i) Na^+	0.3
(ii) K^+	0.2
(iii) Ca^{2+}	0.9
(iv) Mg^{2+}	0.6
(g) Exchangeable acidity (Cmol(+)/kg)	
(i) H^+	0.11
(ii) Al^{3+}	0.3
(h) CEC	2.1

Table 1: Properties of the soil (0-15 cm depth) used for the experiment.

The effect of tillage passes (0, 3 and 6) were determined on bulk density (Table 2), the no-tilled bulk density was the highest (1.7 g/cm^3) while the 3 passes (1.3 g/cm^3) reduce the bulk density and the bulk density increased at 6 passes (1.5 g/cm^3), the tractor and the implements specifications used for this study (Table 3) was not a heavier type according to Erbach [42]. Result presented here was also consistent with those obtained by Barzegar et al. [43] who studied the influence of different tillage systems on bulk density.

Means separation indicated a significant (α=0.05) effect of no tillage when compared with other tillage passes. Osunbitan et al. [17] similarly observed significantly higher bulk density under no tillage cultivation when compared to conventional tillage treatment. This finding was also in agreement with what was reported by Hammad and Davelbeit [44], and Olaoye [45].

Tillage passes	R1	R2	R3	AV BD
0	1.7	1.7	1.7	1.7a
3	1.3	1.3	1.3	1.3b
6	1.5	1.5	1.5	1.5b

*Average of twelve observations per replicate. Means in the same column with the same letter are not significantly (α=0.05) different according to least significant difference (LSD).

Table 2: *Effects of tillage passes on soil bulk density (n=36).

Item	Specification
(a) Disc plough	-
(i) Number (ii) Dimension	3 2.2 m
(b) Tractor source of power	Diesel
(c) Weight of tractor	2.4 tons
(d) Number of cylinder	4
(e) Model of tractor	Mahindra 605 D1
(f) Horse power	65

Table 3: Tractor and implement specification.

Three passes tillage treatment, provided the best bulk density (1.3 g/cm^3) condition for all nutrient elements for nutrient uptake by *A. viridis* (Table 4) as it indicated the highest uptake at this bulk density (1.3 g/cm^3) followed by 1.5 g/cm^3 bulk density and the lowest nutrient uptake was at the highest bulk density of 1.7 g/cm3 corresponded with 0-pass or the control treatment (Table 4), Nitrogen (0.46% to 0.55%), Phosphorous (0.002% to 0.004%) and Potassium (0.04% to 0.06%) uptake were increased due to lowered bulk density from 1.7 g/cm^3 (0 pass) to 1.5 g/cm^3 (6-passes), and was supported by the statistical analysis, which showed that tillage passes had effects on all nutrient elements, but greatest effects was on potassium uptake than other elements (Table 5), 0 /1.7 g/cm^3 passes/bulk density significantly ($p \leq 0.001$) reduced the uptake of potassium (t=-89.0), but at 3 passes/ 1.3 g/cm^3, there was significant ($p \leq 0.005$) increased in Nitrogen (t=14.0) and Potassium ($p \leq 0.05$, t=5.0) uptake, but no significant increased uptake was observed for Phosphorous, similar result was reported on maize and wheat [46]. Parish, also in his study, observed that high bulk density hindered the diffusion and mass flow of Phosphorous, Potassium and Nitrogen respectively [47].

Tillage passes/ bulk density (g/cm^3)	Percentage of N	Percentage of P	Percentage of K
0/1.7	0.46	0.002	0.04
3/1.3	0.58	0.005	0.13
6/1.5	0.55	0.004	0.06

Table 4: Effects of tillage passes/ bulk density on N, P, K uptake by *Amaranthus viridi.*

Tillage passes/bulk density (g/cm^3)	Percentage of N		Percentage of P		Percentage of K	
	t	Sig (2-tailed)	t	Sig (2-tailed)	t	Sig (2-tailed)
0/1.7	-20.0**	0.002	-7.0*	0.038	-89.0***	0.0001
3/1.3	14.0**	0.005	1.0	0.423	5.0*	0.036
*Significant at p ≤ 0.05, **Significant at p ≤ 0.005, ***Significant at p ≤ 0.001						

Table 5: t-Test of effects of tillage passes/bulk density on N, P, K uptake by *Amaranthus viridis.*

The increased in fertilizer rates also increased the uptake nutritional elements as expected (Table 6), both Nitrogen and Phosphorous exhibited increased uptake as the fertilizer application rate increased from 0 to 200 kg/ha, except Potassium that had the same percent uptake at 100 and 150 kg/ha application rates, however, all nutrient elements percent uptake were increased with increased in application rates; percent Nitrogen (0.11-0.58), Phosphorous (0.0004-0.005) and Potassium (0.04-0.07), t-test analysis (Table 7), confirmed that 0 kg/ha had significant ($p \leq 0.005$) reduced effects on percent N and K (t=-50.2 and -41.6 respectively) and P ($p \leq 0.001$; t=-77.0) uptake when compared with 150 and 200 kg/ha application levels, 0 kg/ha had the most negative effects on uptake on nutrient elements especially Phosphorous (t=-77.0), thus Nitrogen, Phosphorous and Potassium uptake were significantly ($p \leq 0.005$) reduced.

Fertilizer Levels (kg/ha)	Percentage of N	Percentage of P	Percentage of K
0	0.11	0.0004	0.04
100	0.35	0.003	0.06
150	0.55	0.004	0.06
200	0.58	0.005	0.07

Table 6: Effects of fertilizer levels on N, P, K uptake by *Amaranthus viridis.*

Fertilizer Levels (kg/ha)	Percentage of N		Percentage of P		Percentage of K	
	t	sig (2-tailed)	t	sig (2-tailed)	t	sig (2-tailed)
0	-50.2	0.0001***	-77.0	0.0001***	-41.6**	0.001
100	-16.0	0.004**	-2.0	0.184	-1.0	0.423
150	46.0	0.0001***	13.9	0.005**	-4.0	0.057
200	31.2	0.001**	47.0	0001***	15.6**	0.004
*Significant at p ≤ 0.05, **Significant at p ≤ 0.005, ***Significant at p ≤ 0.001						

Table 7: t-Test of effects of fertilizer levels on N, P, K uptake by *Amaranthus viridis.*

Fertilizer amendment, conversely both 150 and 200 kg/ha fertilizer rates increased significantly ($p \leq 0.005$) the uptake of Nitrogen (t=46.0 and 31.2) and Phosphorous (t=13.9 and 47.0), statistically ($p \leq 0.001$), 150 kg/ha was better than 200 kg/ha application rate for Nitrogen (t=46.0) uptake and 200 kg/ha was better for Phosphorous (t=47.0) uptake, while 150 kg/ha had no significant ($p \leq 0.05$) effect in reduced potassium uptake, however, 200 kg/ha fertilizer rates significantly ($p \leq 0.005$) increased potassium (t=15.6) uptake; these differential uptake could be due to the increased in the fertilizer rates as similarly reported by Bymes et al. that the effect of high bulk density on nutrient uptake depends on the nutritional level of the soil [30].

Table 8 indicated that the highest percent Nitrogen (0.08-0.79) and Potassium (0.029-0.15) uptake were all achieved at T2F2 (6 passes × 150 kg/ha fertilizer), while highest percent of Phosphorous (0.0002-0.014) was at T2F3 (6 passes × 200 kg/ha fertilizer) which might be due to the increased of levels of fertilizer application rate, the interaction of tillage and 15-15-15 NPK fertilizer effects; the average uptake of nutrients (NPK) from T0F0 to T0F3 (first level of interaction), T1F0 to T1F3 (second level of interaction) and T2F0 to T2F3 (third level of interaction), were for N (0.31%, 0.68% and 0.68%), P (0.0005%, 0.007% and 0.009%) and K (0.06%, 0.08% and 0.10%), showed that the second (T1F0 to T1F3) and third (T2F0 to T2F3) level of interaction had the same effects but different from the first (T0F0 to T0F3) level of interaction for Nitrogen uptake which was confirmed by Table 9 where the t-test for all nutrient elements (NPK) were significantly ($p \leq 0.005$) reduced at the first level of interaction and Phosphorous uptake was most affected (t=-201.1) at T0F0 (0 pass × 0 kg/ha fertilizer) and this might be due to the high bulk density (1.7 g/cm^3) (Table 2), however, the second and third levels of interaction had no significant ($p \leq 0.05$) effect on Nitrogen and Potassium, but the third level of interaction at T2F2 and T2F3 had significant ($p \leq 0.05$) effects on uptake of Phosphorous. Tillage passes improved all the nutrient elements uptake as the bulk density was reduced from the zero (control treatment) to the 6 passes which had higher bulk density than the 3 passes, however, this increase was only significant ($p \leq 0.05$) on phosphorous uptake especially at T2F2 (T=8.5), Castillo et al. [48] observed similar results, while in the study of barley; Linberg and Petterson observed that high bulk density reduced concentration of Nitrogen in roots and shoots and little effect on the uptake of Potassium and Sulphur [28].

The appearance (Phenotype) of the *Amaranthus viridis* that uptake the nutrient elements had a distinct leaf venation with long petioles; longer than the blades which was ovate and rounded at the tip, the stem was erect and ascending. Green leaves, glabrous on the veins of the lower surface.

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Tillage × Fertilizer levels	Percentage of N	Percentage of P	Percentage of K
T0F0	0.08	0.0002	0.029
T0F1	0.30	0.00048	0.06
T0F2	0.40	0.00059	0.07
T0F3	0.45	0.00069	0.09
Mean	**0.31**	**0.0005**	**0.06**
T1F0	0.52	0.0041	0.004
T1F1	0.63	0.007	0.075
T1F2	0.74	0.009	0.095
T1F3	0.82	0.008	0.11
Mean	**0.68**	**0.007**	**0.08**
T2F0	0.50	0.005	0.045
T2F1	0.66	0.0075	0.085
T2F2	0.79	0.010	0.15
T2F3	0.77	0.014	0.12
Mean	**0.68**	**0.009**	**0.10**

Table 8: *Effects of interaction of tillage passes and levels of 15-15-15 NPK fertilizer on % N, P, K uptake by *Amaranthus viridis*.

Tillage × Fertilizer	Percentage of N		Percentage of P		Percentage of K	
	t	sig (2-tailed)	t	sig (2-tailed)	t	sig (2-tailed)
T0F0	-49.0***	0.0001	-201.1***	0.0001	-61.0***	0.0001
T0F1	-15.6**	0.004	-23.9**	0.002	-1.7	0.225
T0F2	-2.8	0.108	-16.2**	0.004	-0.8	0.529
T0F3	-2.3	0.147	-17.7**	0.003	-0.0	1.000
T1F0	-0.4	0.723	-0.6	0.636	-5.0	0.058
T1F1	1.0	0.438	1.5	0.277	-0.5	0.650
T1F2	1.6	0.249	2.0	0.182	0.2	0.851
T1F3	1.9	0.204	0.9	0.448	1.6	0.258
T2F0	-0.6	0.623	-0.3	0.819	1.3	0.051
T2F1	1.4	0.283	3.2	0.087	0.2	0.845
T2F2	2.1	0.170	8.5*	0.014	1.7	0.226
T2F3	1.8	0.218	4.5*	0.046	0.9	0.478

*Significant at $p \le 0.05$, **Significant at $p \le 0.005$, ***Significant at $p \le 0.001$

Table 9: t- Test of effects of interaction of tillage passes and levels of 15-15-15 NPK fertilizer on N, P and K uptake by *Amaranthus viridis*.

The agronomic parameters and soil bulk density (Table 10), observed that the highest plant height (cm), stem girth (cm), fresh weight (g/plot), root length (cm) were 75, 0.8, 8.8 and 4.8 at T2F2 respectively, except leaf area at T2F3, while average plant height (cm), stem girth (cm), leaf area (cm^2), fresh weight (g/plot), root length (cm) and soil density (g/cm^3) from first, second and third level of interactions were (43.3, 61.3 and 64.9), (0.4, 0.7 and 0.7), (4.3, 8.0 and 8.2), (3.1, 7.3 and 7.7), (2.7, 4.3 and 4.7) and (1.7, 1.3 and 1.5) for agronomic parameters and soil bulk density respectively, generally the average parameters increased from first to the third level of interaction except the stem girth, the second and third level of interaction produced the same results and the soil bulk density decreased from first level to second level and increased again at the third level of interaction. Significant ($p \le 0.05$) or no interaction between tillage passes and the levels of NPK application was also observed according to t-test analysis (Table 11) on plant height (cm), stem girth (cm), leaf area (cm^2), fresh weight (g/plot), root length (cm) of *Amaranthus viridis* and soil density (g/cm^3) and showed that T2F2 (t=11.6) had most positive significant ($p \le 0.05$) increased effect on the plant height and no positive significant ($p \le 0.05$) increased effects was observed on the stem girth, leaf area, fresh weight and root length. Report by Bolton et al. and Ide et al. [25,26], supported the reduced growth parameters in this study which were due to lower nutrient elements uptake as a result of high bulk density of the no tilled plot, therefore, reducing the rooting zone and root length.

Tillage × Fertilizer Levels	Plant Height (cm)	Stem Girth (cm)	Leaf Arem (cm^2)	Fresh Weight (g/plot)	Root Length (cm)	Soil Bulk (g/cm^3)
T0F0	22	0.2	3.3	2	2.6	1.7
T0F1	46.8	0.3	4.1	3	2.5	1.6
T0F2	50.6	0.5	4.8	3.5	2.7	1.6
T0F3	53.6	0.4	5.1	3.8	2.8	1.7
Mean	**43.3**	**0.4**	**4.3**	**3.1**	**2.7**	**1.7**
T1F0	38.4	0.6	7.2	5.5	4.1	1.2
T1F1	66	0.7	8.1	7.1	4.4	1.3
T1F2	70.8	0.8	8.5	8.3	4.2	1.3
T1F3	70.1	0.7	8.3	8.4	4.3	1.4
Mean	**61.3**	**0.7**	**8**	**7.3**	**4.3**	**1.3**
T2F0	40.3	0.7	7.5	6	4.5	1.5
T2F1	74	0.7	7.8	7.2	4.7	1.5
T2F2	75	0.8	8.6	8.8	4.8	1.6
T2F3	73.2	0.7	8.9	8.6	4.6	1.5
Mean	**64.9**	**0.7**	**8.2**	**7.7**	**4.7**	**1.5**

*Average of three replication

Table 10: Effects of interaction of tillage passes and levels of 15-15-15 NPK fertilizer on plant height, stem girth, number of leaves, leaf area, fresh weight of *Amaranthus viridis* and soil bulk density.

Tillage × Fertilizer	PH		SG		LA		FW		RL		BD	
	t	sig	t	sig	t	sig	t	sig	t	sig	t	sig
T0F0	-13.0*	0.01	-7.7*	0.02	-4.2*	0.05	-3.2	0.09	-7.7*	0.02	13.0*	0.01
T0F1	-1.6	0.26	-19.1***	0.001	-3.4	0.08	-5.6*	0.03	-10.8*	0.01	5.3*	0.03
T0F2	-3.0	0.10	-2.6	0.12	-2.4	0.14	-3.6	0.07	-5.6*	0.03	13.0*	0.01
T0F3	-0.4	0.75	-2.2	0.16	-2.6	0.12	-2.7	0.12	-5.7*	0.03	3.9	0.06
T1F0	-9.9*	0.01	0.4	0.74	0.4	0.74	-1.1	0.37	0.5	0.64	-8.0*	0.02
T1F1	2.5	0.13	1.8	0.21	1.4	0.30	0.9	0.47	0.9	0.46	-3.5	0.07
T1F2	2.0	0.18	3.3	8.0*	2.3	0.15	1.6	0.26	0.9	0.48	3.5	-0.07
T1F3	4.3*	0.05	1.7	0.24	1.3	0.31	2.0	0.18	1.1	0.38	-3.5	0.07
T2F0	-18.1***	0.001	1.8	0.21	0.6	0.60	0.0	1.00	1.1	0.38	-4.0	0.06
T2F1	3.6	0.07	2.3	0.15	1.2	0.36	1.2	0.37	1.7	0.24	4.0	0.06
T2F2	11.6*	0.01	3.1	0.09	2.3	0.15	1.1	0.38	2.0	0.19	2.0	0.18
T2F3	4.1*	0.05	2.0	0.18	2.4	0.14	1.5	0.27	1.8	0.21	-4.0	0.06

PH=Plant Height (cm), SG=Stem Girth (cm), LA=Leaf Area (cm^2), FW=Fresh Weight (g/plot), BD=Soil Bulk Density (g/cm^3). *Significant at $p \leq 0.05$, **Significant at $p \leq 0.005$, ***Significant at $p \leq 0.001$

Table 11: t-Test of effects of interaction of tillage passes and levels of 15-15-15 NPK fertilizer on plant height, stem girth, number of leaves, yield of *Amaranthus viridis* and soil bulk density.

Summary and Conclusion

Plants needs loosen soil for distribution of air, water and nutrients as this was evident in the study carried out, the tillage passes pulverized the soil with both 3 and 6 passes as against the no tillage pass where the soil dry bulk density was lowered compared with the no tillage pass, however both the 3 and 6 passes are statistically (α=0.05) the same but statistically (α=0.05) different from no tillage pass.

Zero tillage reduced the percent uptake of N (0.58-0.46), P (0.002-0.0005) and K (0.13-0.04), however statistically, the reduced effects were more pronounced on Nitrogen and Potassium uptake. Fertilizer rates significantly ($p \leq 0.05$) improved percent uptake of N (0.11- 0.58), P (0.0004-0.0005) and K (0.04-0.07). Interaction (tillage passes × fertilizer rates) effects were observed on percent N (0.31-0.68), P (0.0005-0.0009) and K (0.06-0.10) uptake, but only T2F2 (6 passes × 150 kg/ha) significantly ($p \leq 0.05$) improved uptake of Phosphorous. The mean interaction effects on plant height, stem girth, leaf area, fresh weight and the root length increased due to the effect of reduced bulk density (1.7-1.5 g/cm^3) and increased fertilizer rates (0-200 kg/ha), however, T2F2 had the most significant ($p \leq 0.05$) effect on the increased plant length (t=11.6) and significant ($p \leq 0.05$) effects was not observed for other growth parameters, therefore, 6 passes and 150 kg/ha 15-15-15 NPK could be more suitable for optimum production for *Amaranthus viridis* on a sandy clay soil.

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