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Relative Effect of Tillage Methods and Weeding Regimes on Seasonal Weeds Biomass and Maize Performance

Samuel APPAH[1*], Eric Amoah ASANTE[2], Christopher Amigangre AYAMBIRE[3]

[1,3]Department of Agricultural Mechanization and Irrigation Technology, University for Development Studies, Tamale, GHANA
[2]Department of Agricultural and Biosystems Engineering, Kwame Nkrumah University for Science and Technology, Kumasi, GHANA

[1]https://orcid.org/0000-0003-3226-9269, [2]https://orcid.org/0000-0001-8078-0702, [3]https://orcid.org/0000-0002-2784-6626

*Corresponding author: skappah@yahoo.com

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ABSTRACT

An experiment to investigate relational effect of tillage methods and weeding regimes on seasonal weeds biomass, maize growth and yield parameters was conducted in both major and minor cropping seasons. On randomized complete block design, 2-tillage methods and 4-weeding regimes were factorially assigned at three replicate levels. A no-tillage (NT) and plough + harrow (P+H) with a 47 hp tractor were the tillage methods, whereas 0-hoeing, 1-hoeing, 2-hoeing and 3-hoeing were the weeding regimes at 2, 5 and 7 weeks after sowing (WAS). *Akposoe maize* (Zea mays. L) variety was sown and monitored over a period of 10 WAS. And there was higher growth and yield parameters on P+H than NT treatments at various weeding regimes, whereas weeds biomass was greater on NT than in P+H. An interaction of 2-hoeing regime on P+H recorded mean maximum growth parameters of 14.2 number of leaves, 82.89 mm stem girth, 45.53 cm root length in major seasons and 225.7 cm plant height in minor seasons than NT at different weeding regimes. Also, yield attributes from P+H at 2-hoeing regimes recorded maximum maize dry matter yield (9.189 tha^{-1}) in minor season but total grain yield of approximately 8.167 tha^{-1} in major season. A 0-hoeing on NT produced denser weed biomass of 6.4497 tha^{-1} in minor season and 9.0967 tha^{-1} in major season. It is therefore recommended to plant maize on plough and harrow fields, and clear weeds by hoeing at 2 and 5 WAS for optimum growth and yield parameters at reduced weeds interaction.

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INTRODUCTION

Effective land preparation is a critical factor influencing maize establishment, growth, and yield, and the nature of vegetative cover determines the kind of land clearing and tillage method required to open-up soil surface for cultivation. On uncultivated soils, an initial weed control precedes tillage practices by using tractor mounted plough and harrow or sowing without tillage. These activities tend to clear the vegetation and create favourable soil environment for direct seeding operation. A better exposure of soil surface is primarily achieved through ploughing followed by harrowing (Panachuki et al., 2015, Appah and Aikins, 2020). So, an interactive effect of mechanical and no tillage practices on maize growth and yield parameters needs to be ascertained fully. The tillage modifies soil surface to provide medium for crop growth and development either by conservation or conventional means (Issaka et al., 2019). A conservation tillage as a green philosophy seeks to extensively prevent disturbances of soil media, flora and fauna but provides an avenue for cultivation (Busari et al., 2015). This presupposes that, no-tillage zeros to the concept of paving way for cultivation without turning the soil medium (Uri et al., 1999; Blanco-Canqui and Ruis, 2018). Besides the merits of preserving natural environment by conservation tillage, the practice rarely give way to large scale production, as machinery are prevented from smooth operation on undeveloped land. In view of this, the concept of resorting to conventional ploughing and harrowing becomes an alternative. Ploughing drags and overturn soil medium creating lumps and burying debris to make the soil surface exposed for direct planting and sowing. In most instances, ploughing is followed by harrowing to break soil lumps, but depending on soil mass and previous activity, land could either be subjected to ploughing, harrowing or a combination before planting. These tillage practices invariably influence emergence of weeds and subsequent weeding regimes (Weber et al., 2017).

Weeds emergence under both conservation and conventional tillage practices radically change overtime. Therefore, the influence of tillage methods on emergence and density of weeds from no-tillage and/or plough and harrow fields need to be investigated. As the land is undisturbed, the possibility of weeds outgrowing than pulverised soils after plough and harrow deserve critical monitoring, since weeds interfere with crop growth and compete for soil nutrients. The rate at which weeds grow on the field determines the time and frequency of weeding (Appah and Aikins, 2020; Mamudu et al, 2022). Early weeding on crop fields maximises growth, reduces pest infestation and improves crop quality (Abouziena et al., 2007; Aikins et al., 2012). On crop fields, it is important to control weeds within two weeks after planting, when leaves per plant reach 2-8 stage (James et al., 2000). However, the frequency of weeding is mainly at a discretion and would not be economically feasible if yield is dependent on weeds removal at the critical stages of crop growth (Adenawoola et al., 2005). In crop farming, both tillage methods, weeds and weeding regimes play an important role in growth and yield parameters. An interactive effect of ploughing, harrowing and weeding regimes reduces penetration resistance and bulk density but increases porosity and moisture content of soil mass (Appah and Aikins, 2020). However, the relational upshot of tillage and weeding regimes on maize growth parameters, yield and weeds biomass need to be determined. In this study, we examined a comparative effect of tillage methods and weeding regimes on seasonal *Akposoe (Zea mays. L)* maize growth parameters, yield attributes, total grain yield and weeds biomass under rainfed agriculture.

MATERIAL and METHOD

Experimental Setup

A factorial experiment with three replicate trials for two factors of tillage methods and weeding regimes was setup on a randomized complete block design (RCBD) in two consecutive seasons.

Table 1. Seasonal climatic conditions and soil physico-chemical properties

Monthly climatic conditions												
	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
T °C	26.0	27.5	27.6	28.1	27.6	26.9	25.4	25.3	25.8	22.5	27.0	27.2
R mm	20.2	66.6	256.4	157.4	149.9	197.7	247.6	134.9	201.8	163.3	111.1	47.0

Seasonal soil physico-chemical properties before ploughing															
Soil properties	Sand	Silt	Clay	ϱ_b (Kg/cm^3)	θ_m (%)	PR (kPa)	Porosity (%)	OMC (%)	pH	NH_4^+N (cmol/kg)	P(cmol/kg)	N (%)	K(cmol/kg)	Na (cmol/kg)	Ca (cmol/kg)
Minor	64.6	29.4	6.0	1.41	11.8	299	46.9	2.0	4.8	4.25	12.0	0.10	0.13	0.35	3.07
Major	78.7	16.3	5.0	1.41	8.85	175	46.7	0.8	5.4	0.98	19.7	0.06	0.18	0.04	1.74

Seasonal soil physical properties of treatments								
	Minor season				Major season			
	ϱ_b (Mgm^{-3})	Pr kPa	θ_m (%)	Φ (%)	ϱ_b (Mgm^{-3})	Pr KPa	θ_m (%)	Φ (%)
NT x 0 Hoeing	1.50	291.4	10.57	43.28	1.376	170.4	10.78	48.09
NT x 1 Hoeing	1.49	320.3	13.96	43.76	1.396	175.6	10.51	47.30
NT x 2 Hoeing	1.48	243.1	14.58	44.32	1.402	202.0	10.95	47.10
NT x 3 Hoeing	1.53	293.0	13.14	42.37	1.402	174.4	11.42	47.11
P+H x 0 Hoeing	1.46	160.4	13.66	44.89	1.359	163.0	16.99	48.72
P+H x 1 Hoeing	1.47	159.9	11.38	44.46	1.330	147.3	14.99	49.82
P+H x 2 Hoeing	1.48	176.4	15.66	44.19	1.303	116.0	16.64	50.83
P+H x 3 Hoeing	1.51	165.3	13.73	43.06	1.317	136.8	14.58	50.29
LSD ($p < 0.05$)	NS	NS	2.29	NS	NS	NS	NS	NS

NS (Non-Significance), T (Temperature), R (Rainfall), ϱb (bulk density), PR (penetration resistance), Φ (porosity), θ_m (Moisture content, OMC (organic matter content)

The tillage treatments were no-tillage (NT) and plough + harrow (P+H), whereas weeding regimes consisted of 0-hoeing, 1-hoeing at 2 WAS (weeks after sowing), 2-

hoeing at 2, 5 WAS and 3-hoeing at 2, 5 and 7 WAS. There were twenty-four plots on three replicate blocks at eight plots per block per season. The dimension of every plot was 4 m × 4 m with an intra buffer zone of 2 m and border buffer of 4 m to allow unobstructed movement in and around experimental plots. At every dimension, the field was marked, ploughed and harrowed where applicable to the design specification. A 47 hp tractor wheel pass was directed carefully to safeguard passage on NT plots during ploughing and harrowing. Each plot was again pegged and lined to a planting distance of 0.75 m inter rows and 0.35 m intra rows to obtain approx. 60 hills per plot and 1440 hills per area of 0.1 ha. The experiment was undertaken in two major and minor cropping seasons on *Ferric Acrisol* sandy loam soil under rainfed agriculture at the site of Crop Science Department, KNUST, Ghana. A measured characteristic feature of climatic conditions and soil physico-chemical properties of the field is presented in Table 1.

Maize Growth and Weeds Regeneration

A high yielding and drought resistant *Akposoe* maize variety seeds were obtained from Crops Research Institute (CRI), Kumasi, Ghana. A germination test of 85% was conducted by counting 100 seeds and sown to determine viability ratio. At the recommended planting distance of 0.75 m × 35 m hill spots, a wooden dibber was used to create 5 cm depth holes. In every hill, 2 seeds were sown and firmed to obtain 120 seeds per plot (16 m^2), 2880 seeds per entire field, equivalent to a plant population of 75,000 per hectare. After germination, weeding regimes with a draw hoe were applied on respective plots as per design. Also, at 2 WAS, granule fertilizer NPK 15-15-15 at 250 $kgha^{-1}$ was applied as top-dress, whereas on 5 WAS, ammonium sulphate, NH_4SO_4 fertilizer at 125 $kgha^{-1}$ was applied to each maize hill. The plants were sprayed at 2 and 5 WAS with KILSECT 2.5 EC insecticide at 800 ml ha^{-1} using backpack knapsack sprayer. The number of seedlings emerged after sowing were counted daily on each plot until all viable seeds emerged from the soil, and computed as, total seedling emerged divided by total seeds planted multiplied by hundred. Also, all indigenous weed species were allowed to spontaneously grow onsite days after land preparation. With the exception of 0 hoeing treatment, all plots were hoed at respective 1, 2 and 3 weeding regimes. In the middle of each treatment plot, six plants were tagged for data collection on maize growth and yield parameters, whereas weeds population were also sampled as monocots and dicots for data analysis from 1 to 10 WAS.

Data Collection and Analysis

On weekly basis, maize growth parameters were determined. Height of maize plant was measured from base to top of highest leaf using a pole and meter rule. A thread was wrap around the stem and stretched on ruler to determine maize stem girth. All leaves on each sampled maize were counted till the plants reached 10 WAS. The width

(W) and length (L) of broadest leaves from each tagged plants were measured with meter rule to determine leaf area (LA) $= (L \times W)k$ at k = 0.75 value for all cereals (Xu et al., 2017; Zhang et al., 2021). As length of maize root indicates its conductive and adsorptive capacity, it was dug around and critically uprooted. The observable longest roots length was recorded from each of the targeted tagged plants. Also, dry matter yield (kg/ha) was determined by manually harvesting tagged plants per plot at harvest, washed and cleaned before oven dried in brown envelopes at 70 °C for 48 hours. Maize yield was determined from harvested and processed ears at physiological maturity in 90 DAS. The weight of ears was taken using electronic balance after harvest, then dried for seven days and reweighed. Additionally, girth and length of ears were also recorded using a thread and meter rule. The dried ears were dehusked and weighed as biological yield, then threshed and grains measured as economic yield. The fresh threshed grains were open air dried in a sun to reach 13% moisture content, weighed and divided by weight of dried ears as shelling (%). That 13% moisture content was obtained by oven dried 25 whole grains at 105 °C for 14 hours, weighed and divided by air dried grain weight. The ratio of economic yield to biological yield measured maize harvest index (%), and the weight of 1000 dried seeds was also recorded. Weed density was determined at 2, 5, 7 WAS and at harvest (90 DAS) using a 1 m × 1 m quadrat randomly cast on each plot. The weeds were harvested above ground, and transported to a laboratory in black polythene film sheets, then oven dried in envelopes for 48 hours at 70 °C. The weight of dried weed matter was recorded using an electronic balance for analysis. All data collected from field experiment were subjected to statistical analysis using Minitab Statistical Software Release 17 (MINITAB Inc., 2007), whereas General Linear Factorial Model ANOVA helped to draw significance among data set at $p < 0.05$.

RESULTS and DISCUSSION

Effect of Tillage Methods and Weeding Regimes on Maize Growth Parameters

Seedling Emergence as Influenced by Tillage Methods and Weeding Regime

The structure of soil medium prior to seeds sowing could have effect on number of seedlings emerged irrespective of seed type and variety. An influence of NT and P+H on seasonal maize seedling emergence is presented in Fig. 1. Seeds began to emerge at 4 DAS and stabilized after 7 DAS on all fields, thus, no viable seed remained in the soil mass from 8 DAS onwards. The P+H fields emerged seedlings significantly higher due to pulverised soil medium than NT in a mean value of 99% than 95% respectively. This lower percentage of emergence on NT plots could be attributed to varied soil characteristics. This suggests that irrespective of the tillage method applied, maize seeds emerged at 4 DAS and emergence stabilised at 8 DAS. Invariably, as no weeding was carried out within the first 14 DAS, no observable data on seedling emergence was recorded on such fields, hence, weeding regimes had no effect on seedling emergence of *Akposoe* maize.

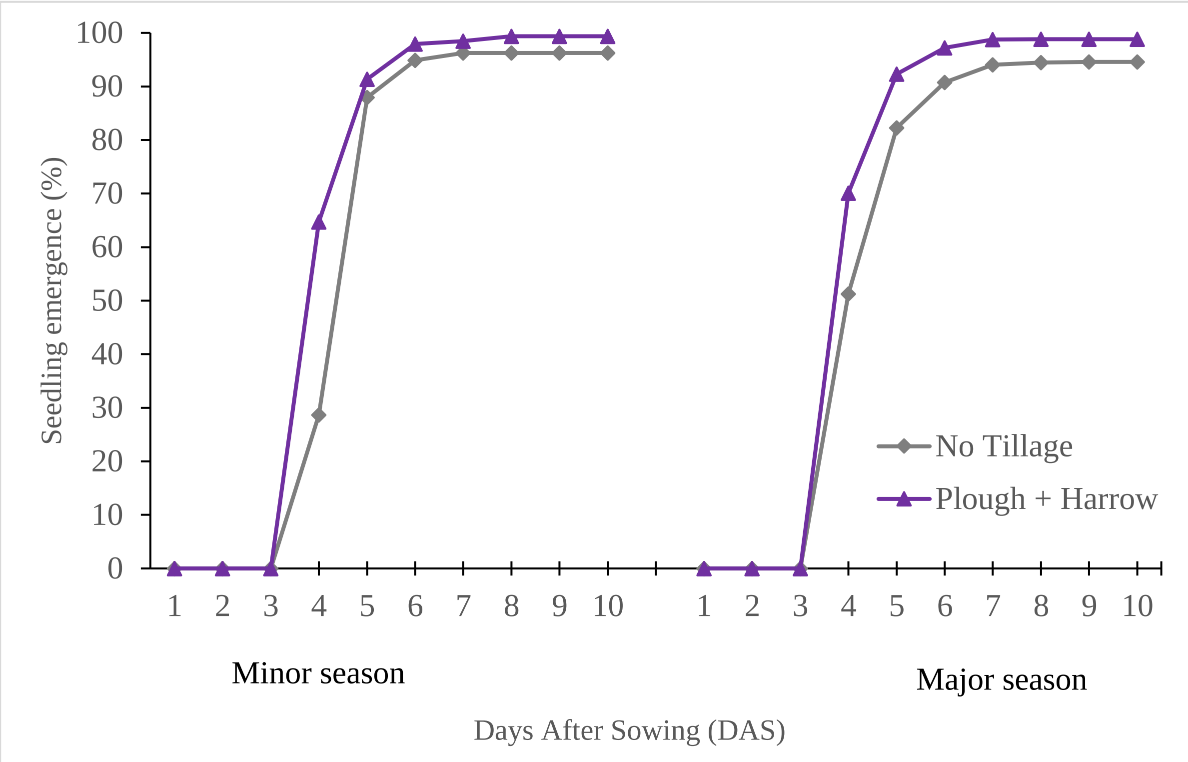

Figure 1. Effect of tillage methods on mean seasonal seedling emergence

Effect of Tillage Methods and Weeding Regimes on Seasonal Maize Leave Characteristics

From 1 to 10 WAS, mean number of leaves per plant increased to a point of inflexion at 7 WAS and declined as affected by tillage methods and weeding regimes (Fig. 2). The increasing many leaves observed from 1 to 8 WAS, was due to vegetative growth phase, whereas downsizing number of leaves recorded from 8 to 10 WAS, was from gradual withering of older leaves upwards due to water stress and near to physical maturity. On P+H treatments, maximum (13) leaves were recorded than that of NT plots (11) leaves per plant both at 8 WAS in minor season. This shows that maize establishes faster on plough and harrow plots than no-tillage fields, due to interactive effect of soil physical properties in the soil medium (Appah and Aikins, 2020). Consequently, weeding regimes also influenced number of leaves emerged and maintained on the plant up to physiological maturity. Though, 2-hoeings produced plants with maximum number of leaves throughout the experimental season, there was no significant difference with that from 1-hoeing and 3-hoeing regimes at 1 to 7 WAS. But the interference of weeds on crops yielded a smaller number of leaves on 0-hoeing plots altogether, and irrespective of tillage method and weeding regime, the number of leaves dropped at 10 WAS. As leaves determine photosynthetic activities and yield of plant, plough + harrow and 2-hoeings are therefore recommended in seasonal maize production.

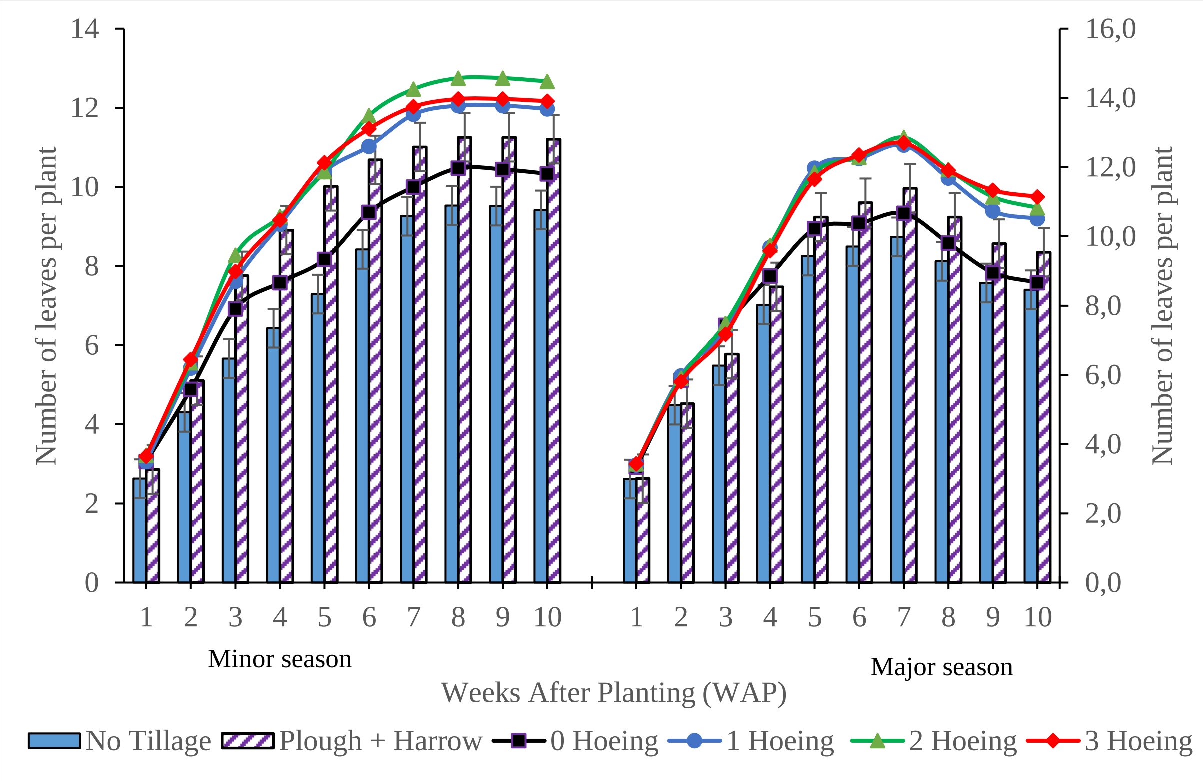

Figure 2. Effect of tillage methods and weeding regimes on mean number of leaves per plant

Subsequently, as in Fig. 3, the broadest leaves significantly emerged from P + H fields than NT. Altogether, on P + H fields, maize tended to produce higher leaf area than NT plots, but as higher leaf area connotes better utilization of sunlight for photosynthetic activities, excessive leaf area however prevented lower leaves from receiving sunlight for photosynthetic activities (Karunatilake and Schindelbeck, 2000). Since leaf area increased probably under weed-free and well aerated field conditions (Fig. 4), 3-hoeing regimes recorded the highest (607 cm^2) leaf area while 0-hoeing produced 468 cm^2 leaf area per plant in minor season. On the other hand, 2-hoeing regimes recorded the highest (432 cm^2) leaf area whiles 0-hoeing treatment recorded the lowest (313.0 cm^2) leaf area per plant in major season. However, there were no significant differences among seasonal leaf areas obtained under 1, 2 and 3 hoeing regimes at all levels of production in both seasons.

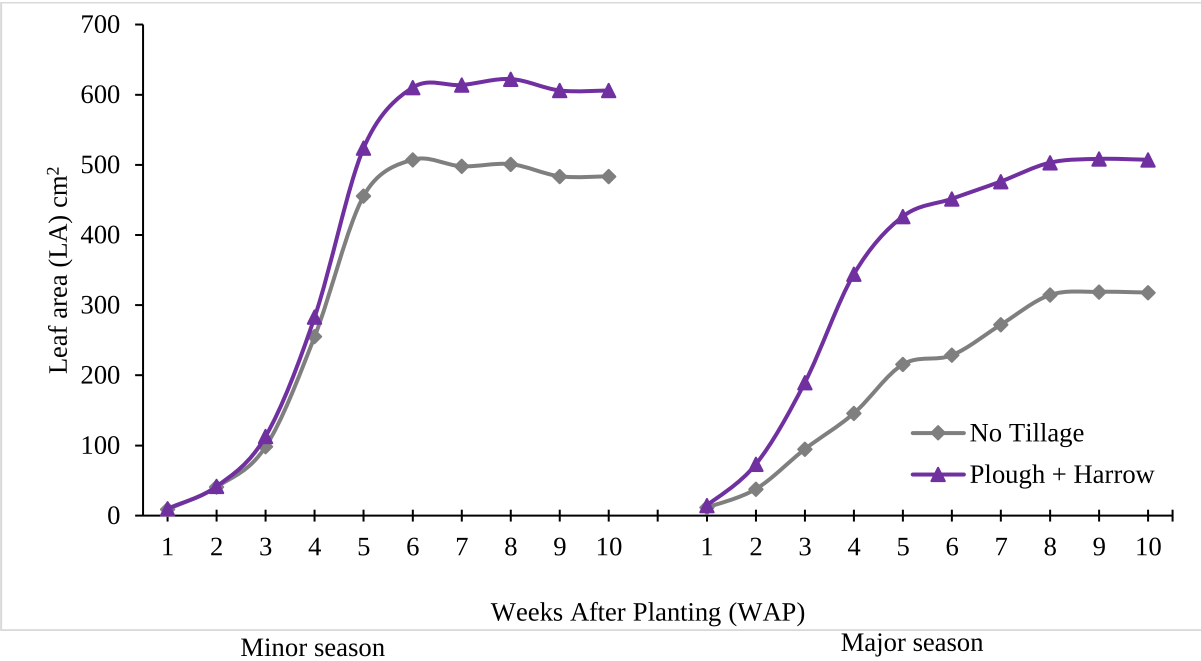

Figure 3. Effect of tillage methods on mean leave area

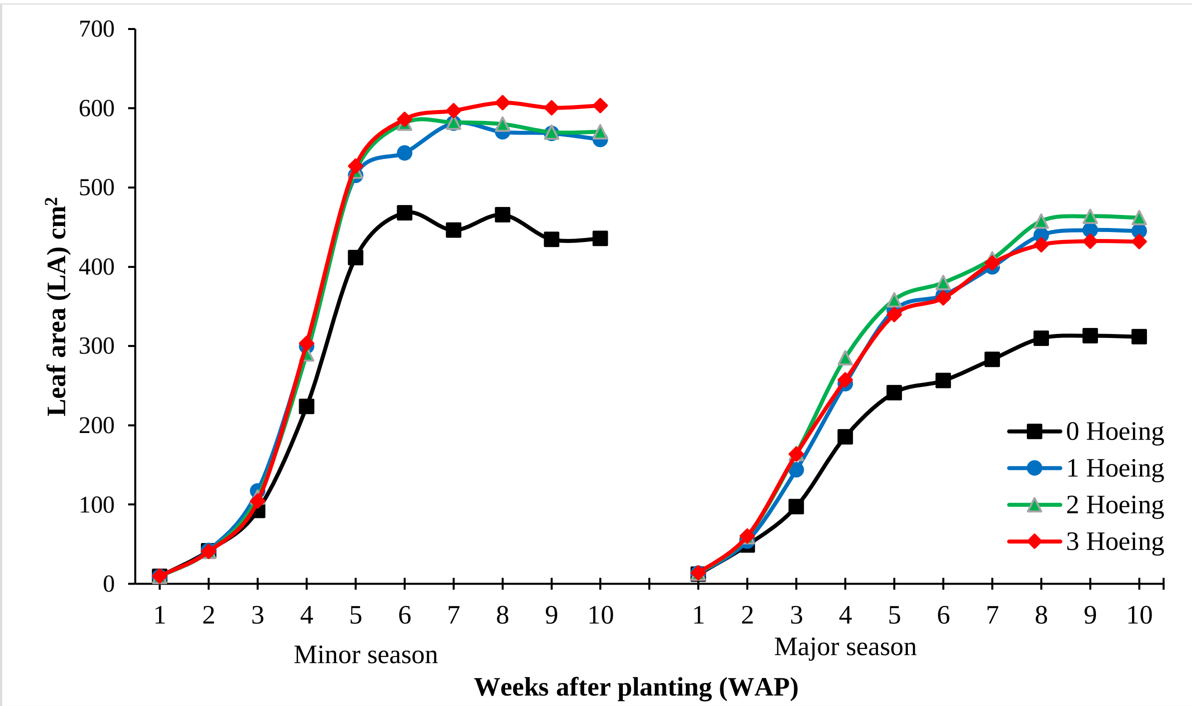

Figure 4. Effect of weeding frequency on mean leaf area

Effect of Tillage Methods ond Weeding Regimes on Seasonal Plant Height

Plant height of *Akposoe* maize variety as influenced by tillage methods and weeding regimes at different cropping seasons is shown in Fig. 5. At 10 WAS, P + H treatments yielded plant heights of 219 cm during minor season and 202 cm in major season, higher than that of NT of 201 cm and 164 cm respectively (Aikins et al., 2012). An increase in plant height requires effort to ensuring weed-free environment in maize fields at vegetative growth phase (Adenawoola et al., 2005). With 2-hoeing regimes, highest plant was recorded from 3 to 8 WAS whereas that of 3-hoeings was highest at 9 to 10 WAS, but with no significant differences between 2 and 3-hoeing regimes, whereas 0-hoeing produced the least height at all levels of growth stages (Abouziena et al., 2007). Notably, the plant height was affected by tillage methods but not affected by weeds interference in the early true leaves stages at 2 WAS (James et al., 2000).

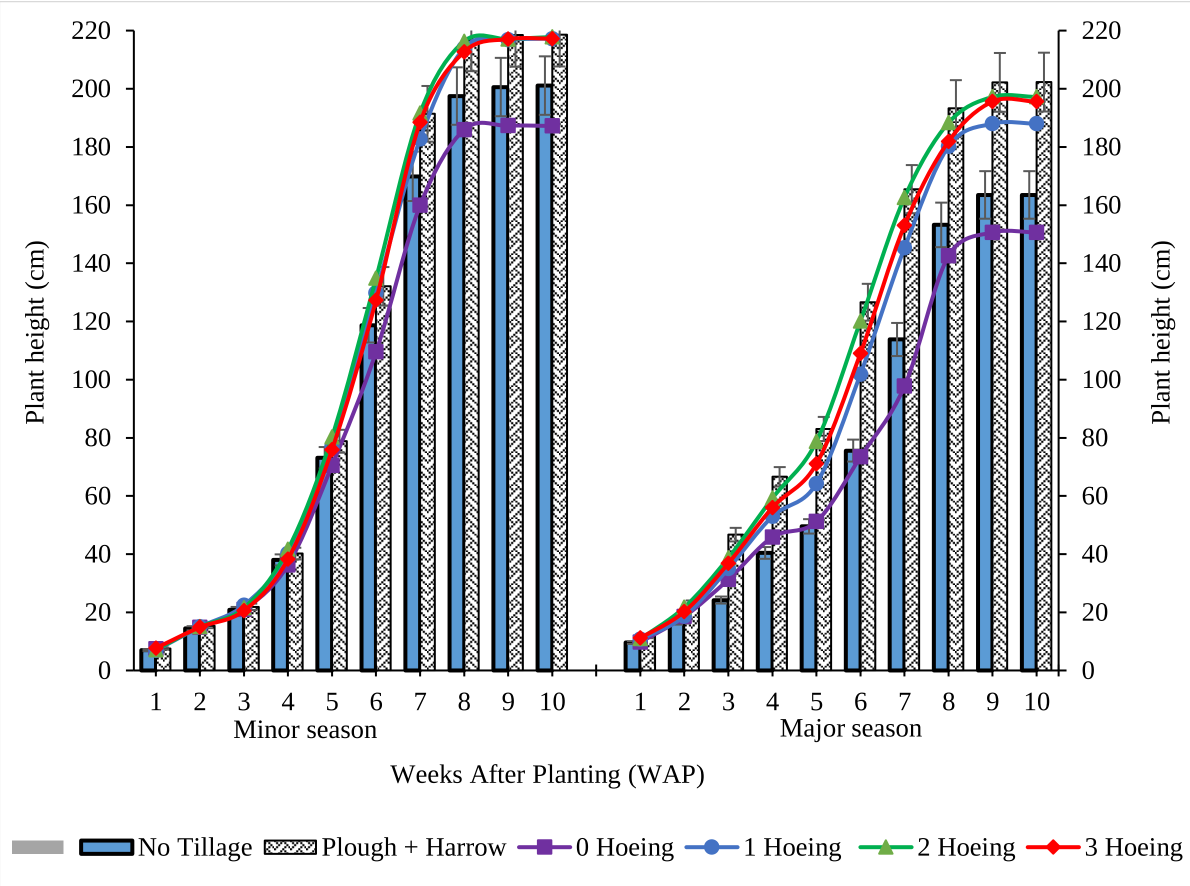

Figure 5. Effect of tillage methods and weeding regimes on seasonal mean plant height

Effect of Tillage Methods and Weeding Regimes on Stem Girth

Stem girth anchors maize plant to bear number of ears, hence, a tillage method capable of providing suitable soil medium that yields bigger stems to resists storm and maintains uprightness is required. Fig. 6 therefore presents effect of tillage methods and weeding regimes on seasonal maize stem girth. In both seasons, plough and harrow fields gave stem girth significantly bigger than no-tillage over the period of experiment. The plough + harrow treatments produced mean girth of 79.19 mm in minor season and 75.89 mm in major season, whereas no-tillage plots respectively gave 64.92 mm and 57.90 mm stem girths. A shrunk in maize stem girth in major season could be a function of time of planting and erratic rainfall pattern in March-April (Table 1), while stem turgidity in minor season could also be attributed to regular rains in August-September (Table 1) which occur at same vegetative growth phases.

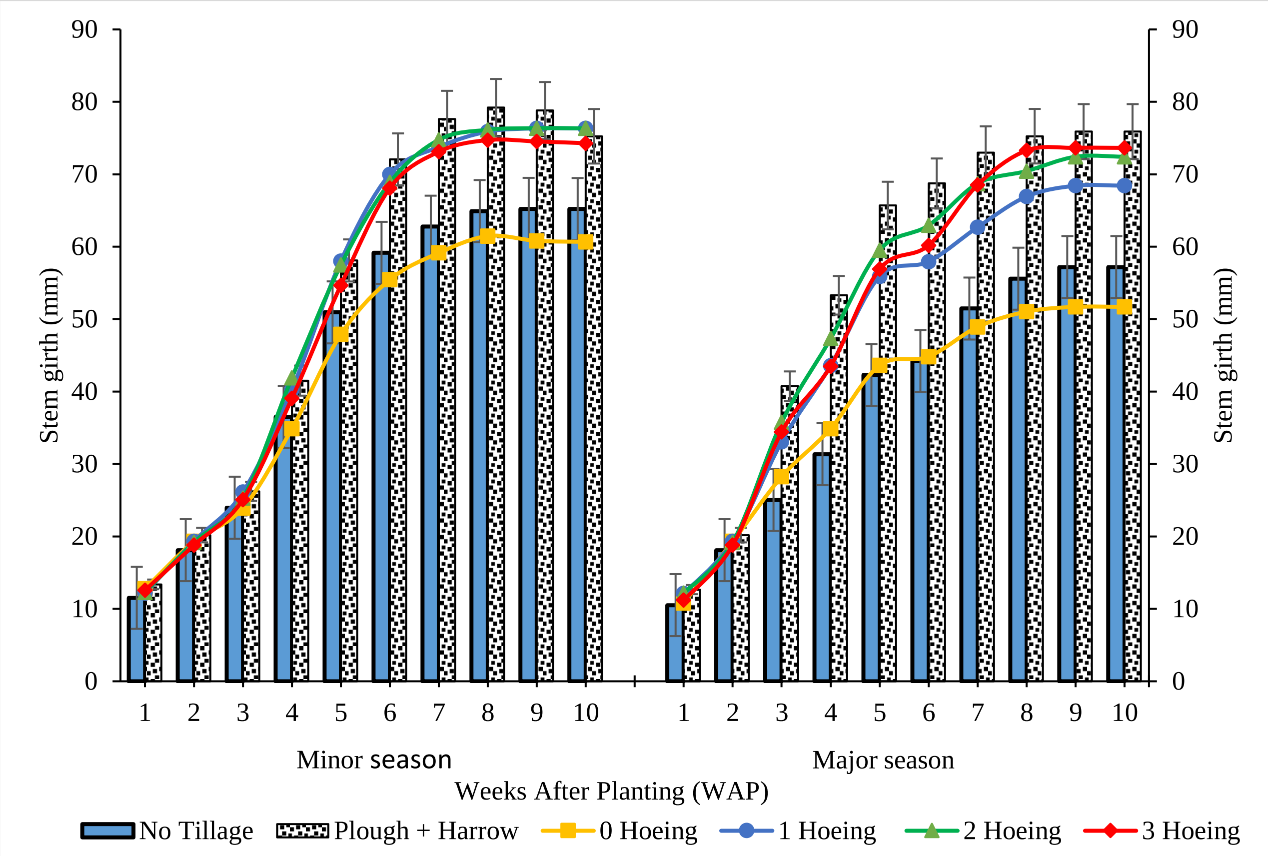

Figure 6. Effect of tillage methods and weeding regimes on stem girth

In both minor and major seasons, girth of maize at 1 to 3 WAS shown no significant differences among weeding regimes which radically changed from 4 to 10 WAS. The largest stem girth of 77.69 mm was recorded on 2-hoeing treatment plots whereas smallest girth 60.67mm was obtained from 0-hoeing regime at 10 WAP in the minor season. Moreover, in major season, girth of 73.64 mm was found on 3-hoeing treatment plots, higher than that of 2-hoeing regimes of 72.42mm, while 0-hoeing plots recorded stem girth of 51.69 mm at 10 WAS. On 0-hoeing regime, there was an initial increase in stem girth at a decreasing rate, whereas stem girth from 1, 2 and 3-hoeing regimes increased at an increasing rate till no increase occurred from 8 WAS onwards-a phenomenon likened to approach of physical maturity growth phase.

Effect of Tillage Methods and Weeding Regimes on Root Length

The pulverisation of soil mass through tillage practices and weeding frequency regimes, influenced root length of *Akposoe* maize (Fig. 7). As root favours water and nutrient uptake by osmotic or diffusive principles, the rate of activity depends on density, depth and spread in the soil (Nitant and Singh, 1995). Statistically, cropping season affected root length under different tillage methods. Plough and harrow treatments grew longer roots of 33.32 cm and 40.32cm than no-tillage of 21.43cm and 27.42 cm respectively in minor and major seasons (Rashid et al., 2008). This shows that root-soil penetration is longer in plough + harrow field than well concentrated short roots on the surface layer of no-tillage fields (Maurya and Lal, 1980; Ball-Coelho et al, 1998). Additionally, weeding regimes significantly affected maize seasonal root length with 3-hoeing regime producing longest root (30.19cm) followed by 2- hoeing regime of 28.72cm while shortest root of 24.15cm was recorded in minor season. However, in major season 2-hoeing regime yielded the longest root 37.42cm while shortest root of 26.77cm was dug from 0-hoeing fields. Hence, weeding twice in maize farms is recommended for economic gains (Zimdahl, 1999).

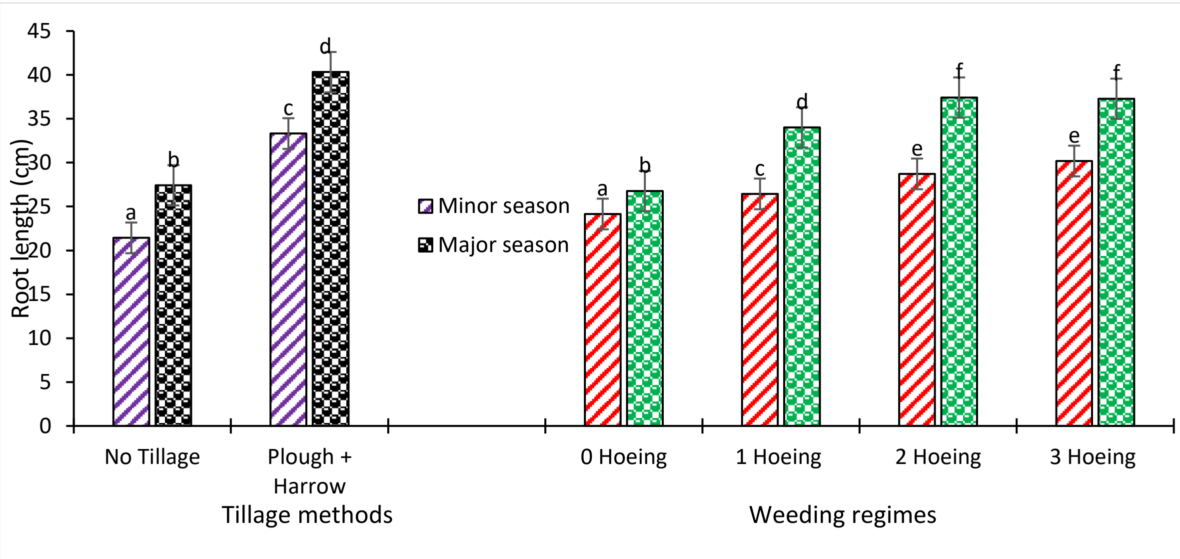

Figure 7. Effect of tillage Methods and weeding regimes on seasonal mean root length

Generally, an interaction effect of tillage methods and weeding regimes on maize growth parameters shown no significance effect, with the exception of stem girth in major season (Table 2). The P + H under different weeding regimes produced better results than NT treatments at various weeding regimes. It is therefore suitable to plough and harrow fields before sowing and weed twice to maximise yield in all seasons.

Table 2. Interaction effect of tillage methods and weeding regime on seasonal maize growth parameters

Tillage Method x Weeding regimes	Number of Leaves	Stem girth (cm)	Plant Height (cm)	Root length (cm)
Minor season				
No Tillage x 0 Hoeing	6.833	61.39	171.5	18.71
No Tillage x 1 Hoeing	8.500	72.17	213.4	21.12
No Tillage x 2 Hoeing	9.000	73.89	211.1	21.82
No Tillage x 3 Hoeing	9.500	72.56	208.6	24.10
Plough + Harrow x 0 Hoeing	8.333	73.94	202.8	29.60
Plough + Harrow x 1 Hoeing	9.889	67.50	221.1	31.77
Plough + Harrow x 2 Hoeing	10.000	81.50	225.7	36.29
Plough + Harrow x 3 Hoeing	9.944	78.00	224.6	35.63
LSD (p<0.05)	NS	NS	NS	NS
Major season				
No Tillage x 0 Hoeing	9.278	38.44	126.0	22.42
No Tillage x 1 Hoeing	11.222	60.83	175.9	27.94
No Tillage x 2 Hoeing	11.111	61.94	173.9	29.31
No Tillage x 3 Hoeing	11.444	67.56	178.2	30.03
Plough + Harrow x 0 Hoeing	11.389	64.94	175.3	31.12
Plough + Harrow x 1 Hoeing	12.722	76.00	200.2	40.09
Plough + Harrow x 2 Hoeing	14.222	82.89	220.6	45.53
Plough + Harrow x 3 Hoeing	9.278	79.72	213.0	44.53
LSD (p<0.05)	NS	1.82	NS	3.65

NS = Not Significant

Effect of Tillage Methods and Weeding Regimes on Maize Yield Parameters

Tillage Methods and Weeding Regimes Effect on Ear Girth, Ear Length and Dry Matter Yield

The determinant proceeds of maize ear, length and dry matter yield parameters under different tillage methods and weeding regimes were statistically significant at harvest irrespective of cropping season (Table 3). On tillage treatments, a maximum dry matter of 6582 kg ha^{-1} and ear girth of 18.75 cm were obtained in minor season while that of ear length (15.05 cm) was measured in major season from P + H plots, relatively higher than that recorded on NT plots. Similarly, under weeding regimes, dry matter (7870 kg ha^{-1}) and ear girth (18.29 cm) performed well in minor season, and that of ear length was higher (15.38 cm) in major season, all from 2-hoeing treatments, much better than other weeding regimes. Although there was no significant difference between 2 and 3 hoeing regimes on seasonal dry matter, ear girth and length, increasing number of weeding regimes had repercussion on drudgery and cost of production (Zimdahl, 1999). Therefore, weeding twice is considered suitable for maximum dry matter, ear girth and ear length in seasonal *Akposoe* maize production.

Table 3. Effect of tillage methods and weeding regimes on dry matter, ear girth and length

Tillage methods /Weeding regimes	Minor Season			Major Season		
	Dry matter (kgha^{-1})	Ear Girth (cm)	Ear Length (cm)	Dry matter (kg ha^{-1})	Ear Girth (cm)	Ear Length (cm)
No Tillage	4958	15.03	11.02	4456	12.37	11.10
Plough + Harrow	6582	18.75	13.00	6080	16.10	15.05
LSD (p<0.05)	*1379.91*	*1.37*	*1.50*	*1382.30*	*1.71*	*1.21*
0 Hoeing	2876^{a}	13.86^{a}	8.79^{a}	2373^{a}	9.90^{a}	8.531^{a}
1 Hoeing	5429^{b}	17.27^{b}	12.55^{b}	4926^{b}	14.87^{b}	13.46^{b}
2 Hoeing	7870^{c}	18.29^{c}	13.75^{c}	7372^{c}	16.04^{c}	15.38^{c}
3 Hoeing	6905^{c}	18.13^{c}	13.61^{c}	6402^{c}	16.13^{c}	14.94^{c}
LSD(p<0.05)	*975.74*	*0.97*	*1.06*	*977.43*	*1.21*	*0.86*

Columns having same letters are statistically non-significant

Effect of Tillage Methods and Weeding Regime on Biological Yield, Shelling, Harvest Index and Total Grain Yield

Table 4 depicts biological yield, shelling percentage, harvest index and total grain yield as influenced by tillage methods and weeding regimes. In both seasons, though P + H treatments produced higher yield parameters than NT, that of biological and total grain yields were statistically significant (Gul et al., 2009), but contrary to what was obtained on harvest index (Sharma et al., 2019). Consequently, harvest index was also not statistically affected by weeding regimes. With the exception of high biological yield of 11172 kg ha^{-1} harvested in minor season, shelling (58.87%) and harvest index (64.38%) were maximum in major season. Also, mean grain yield harvested on P + H plots was 6.635 t ha^{-1} in major season higher than that of minor season (6.548 t ha^{-1}) which were respectfully higher than that of 4.686 t ha^{-1} and 5.008 t ha^{-1} recorded on NT treatments (Ahmad et al., 2021), all corresponding to relative seed-weight basis (Keshavarzpour, 2013). So, to maximise yield, cultivable land should be ploughed following harrowing before sowing in major cropping season. On the contrary, maximum biological yield (12590 kg ha^{-1}), shelling (58.80%) and total grain yield of 7.202 t ha^{-1} were all harvested in minor season under 2 hoeing treatment except, harvest index of 66.06% measured in major season from 3 hoeing plots. In all, the interaction effect that produced maximum total grain yield was recorded on plough + harrow under 2-hoeing regimes in minor season of 8.110 t ha^{-1} lesser than major seasons of 8.167 t ha^{-1} (Table 5).

Table 4. Effect of tillage methods and weeding regimes on biological yield, harvest index, shelling and total grain yield

Tillage Methods	Minor Season				Major Season			
	Bio-Yield (kg ha^{-1})	Shelling (%)	HI (%)	Grain Yield (kg ha^{-1})	Bio- Yield (kg ha^{-1})	Shelling (%)	HI (%)	Grain Yield (kg ha^{-1})
No Tillage	8896	53.60	55.69	5008	8259	53.18	57.25	4686
P + Harrow	11172	57.04	59.19	6548	10386	58.87	64.38	6635
LSD (p<0.05)	*2156.88*	*NS*	*NS*	*1083.78*	*1965.11*	*6.30*	*NS*	*920.31*
Weeding Regimes								
0 Hoeing	5517	50.67	52.63	2969	4898	51.42	58.48	2912
1 Hoeing	10295	54.05	58.98	6040	9460	56.59	61.65	6215
2 Hoeing	12590	58.80	58.32	7202	11973	58.15	57.09	6846
3 Hoeing	11733	57.77	59.84	6902	10958	57.94	66.06	6674
LSD (p<0.05)	*1525.14*	*4.00*	*NS*	*766.35*	*1389.55*	*NS*	*NS*	*650.76*

NS = Not Significant, HI (Harvest index)

Table 5. Interaction effect of tillage methods and weeding regime on seasonal maize yield parameters

Tillage Method x Weeding regimes	Minor season				Major season			
	Bio-Yield (kg ha^{-1})	Shelling (%)	HI (%)	Grain Yield (kg ha^{-1})	Bio-Yield (kg ha^{-1})	Shelling (%)	HI (%)	Grain Yield (kg ha^{-1})
NT x 0 Hoeing	4125	48.69	50.49	2159	3507	49.56	57.43	2101
NT x 1 Hoeing	9880	49.78	54.30	5295	9257	50.15	57.61	5237
NT x 2 Hoeing	10654	58.87	59.64	6294	10077	56.38	58.66	5525
NT x 3 Hoeing	10925	57.07	58.35	6286	10194	56.65	59.30	5889
P + H x 0 Hoeing	6909	52.65	54.77	3780	6289	53.28	59.29	3722
P + H x 1 Hoeing	10711	58.31	56.99	6785	9664	63.04	74.70	7193
P + H x 2 Hoeing	14526	58.73	63.67	8110	13870	59.92	59.52	8167
P + H x 3 Hoeing	12541	58.46	61.34	7517	11722	59.23	63.99	7460
LSD (p<0.05)	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not Significant

This indicates that, for higher economic grain yield, maize should be cultivated in major cropping season than minor season. The lower yield obtained from no-tillage under 0-hoeing in both seasons could be attributed to weed interference weeds interference with maize and competition for nutrient, space and light for growth and development (Chikoye et al., 2004; Abouziena et al., 2007). Such weed-maize interactions invariably hindered the photosynthetic activities and yield parameters of maize, since weeds thrived better under harsh environmental conditions than maize on no tilled soils.

Effect of Tillage Methods and Weeding Regime on Weed Biomass

In *Akposoe* maize production, effect of tillage methods on seasonal dry matter weeds decreased with an increased weeding regimes at 2, 5, 7 WAS and after harvest (Table 6). The total weed biomass for first and second weeding at 2 and 3 weeks after sowing was significant, but was not significant for third weeding at 7 WAP in both seasons. At harvest, weeds biomass collected from plough and harrow fields were smaller (0.95592 t ha^{-1}) than that obtained from no tillage plots (1.91733 t ha^{-1}) during minor season (Ahmad et al., 2021). There was an increased in dry matter yield during major season on both fields, with no-tillage exceedingly producing higher of 2.99375 t ha^{-1} than plough and harrow of 1.69967 t ha^{-1}. Therefore, to reduce weeds density and biomass on maize farms, it is important to plough and harrow before sowing.

Table 6. Effect of tillage methods on seasonal total weed biomass

Tillage Methods	Total Weed Biomass ($kgha^{-1}$)			
(Minor season)	1st Weeding 2 WAP	2nd Weeding 5 WAP	3rd Weeding 7 WAP	Weeding After Harvest
No Tillage	254.917	14.9250	0.3	1917.33
Plough + Harrow	8.250	1.5417	0.26667	955.92
LSD (p<0.05)	97.43	9.69	NS	NS
(Major season)				
No Tillage	336.50	47.158	2.7500	2993.75
Plough + Harrow	33.25	6.625	1.8333	1699.67
LSD (p<0.05)	215.34	32.30	NS	1147.79

NS = Not Significant

Additionally, weeding regimes significantly influenced weeds density and biomass on maize fields (Table 7). As the quantity of weeds biomass is inversely proportional to weeding frequency, 3-hoeing recorded the least (61 kg ha^{-1}) biomass, whiles 0-hoeing produced the largest (4559.33 kg ha^{-1}) biomass in minor planting seasons, similar to biomass harvested during major season as 208.5 kg ha^{-1} and 6971.5 kg ha^{-1} respectfully (Idziak et al., 2022). The total weed biomass obtained in major season exceeded that of minor season, a result somewhat attributed to regeneration of viable seeds and parts that were dormant in the soil medium at peak rainfall. Looking at the drastic reduction in weed density and biomass at 3-hoeing regime (El-Gedwy, 2019), it is prudent to adopt 2-hoeing for efficient weed control (Sharara et al., 2005), as there is no significant difference between their seasonal yields as well. In regimes where weeding was not done, no data was collected, except after harvest.

Table 7. Effect of weeding regime on seasonal total weed biomass

Weeding regimes	Total Weed Biomass (kgha^{-1})			
Major season	1st Weeding 2 WAP	2nd Weeding 5 WAP	3rd Weeding 7 WAP	Weeding After Harvest
0 Hoeing	-no data-	-no data-	-no data-	4559.33
1 Hoeing	102.167	-no data-	-no data-	1018.33
2 Hoeing	189.333	12.0333	-no data-	107.83
3 Hoeing	234.833	20.90	1.13333	61.00
LSD (p<0.05)	68.90	6.85	0.0185	1170.19
Minor season				
0 Hoeing	-no data-	-no data-	-no data-	6971.5
1 Hoeing at 2WAS	152.333	-no data-	-no data-	1484.5
2 Hoeing at 2 and 5 WAS	301.667	32.583	-no data-	722.33
3 Hoeing at 2, 5 and 7 WAS	285.500	74.983	9.1667	208.5
LSD (p<0.05)	152.34	22.84	0.2365	1147.79

Invariably, an interaction effect of both tillage methods and weeding regimes was significant in both seasons (Table 8).

Table 8. Interaction effect of tillage methods and weeding regimes on seasonal weeds biomass

Tillage Method x Weeding Regimes	Total Biomass (kg ha^{-1})	
	Minor season	Major season
No Tillage x 0 Hoeing	6449.67	9096.67
No Tillage x 1 Hoeing	978.67	1419
No Tillage x 2 Hoeing	134	1123.33
No Tillage x 3 Hoeing	107	336
Plough + Harrow x 0 Hoeing	2669	4846.33
Plough + Harrow x 1 Hoeing	1058	1550
Plough + Harrow x 2 Hoeing	81	321.33
Plough + Harrow x 3 Hoeing	15	81
LSD (p<0.05)	1000.8	2295.58

NS = Not Significant

No tillage plots under 0 hoeing produced highest weed biomass of 6449.67 kg ha^{-1} in the minor season and 9096.67 kg ha^{-1} during the major season. Whereas P + H fields subjected to 3-hoeings recorded the least of 15 kg ha^{-1} in the minor season and 81 kg ha^{-1} during the major season (Ahmad et al., 2021). So, in major season more weeds grow in maize fields than minor season.

CONCLUSION

A significant difference was observed between the two sowing dates in terms of shoot dry weight, plant height, the number of siliques per plant, grain yield, the concentration and uptake of N and P, and the uptake of K. For each day delay in cultivation time, a 1.37% growth reduction occurred for shoot dry weight. In the normal sowing date, the effect of mixed treatment on grain yield was more, but in the late sowing time, foliar application of seaweed extract was more preferable. One of the reasons for the increase in grain yield of seaweed treatment may be the higher uptake of P and increase in silique per plant. It seems that the application of these materials can be considered in reducing the cold stress and increasing the economic efficiency of the canola crop. The use of all the growth-promoting substances (except fulvic acid) in the delayed condition had a benefit-cost ratio greater than one. The economic evaluation of the treatments showed that in both normal and delayed conditions, the use of seaweed extract had the highest benefit-cost ratio and had a higher economic efficiency than other treatments.

In a comparative study, effect of tillage methods and weeding regimes on seasonal production of *Akposoe* maize variety and weeds biomass gave dynamic growth parameters, yield and weed variations. After sowing, plough and harrow emerged many seedlings (99.38%) than no-tillage (94.54%) treatments, though there was no emergence between 0 to 4 DAS and after 7 DAS, a period when weeding regime had not started. A 2-hoeing regime on plough + harrow treatments recorded maize growth parameters with maximum number of leaves (14.2), stem girth (82.89mm), root length (45.53 cm) in major cropping seasons and plant height of 225.7 cm in the minor cropping seasons than no-tillage treatment at different weeding regimes. Also, yield attributes of maize from plough and harrow treatment at 2-hoeing regimes gave maximum dry matter (9189 kg ha^{-1}) in minor season and overall maximum total grain yield of 8.167 t ha^{-1} in major season. The weeds biomass harvested on no-tillage at varied weeding regimes were higher than those obtained from P+H treatments. In all, 3 hoeing regimes recorded least weed biomass yield of 61 kg ha^{-1} and 208.5 $kgha^{-1}$ in minor and major seasons respectfully as compared to 0-hoeing of 4559.33 kg ha^{-1} and 6971.5 $kgha^{-1}$ weeds biomass. An interactive effect of 0-hoeing on no-tillage treatments produced denser weed biomass of approx. 6.5 t ha^{-1} in minor season and approx. 9.1 t ha^{-1} in major season than 3-hoeing on P+H treatments at 0.015 t ha^{-1} and 0.081 t ha^{-1} at respective seasons. It is therefore postulated for the adoption of P+H at 2 hoeing regimes to maximize seasonal growth and yield parameters of maize at reduced weed density and biomass on the field.

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Conflict of Interest

Authors have declared that there is no conflict of interest.

Author Contribution

Authors contributed equally toward the study.

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