ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230**, ISSN (online):** 2412-3986**, DOI: http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Effect of Tillage Implement practices on Growth, Yield and Yield Components of Two Maize Hybrid (*Zea mays* L.)

Saefaddin Hassan Blbas[1], Abdullah fathi Younis [1]

1 Department of Field crop, College of Agriculture Engineering sciences, Salahaddin University-Erbil, Kurdistan Region, Iraq

A B S T R A C T:

The field experimental was conducted (2020-2021) at Trppaspyan village and Research center of Agriculture Ainkawa to evaluate the influence of different tillage systems with two cultivars in two locations on growth and yield of maize. The experimental design includes eight treatments with three replication and laid out in a Randomized Complete Block Design factorial. The treatments include: chisel plow (T1), moldboard plow (T2), harrow disc (T3), zero tillage (T4) with two cultivars. Each plot measured 30 m long x 3 m wide with spacing of 75 cm and distance plant to plant contain 20 cm between replicates. A tacks soil sample (30 cm) to test soil analysis in the Laboratory of Soil Science, Research center of Agriculture (Ainkawa). The data collected where analysis of variance (ANOVA) table after which significant mean values were separated using Duncan test at P <0.05) according SAS program and excel statistical program. The results of the study showed various tillage systems had no significant effect on the growth and yield parameters. Meanwhile, there was significant effect in some of growth parameters, as well as the grain yield of maize. It can be concluded that the effect moldboard plow and harrow disc implement of tillage systems due to improving growth and yield component of maize compared to other tillage treatments and decrease weed growth in arid lands.

KEY WORDS: Tillage system; Maize variety; locations; maize growth and yield component.
DOI: http://dx.doi.org/10.21271/ZJPAS.34.5.11
ZJPAS (2022) , 34(5);123-130 .

1.INTRODUCTION :

Corn (***Zea mays L.***) one of most important foods' crops in the worlds, maize is third cereal crop, after wheat and rice. Tillage system is one of most significant operations in the field to improve physical qualities of the soil, to development, and to increase vegetative growth sowing to the fracturing of layers under the surface soil (Atiya, A. H. 2005). When compared to zero tillage systems, (Muršec, B. and Čuš, F., 2003) found that seedbed preparations utilizing moldboard or chisel plough with or without deep tillage increased corn production. In corn, deep plowing using a chisel plow yielded greater grain yields than moldboard plowing Wasaya, A et al., (2011). Grain yields were usually greater in dry years but lower in rainy ones under no-tilled soil conditions Wang et al., (2011). Zero tillage maize yields just (4%) less than conventional tillage, but can save up to 82.6 percent in production expenses and boost soil microbiological activities (S. Koutiü, D. Filipoviü, Z. Gospodariü, 2001). Maize cultivated in (76 cm) row spacing had better yields than corn grown in (38 cm) rows, according to Farnham, D.E., (2001). Another study found that by reducing row width from 76 centimeter to (56centimeter and 38-centimeter), maize grain production improved by (2% and 4%), respectively (Widdicombe, W.D. and Thelen, K.D., 2002). Different on-farm participatory studies found little or no change in zero-till planted corn development and yield features when compared to conventional tillage planted maize (Hobbs, P.R. and Gupta, R.K., 2003). For high and long-term crop yields, additional studies have advocated prudent and balanced nitrogen, phosphorus and potassium fertilization paired with organic matter additions Makinde et al., (2001). Tillage is among the key causes of weed community assembly because

*** Corresponding Author:**
Saefaddin Hassan Blbas
E-mail: saefaddin.mohammed@su.edu.krd
Article History:
Received: 06/04/2022
Accepted: 28/06/2022
Published: 20/10 /2022

primary tillage simultaneously covers and encourages weed germinating seeds Cordeau, S et al., (2015), or secondary tillage systems kills the resultant seedlings, lowering seed density in the soil results by Schutte, B.J. et al., (2014). Weed plants, among other things, have the potential to drastically impair maize yield Abouziena et al., (2014). In addition, multiple studies have shown that maize-based conservation systems have much higher and more stable grain yield trends than conventional tillage systems (Thierfelder C et al., (2013). The aims to research determined: Effect of tillage systems on corn growth and yield components (Zea maize L.) and choosing the suitable tillage system with variety.

2.MATERIALS AND METHODS

2.1 Description of the study site:

The study was carried out applied in summer season 2021, in tow locations. The area is trppaspyan location at (G.P.S., Latitude = 35°59′18'' north (N), longitudinal: 43°56′18'' East (E), elevation (altitude): 341-meter Amsl and Ainkawa location at (Latitude = 36°14′32'' North(N), longitudinal: 43°59′33'' East (E), Elevation (Altitude): 415-meter Amsl for study the Effect of Tillage systems on growth, yield and yield components of Tow Maize hybrid (Zea mays L.,).

The experimental design was a Randomized complete block design factorial with three replicates. This research includes two factors, first factor was four different tillage systems while the second factor includes two seed variety mazes hybrid crops. cultivation seed varieties must be moisture seeds and the rates germination seed percentages (95 %). The supply of (NPK fertilizer) with seed cultivars, Dap (18 – 46 – 00) fertilizers, types; RAZY RUSI fertilizer materials. Pest and weed control were performed in the field by spryer machines.

2.2 Soil sampling and analysis:

These samples soil taken in soil the used to sieved mish size 2mm sieve, and then saved or stored for analysis because some physical and chemical properties to determined and the results data shown in table (1):

Table (1): Selected soil physical and chemical properties at the experimental sites:

Soil proprieties	Measurement		Depth soil: 30 cm	
			Trppaspyan	**Ainkawa**
Particle size distribution	**Sand (%)**	**g kg^{-1} PSD**	11	19
	Silt (%)		48	43
	Clay (%)		41	38
Soil texture			Silty clay loam	Silty clay loam
Organic matter	**g Kg^{-1}**		0.95	0.92
Electrical conductivity (EC)	**dSm^{-1}**		0.2	0.3
Total (Nitrogen)	**g Kg^{-1}**		0.07	0.11
Available (phosphorus)	ppm **(μg. g^{-1})**		23	6.4
Available (potassium)	ppm **(μg. g^{-1})**		110	196
pH (pH – meter)			7.91	7.82

The testing soils was conduct at the direction of laboratory by Ainkawa research center of Agriculture /Erbil. The tillage treatments contain (Chisel plow from one pass and Moldboard plow from four pass, harrow disc from one pass with Zero tillage treatment as direct drilling method, with tow cultivar seeds contains (DKC-6664 seed verity and Swan seed variety (Hybrid quality). The control pest and weeds were performed using to machines spryer in to locations.

The climate data was obtained from the meteorological in Ainkawa research center of Agriculture and meteorological station in the filed

– Ministry of Agriculture during of the study show (Table 2):

Table 2: Temperature, rainfall and relative humidity at the experiential sites during 2021:

Month	Trppaspyan site			Ainkawa site		
	Monthly rainfall (mm)	Average air temperature (C°)	Relative humidity (%)	Monthly rainfall (mm)	Average air temperature (C°)	Relative humidity (%)
July	0	37.1	13.5	0	36.12	13.82
August	0	36.4	14.2	0	35.41	14.20
September	0	30.0	19.8	0	28.87	19.68
October	4.2	24.4	26.3	0.5	23.01	26.17
November	4.2	17.4	46.0	5.4	15.67	43.26
Total	**200.5**			**210.8**		

2.3 Date collection in field:
The data collected in the field was measured and recorded all the following parameters:
Plant emergence, Plant height (cm), Stem diameter (cm), cob diameter (cm): number of ears per plants, number of rows per ears, number of kernels per row: Weight 1000 of grain (g), Grain yield (ton/h).

3.Result and discussion:

3.1. Effect of locations, cultivars and tillage system on growth characteristics of forage corn (Zea mays L.,):

Plant emergent:
A non-significant (P>0.05) differences affected of different locations on plant emergent during both studies show table 3 and Appendix 1.
The effect of different tillage treatments affected significant (P ≤ 0.0 5) on plant emergence, maximum mean values (14.59) were obtained from harrow disc treatment, show table 3 and Appendix 1.
A non-significant (P>0.05) affected of cultivars treatments on plant emergent during both studies show table 3 and Appendix 1.

Plant height (cm):
The effect of locations factors significant different (p<0.05) on plant height (cm) show table 3 and Appendix 1, the higher data value (234.89) was obtained Ainkawa location.
Table 3 and Appendix 1, presented effect different tillage treatments was found significant difference on plant height treatment, tallest plants data value contain (238.75 cm) were obtained from disc harrow.
The effect cultivations showed effect significant differences on plant height showed in Table 3 and Appendix 1, taller plant data value contain (240.22 cm) was obtained from swan seed treatment.

Table (3): Effect of factors on plant emergence and plant height during in year (2020 – 2021).

	plant emergence L/3m.	plant high l/m
Over all Mean	**13.89**	**231.47**

Location		
Trppaspyan	13.79 **a**	228.05 **b**
Ainkawa	14 **a**	234.89 **a**
Tillage system		
Chisel plow	12.71 **c**	227.93 **b**
Moldboard plow	13.7 **b**	238.56 **a**
Disc harrow	14.59 **a**	238.75 **a**
Zero tillage	14.57**a**	220.66 **c**
Cultivation		
DKC 6664 seed	13.73 **a**	222.73 **b**
Swan seed	14.0.5 **a**	240.22 **a**

Means with the same letter are not significantly different location, tillage systems and cultivars.

3.2. Effect of locations, cultivars and tillage systems on growth characteristics of forage corn (Zea mays L.):

Stem dimeter (mm):

Table 4 and Appendix 1, showed effect locations significant differences (P < 0.05) on stem diameter treatment, highest data value contains (21.52 mm) was obtained from trppaspyan location.

Effect tillage treatments on the stem diameter (mm) was found significant (P ≤ 0.05) show table 4 and Appendix 1, high data value (21.73 mm) was obtained from chisel plow treatment.

Effected cultivations on stem dimeter was found significant (P < 0.05) show table 4 and Appendix 1, the highest data value (22.38 mm) was obtained from DKC 6664 seed treatment.

Cob dimeter (mm):

The effect of locations on cob dimeter shows table 4 and Appendix 1, the mean value revealed significant differences (P < 0.05), highest mean values (51.94 mm) was obtained from trppaspyan location.

A non-significant (P > 0.05) that effected of different tillage treatments on cob dimeter during both studies show table 4 and Appendix 1.

As shown table 4 and Appendix 1, effect of cultivations on cob diameter was found significant difference (P ≤ 0.05) during both studies, highest mean values contain (51.55 mm) was obtained from DKC-6664 seed treatment.

Table (4): The effect of factors on stem diameter and cob diameter during year (2020 – 2021):

	Stem dimeter (mm).	Cob dimeter (mm).
Over all Mean	**20.78**	**50.56**
Location		
Trppaspyan	21.52 **a**	51.94 **a**
Ainkawa	20.03 **b**	49.18 **b**
Tillage system		
Chisel plow	21.73 **a**	50.39 **a**
Moldboard plow	20.48 **bc**	50.61 **a**
Disc harrow	21.3 **a**	50.33 **a**
Zero tillage	19.6 **c**	50.93 **a**
Cultivation		
DKC 6664 seed	22.38 **a**	51.55 **a**
Swan seed	19.18 **b**	49.58 **b**

Means with the same letter are not significantly different location, tillage systems and cultivars.

3.3 Effect of locations, cultivars and tillage systems on yield and yield components of forage corn (Zea mays L.):

Number ear per plant:

A significant effect of different location factors shows table 5 and Appendix 1, maximum mean value ear per plant (1.67 ear) was obtained from trppaspyan site.

A non-significance affected (P> 0.05) of different tillage treatments on number ears per plants show table 5 and Appendix 1.

A non-significant effect of different cultivation treatment on number ears per plant was found during summer season between experimental sites show table 5 and Appendix 1.

Number rows per ear:

Table 5 and Appendix 1, show effect significant of different locations on number grains row per cob, the highest mean values (16.5 rows) were obtained from trppaspyan site.

A non-significant (P > 0.05) effect of different tillage systems on the number grains row per ear of maize varieties during both studies show table 5 and Appendix 1.

Effect of cultivation on grain rows per ear was also found a significant show table 5 and Appendix 1, the higher mean values (17.17) was obtained from DKC-6664 seed treatment.

Number grains per row:

The effect of different locations on number of kernels per row show table 5 and Appendix 1, was found significant on grains per row, the highest mean values (38.68) was obtained from trppaspyan site,

A significant (P ≤ 0.05) effect of different tillage treatments on number of grains per row was show table 5 and Appendix 1, maximum mean values (39.43) was obtained from moldboard plow treatment.

show table 5 and Appendix 1, effect significant of different cultivation on grains per ear, the highest mean values (39.02) were obtained from swan seed treatment.

Grain yield (ton/h):

Table 5 and Appendix 1, clearly effect of different locations on grain yield was significant (P < 0.05) affected on grain yield, the highest mean values (11.13 ton/h) were obtained from trppaspyan site.

The effect of tillage treatment on grain yield was found significant difference show table 5 and Appendix 1, of experiment sites, the maximum data values (11.05 ton/h) obtained from moldboard plow treatment.

Effect of cultivars revealed was a significant (P < 0.05) on grain yield show table 5 and Appendix 1, the higher mean values (11.85 ton/h) were obtained from DKC-6664 seed treatment.

Weight 1000 of grain:

Table 5 and Appendix 1, revealed effect significant (P < 0.05) on weight 1000-grain of study, Increase the values (284.63 g) was obtained from trppaspyan location.

A significant effect of tillage systems on weight 1000 of grain show table 5 and Appendix 1, of study during summer season, the highest mean values (308.74 g) recorded from moldboard plow treatment,

Table 5 and Appendix 1, revealed the effect of cultivars treatments were significantly affected on weight 1000-of grain; maximum data values (309.38 g) were observed for DKC-6664 seed treatment.

Table (5): The effect of factors and their interaction on number of Ear corn per plant and heigh first ear per plant during year (2020 – 2021):

	ear/plant	Row/ear.	grains/row.	Grain yield (ton/h).	Wt.1000 grain
Over all Mean	**1.55**	**16.19**	**37.51**	**10.41**	**280.45**
Location					
Trppaspyan	1.67 **a**	16.5 **a**	38.68 **a**	11.13 **a**	284.63 **a**
Ainkawa	1.43 **b**	15.88 **b**	36.34 **b**	9.7 **b**	276.27 **b**
Tillage system					
Chisel plow	1.73 **a**	16.37 **a**	34.65 **c**	9.43 **c**	261.47 **c**
Moldboard plow	1.53 **ab**	16.38 **a**	39.43 **a**	11.05 **a**	308.74 **a**
Disc harrow	1.48 **b**	16.97 **a**	37.22 **b**	10.65 **ab**	275.05 **b**
Zero tillage	1.47 **b**	15.06 **b**	38.76 **ab**	10.51 **b**	276.52 **b**

Cultivation					
DKC 6664 seed	1.61 **a**	17.17 **a**	36.05 **b**	11.85 **a**	309.38 **a**
Swan seed	1.48 **a**	15.27 **b**	39.02 **a**	9.21 **b**	251.51 **b**

Means with the same letter are not significantly different location, tillage systems and cultivars.

4..Discussion:

In this research, response of corn forage to different sites and cultivation variety seeds, different tillage systems were investigation. The indicates growth and yield components of corn forage that includes: plant emergent, plant height, number ears per plant, stem dimeter, cob diameter, number rows per ear, number grain per rows, weight of 1000 grain and grain yield. The mean results show of locations was significantly ($P \leq 0.05$) effected on plant heigh, stem diameter, cob diameter, ear per plant, rows per ear, grains per rows, grain yield and weight 1000 of grain corn, but the effect tillage systems there was non-significant different in other growth and yield components include: plant emergent of forage corn among the different locations and tillage systems and cultivars show (Table 3,4,5). The high value plant emergence (14.59) obtained from harrow disc, so the best depth soils than the other tillage. The maximum mean values plant heigh (234.89) record from Ainkawa, while maximum values (238.75) obtained for harrow disc treatment. Meanwhile high mean values (240.22) were obtained swan seed treatment. The maximum means values stem dimeter (21.52, 21.73,22.38) was obtained from effect locations, tillage systems with cultivars, and the highest mean values cob dimeter (51.94, 51.55 mm) were recorded from effects locations, cultivars. The increase mean values ears per plant (1.67) obtained from factor in Trppaspyan location. The higher data values rows per ear (16.5, 17.17) was obtained from with locations and cultivar due to the high means value due to effect increase plant density or populations. Increase mean values grains per row (38.68, 39.43,39.02) recorded by locations, tillage systems with cultivars. While maximum data values grain yield (11.13,11.05,11.85) was obtained from locations, tillage systems with cultivars. Meanwhile the highest values weight 1000 of grains (284.63, 308.74,309.38) recorded locations tillage systems with cultivars, showed table (3,4,5). The highest values of grain yield from trppaspyan location du to by different climate condition and type of soils, the lowest grain yields du to significantly less nitrogen fertilizers effect of seed germination, root growth, plant population, plant density, due to pale plant corn forage. The plots under heavy-duty disc harrow tillage had the lowest yield of maize forage reported by Bayhan et al. (2006) trials. Weed control is crucial in corn fields since data reveal that if weeds are not managed, maize yield might be decreased by more than (80%) discovered by Baghestani et al., (2007). The findings by (Zamir, M. S. I et al., 2012), who discovered a greatly variation the number of grains per ear as a result of various tillage treatments. These findings are consistent with those of Ijaz, M. et al., (2015), who found that differences in plant population had a substantial impact on yield grain. The findings by Ram et al. (2010), who found no significant differences in maize production between zero and conventional tillage. These findings by (Dodd, J. 2000), who found that maize plant height rose as Phosphorus treatment increased. Wilhem, W.W et al. (2004), findings who found that tillage protection had a significant impact on maize germination, growth, and development. The researcher by (Vetsch and Randall, 2002), who stated that tillage system improves seed germination and resulted in earlier stand establishment compared to no tillage system. Likewise, employing different deep tillage techniques, reported by Sang et al., (2016) achieved non-significant results for number of grains per cob. The findings contrast of Anjum et al. (2014), who found no difference in stem diameter between tilled and non-tilled treatments. These findings by Wasaya et al. (2011), who found that tillage procedures had a significant impact on 1000-grain weight in deep tilled plots. These findings by Memon et al. (2011), who found that deep tillage yielded superior outcomes in terms of yield grain. These findings corroborate those of Gokmen, S. et al. (2001), who found that increasing nitrogen levels increased the number of grains per cob. Mkhabela, M.S. et al. (2001) found that high nitrogen levels due to increases 1000-grain weight, which is consistent with these results. Plant stem diameters of (25.37–31.32 mm) by report (Olgun, 2011) and the diameter (20.05–24.54 mm) by report Kuşvuran et al., (2015) were discovered in investigations done in diverse locales. With (0.6–1.6) found number of ears in various silage corn types, resulted by (Gençtürk, 2007).

Appendix (1): ANOVA table for growth and yield corn forage represented by mean square (MS):

S.o.v. v	df	Plant emergent	Plant high	Stem diameter	Cob diameter	Ear per plant	Row per ear	Grains per row	Grain yield	Wt.1000 grain
A	**1**	0.52 **Ns**	561.02 *	26.55 *	91.30 *	0.70 *	4.56 *	65.80 *	24.49 *	838.68 *
B	**3**	9.53 *	930.81 *	10.66 *	0.88 **Ns**	0.17 **Ns**	7.81 *	53.96 *	5.73 *	4820.48 *
C	**1**	1.27 **Ns**	3669.75 *	122.56 *	46.81 *	0.19 **Ns**	41.07 *	65.33 *	98.68 *	40193.03 *
AxB	**3**	5.022 *	903.11 *	1.41 **Ns**	6.39 *	0.83 *	2.61 *	12.09 **Ns**	1.78 *	228.23 **Ns**
AxC	**1**	0.053 **Ns**	208.75 *	3.36 **Ns**	0.14 **Ns**	0.03 **Ns**	1.20 **Ns**	36.05 *	15.77 *	713.18 **Ns**
BxC	**3**	0.11 **Ns**	837.38 *	26.12 *	35.75 *	0.67 *	1.76 **Ns**	31.87 *	1.10 *	1647.80 *
AxBxC	**3**	0.042 **Ns**	206.79 *	1.35 **Ns**	2.40 **Ns**	0.19 **Ns**	3.29 *	38.86 *	4.96 *	1360.09 *

A= locations, **B** = tillage systems, **C** = cultivars, **A×B** = interaction between location and tillage system, **A×C** = interaction between location and cultivars, **B×C** = interaction between tillage systems and cultivars, **AxBxC =** interaction between location, tillage system and cultivars.
N.s: non-significant *= significant at 0.05 probability levels.

5.Conclusion:

This research it can be concluded the indicates effect of different tillage systems and cultivation seed variety that indicates result effect moldboard plow and harrow disc implement of tillage systems due to improving growth and yield component parameters of maize compared to other tillage treatments and decreases weed.

Reference:

Abouziena, H.F., El-Saeid, H.M. and Amin, A.A.E., 2014. Water loss by weeds: a review. *International Journal of ChemTech Research*, *7*(01), pp.323-336.

Anjum, S.A., Ashraf, E.U., Tanveer, M., Qamar, R. and Khan, I., 2014. Morphological and phenological attributes of maize affected by different tillage practices and varied sowing methods. *American Journal of Plant Sciences*, *2014*.

Atiya, A. H. 2005. Effect of Irrigation and Tillage Systems on Movement of Water and Nitrates in Soil and Yield of Maize (Zea mays L.) M.Sc. Thesis - Soil Department - College of Agriculture, University of Baghdad.

Baghestani, M.A., Zand, E., Soufizadeh, S., Eskandari, A., PourAzar, R., Veysi, M. and Nassirzadeh, N., 2007. Efficacy evaluation of some dual-purpose herbicides to control weeds in maize (Zea mays L.). *Crop Protection*, *26*(7), pp.936-942.

Bayhan, Y.I.L.M.A.Z., Kayisoglu, B., Gonulol, E., Yalcin, H.A.R.U.N. and Sungur, N., 2006. Possibilities of direct drilling and reduced tillage in second crop silage corn. *Soil and tillage research*, *88*(1-2), pp.1-7.

Cordeau, St., Guillemin, J.P., Reibel, C. and Chauvel, B., 2015. Weed species differ in their ability to emerge in no-till systems that include cover crops. *Annals of Applied Biology, 166(3)*, pp.444-445.

Dodd, J.C., 2000. The role of arbuscular mycorrhizal fungi in Agro-and natural ecosystems. *Outlook on Agriculture*, *29*(1), pp.55-62.

Farnham, D.E., 2001. Row spacing, plant density, and hybrid effects on corn grain yield and moisture. *Agronomy Journal*, *93*(5), pp.1049-1053.

Gençtürk, F., 2007. A research possibility on growing some silage maize cultivars in Erzurum plain conditions.

Gökmen, S., Sencar, Ö. and Sakin, M.A., 2001. Response of popcorn (Zea mays everta) to nitrogen rates and plant densities. *Turkish Journal of Agriculture and Forestry*, *25*(1), pp.15-23.

Hobbs, P.R. and Gupta, R.K., 2003. Resource-Conserving Technologies for Wheat in the Rice–Wheat System. *Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts*, *65*, pp.149-171.

Ijaz, M., Raza, M.A.S., Ali, S., Ghazi, K., Yasir, T.A., Saqib, M. and Naeem, M., 2015. Differential planting density influences growth and yield of hybrid maize (Zea mays L.). *J. of Agri. and Environ. Sci*, *2*(3), pp.1-5.

Kosutiç, S., Filipoviç, D. and Gospodariç, Z., 2001. Maize and winter wheat production with different soil tillage systems on silty loam.

Makinde, E.A., Agboola, A.A. and Oluwatoyinbo, F.I., 2001. The effects of organic and inorganic fertilizers on the growth and yield of maize in a maize/melon intercrop. *Moor Journal of Agricultural Research*, *2*(1), pp.15-20.

Muršec, B. and Čuš, F., 2003. Integral model of selection of optimal cutting conditions from different databases of tool makers. *Journal of Materials Processing Technology*, *133*(1-2), pp.158-165.

Ram, H., Kler, D.S., Singh, Y. and Kumar, K., 2010. Productivity of maize (Zea mays)–wheat (Triticum aestivum) system under different tillage and crop establishment practices. *Indian Journal of Agronomy*, *55*(3), pp.185-190.

Sang, X., Wang, D. and Lin, X., 2016. Effects of tillage practices on water consumption characteristics and grain yield of winter wheat under different soil moisture conditions. *Soil and Tillage Research*, *163*, pp.185-194.

Schutte, B.J., Tomasek, B.J., Davis, A.S., Andersson, L., Benoit, D.L., Cirujeda, A., Dekker, J., Forcella, F., Gonzalez-Andujar, J.L., Graziani, F. and Murdoch, A.J., 2014. An investigation to enhance understanding of the stimulation of weed seedling emergence by soil disturbance. *Weed Research*, 54(1), pp.1-12.

Thierfelder, C., Chisui, J.L., Gama, M., Cheesman, S., Jere, Z.D., Bunderson, W.T., Eash, N.S. and Rusinamhodzi, L., 2013. Maize-based conservation agriculture systems in Malawi: long-term trends in productivity. *Field Crops Research*, *142*, pp.47-57.

Vetsch, J.A. and Randall, G.W., 2002. Corn production as affected by tillage system and starter fertilizer. *Agronomy Journal*, *94*(3), pp.532-540.

Wang, J.B., Chen, Z.H., Chen, L.J., Zhu, A.N. and Wu, Z.J., 2011. Surface soil phosphorus and phosphatase activities affected by tillage and crop residue input amounts. *Plant, Soil and Environment*, *57*(6), pp.251-257.

Wasaya, A., Tahir, M., Manaf, A., Ahmed, M., Kaleem, S. and Ahmad, I., 2011. Improving maize productivity through tillage and nitrogen management. *African journal of Biotechnology*, *10*(82), pp.19025-19034.

Widdicombe, W.D. and Thelen, K.D., 2002. Row width and plant density effects on corn grain production in the northern Corn Belt. *Agronomy journal*, *94*(5), pp.1020-1023.

Wilhelm, W. and Wortmann, C.S., 2004. Tillage and rotation interactions for corn and soybean grain yield as affected by precipitation and air temperature. *Publications from USDA-ARS/UNL Faculty*, p.66.

Zamir, M.S.I., Javeed, H.M.R., Ahmed, W., Ahmed, A.U.H., Sarwar, N., Shehzad, M., Sarwar, M.A. and Iqbal, S., 2012. Effect of tillage and organic mulches on growth, yield and quality of autumn planted maize (Zea mays L.) and soil physical properties.