

Crop Response to Different Mulch Type and Furrow Irrigation Methods in Major Irrigated Areas of Ethiopia: A Review

Gebeyehu Tegenu
Ethiopian Agricultural Research Institute Debre Zeit Agricultural Research Center
P.O.Box 32, Debre Zeit, Ethiopia

Abstract

The paper was focused on reviewing of different documents and research findings from studies conducted on interaction effect of different mulch type and furrow irrigation methods on different crop types on major irrigated area of the country. The coverage of the research findings conducted on mulch type and furrow irrigation method was between 2010 and 2021. Approaches followed on reviewing the papers on different mulch type and furrow irrigation methods were through reviewing journals from websites and research output reports. On this paper review, achievements of different mulch type for different furrow irrigation under diverse agro-ecologies are highlighted based on the current knowledge from available sources. Based on different findings the use of plastic mulch type was best option for both crop yield increment and soil moisture conservation. So in current research findings in order to use mulch for crop production purpose was best practice method due to year to year climate change and drought occurrences key solutions to avoid crop yield collapse and failure.

Keywords: mulch, furrow irrigation, crop

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Introduction

Irrigation is a vitally in meeting the food and fiber needs for a rapidly expanding world population (Howell, 2001). Know a day; the agricultural sector around the world is under more pressure for limiting its water use, not only because of increasing water demand, but also because of climatic changes and more frequent droughts (Homayonfar *et al.*, 2014). The challenge of feeding high population growth in the world in general and in developing countries in particular needs improvements in both water and moisture management in irrigated agriculture. To sustain the rapidly growing world population, there is a need to increase agricultural production (Howell, 2001). In irrigation water management and soil moisture conservation must be crucial to remove crop yield penalty and also crop water requirements. Special in arid and semi-arid area there is limiting amount of water source so in order to use that limiting amount water source soil water and soil moisture conservation is mandatory action using different mulching materials like plastic mulch, straw mulch and other local material. Effective management of available water resources (Awulachew *et al.*, 2010) for crop production requires the producer to understand relationships between soil, water, and plants. Knowledge about available soil water and soil texture can influence the decision-making process, such as determining what crops to plant and when to irrigate.

Many studies focus on the use of mulch in agricultural systems (Allison, 1973; Gaur and Mukeherjee, 1980; Monks *et al.*, 1997; Olasantan, 1999; Tolk *et al.*, 1999; Adekalu *et al.*, 2006; Sarkar and Singh, 2007; Głab and Kulig, 2008; Ortiz- Ceballos and Fragoso, 2003; Campiglia *et al.*, 2010; Fang *et al.*, 2010; Kumar and Dey, 2011). Mulching is an effective cropping method that is used widely in annual and perennial crops for saving water and increasing soil temperature (Zegada-Lizarazu and Berliner, 2011), as well as improving crop performance and weed control (Campiglia *et al.*, 2010). Mulching is an agricultural and horticultural technique in which very useful to conserve moisture, to improve the fertility and health of the soil, to reduce weed growth, to enhance the visual appeal of the area. Mulch may be permanent (e.g. plastic sheeting) or temporary (e.g. bark chips). It may be applied to bare soil, or around existing plants. In our country the use of mulch for crop production still not expanding and properly used. It may be not overblown shortage of water resource and not water costing systems.

MATERIALS AND METHODS

The material used for reviewing of such paper was different research conducted on different parts of the country and outputs on integrated effect of Mulching and Furrow Methods different crop types were reviewed.

This includes journals from online websites using www.google.com search and other useful materials

RESULTS AND DISCUSSION

Maize

Different mulch type and furrow irrigation methods have a significant improvement on maize yield indifferent research findings. Meskelu *et al.* (2018) reported that the analysis of pooled mean revealed that 1000-seed

weight was significant ($p < 0.05$) influenced due to different types of furrow irrigation water management methods. On the other hand, different mulching type had no significant effect on 1000-seed weight. The highest (347.1 g) 1000-seed weight was obtained at conventional furrow method and it was statistically similar with that of alternate furrow method. On the other hand, the minimum (304.3 g) 1000-seed weight was obtained at fixed furrow a condition which was statistically inferior to both conventional and alternate furrow method. On the other hand the analysis of pooled means and both season data revealed that different types of furrow irrigation water management methods influenced aboveground biomass and grain yield of maize highly significantly ($p < 0.01$). Maximum aboveground biomass (28.28 t/ha) and grain yield (6.29 t/ha) were observed at conventional furrow irrigation water application method. The maximum aboveground biomass and grain yield obtained at conventional furrow method were statistically superior to both alternate and fixed furrow methods. Contrary to this, minimum aboveground biomass (19.29 t/ha) and grain yield (4.20 t/ha) were obtained at fixed furrow irrigation method. The minimum aboveground biomass and grain yield obtained at fixed furrow were statistically similar with that of alternate furrow irrigation method. The highest aboveground biomass and grain yield of maize obtained at conventional furrow irrigation method lead to an improvement of 46.6 and 49.8% than the fixed furrow method, respectively.

The analysis of pooled means and both season data also revealed that different types of mulch on maize had a highly significant ($p < 0.01$) influence on aboveground biomass. Moreover, grain yield of maize was significantly ($p < 0.05$) affected by different types of mulch. Maximum aboveground biomass (22.59 t/ha) and grain yield (4.98t/ha) were observed at plastic mulching condition. The maximum aboveground biomass obtained at plastic mulching was statistically superior to both treatments which followed by straw mulching condition. Moreover, the minimum (20.73 t/ha) aboveground biomass obtained at no mulching condition was statistically inferior to both treatments. On the other hand, the maximum grain yield obtained at plastic mulching condition was statistically similar with that of straw mulch. Moreover, the minimum (4.67 t/ha) grain yield obtained at no mulching condition was statistically similar with that of straw mulch. The highest aboveground biomass and grain yield of maize obtained at plastic mulching lead to an improvement of 19.1 and 16.9% over the conventional non-mulching condition. The research conducted on wondogent research center showed that maximum above ground biomass and 1000-seed rate both on conventional furrow irrigation method and plastic mulch. This might be due to highest and adequate soil moisture content in the root zone leads to improve aboveground biomass and grain yield of maize.

Similarly the study conducted at were Werer Agricultural Research Center area revealed that above ground biomass production of maize was maximized ((24654.30 kg ha⁻¹)) with conventional furrow irrigation method and (7930.40 kg/ha) was obtained from white plastic mulch (Abebe et al. 2020). Those finding could be important information for the production of maize both using different mulch type and furrow irrigation method.so as the result showed that as the soil moisture more conserved the crop yield also increased where similar agro-ecology and soil type .alternative furrow irrigation method with plastic mulch were best practiced and option both in grain yield production and water use efficiency.

Table: 1. Means of yield and yield components (pooled mean).

(Meskelu E, et al.)	Treatment		PH	CD	CL	CWWS	CWWOS	AgBM	GY	TSW	WUE
	Irrigation type	CFI	155.7 ^a	4.67 ^a	17.12 ^a	190.2 ^a	48.5 ^a	28.28 ^a	6.29 ^a	347.1 ^a	1.15 ^a
		AFI	125.6 ^b	4.35 ^b	15.12 ^b	138.0 ^b	33.3 ^b	20.43 ^b	4.64 ^b	341.0 ^b	1.69 ^a
		FFI	121.9 ^b	4.27 ^b	14.71 ^b	126.2 ^b	31.0 ^b	19.29 ^b	4.20 ^b	304.3 ^b	1.53 ^b
	LSD 0.05		6.94	0.09	0.74	15.55	4.42	1.68	0.53	30.2	0.12
	Mulch type	Straw	134.9 ^a	4.43 ^b	15.52 ^b	149.5 ^b	36.1 ^b	22.59 ^b	4.98 ^{ab}	332.6	1.40 ^b
		Plastic	140.3 ^a	4.53 ^a	16.56 ^a	165.10 ^a	41.50 ^a	24.68 ^a	5.46 ^a	346.4	1.72 ^a
		No mulch	128.1 ^b	4.33 ^c	14.88 ^b	139.8 ^b	35.1 ^b	20.73 ^a	4.64 ^b	313.4	1.26 ^a
	LSD 0.05		6.49	0.09	0.74	15.55	4.42	1.68	0.53	NS	0.12
	CV (%)		4.8	2.04	4.7	10.3	11.8	7.4	10.5	9.1	8.10

Note a,b,c Letter with similar letter in the column are not significantly different; ns not significant at $p < 0.05$; CV: Coefficient of Variation; LSD: Least Significant Difference; CFI: Conventional Furrow Irrigation; AFI: Alternate Furrow Irrigation; FFI: Fixed Furrow Irrigation
 PH: Plant Height; CD: Cob Diameter; CL: Cob Length; CWWS: Cob Weight with Seed; CWWOS: Cob Weight without Seed; AgBM: Aboveground Biomass; GY: Grain Yield; TSW: Thousand Seed Weight; WUE: Water Use Efficiency.

Table: 2. Review on Means of yield and yield components of maize as influenced by main effects of furrow irrigation techniques and mulching materials

(Abebe <i>et al.</i> 2020).	Treatment		PH(cm)	AgBM(kg/ha)	GY(kg/ha)	WUE
		Irrigation type	CFI	230.70 ^a	24654.30 ^a	8193.00 ^a
		AFI	221.90 ^b	21970.10 ^b	7333.00 ^b	1.90 ^a
		FFI	218.49 ^b	21675.10 ^b	6859.00 ^b	1.78 ^a
	LSD 0.05		6.43	1937.20	531.80	0.16
	CV (%)		2.20	6.50	5.45	6.33
	Mulch Type	Straw	226.30 ^a	22907.10 ^{ab}	7403.40 ^b	1.58 ^b
		Plastic	228.59 ^a	23851.30 ^a	7930.40 ^a	1.69 ^a
		No mulch	216.20 ^b	21541.10 ^b	7051.70 ^b	1.49 ^c
	LSD 0.05		7.01	1415.80	458.10	0.09
	CV (%)		3.05	6.05	5.98	6.33
			NS	NS	NS	NS

Potato

In addition to maize, Potato (*Solanum tuberosum L*) production under different mulch type and furrow irrigation technique condition at Kulumsa was reported by Lindi *et.al.*, (2018).As Lindi *et.al* (2018) reported that interaction effect of different mulch type and irrigation method had not significantly affected plant height at $p>0.05$. The result observed that plant height ranges from 76.7 to 80.9cm under different furrow irrigation water application techniques and from 77.3 to 81.7cm under different mulch type. The result of potato yield showed that, different types of irrigation method highly significantly ($p<0.01$) affected potato tuber yield. Moreover, potato tuber yield highly significantly ($p<0.01$) influenced due to different mulch types used. The interaction effect of the two factors, furrow irrigation methods and mulch types, had a significant ($p<0.05$) effect on tuber yield of potato. The highest tuber yield of 44,866 kg/ha was obtained at conventional furrow irrigation method. On the other hand, the minimum tuber yield of 39,782 kg/ha was obtained at fixed furrow irrigation method which is statistically similar with the tuber yield obtained at alternate furrow method. The maximum tuber yield of 44,136kg/ha was obtained under different straw mulch application. The minimum tuber yield of 39,218 kg/ha was obtained at plastic mulch condition which was statistically similar with no mulch condition. The interaction effect showed that higher tuber yield of 50,452 kg/ha was obtained at conventional furrow irrigation water application technique under straw mulching. Under deficit treatments, the higher tuber yield of 41,942 kg/ha was obtained at alternate furrow irrigation under straw mulch.

Table 3 Review on effect of Integrated Mulching and Furrow Irrigation Methods on Potato Yield

Lindi <i>et al</i> (2018)	Treatments	TY(kg/ha)	ABY(kg/ha)	PH(cm)	WP(kg/ha)
		AFI(Alternative Furrow)	40352b	11600	75.98
	FFI (Fixed Furrow Irrigation)	39782b	12637	78.64	18.75a
	CFI (Conventional Furrow Irrigation)	44866a	12908	78.71	10.57b
	SM(straw mulch)	44136a	13685a	76.11	16.84a
	PM(plastic mulch)	39218d	11457d	79.89	15.22d
	NM (mulch)	41646ab	12003b	77.33	16.28a
	CV (%)	5.53	12.37	9.06	6.07
	LSD (0.05)	2506	1665	Ns	0.97
	REP	2965.41*	74.60ns	175.37	5.95*
	IM MS	6984.41**	428.92 ns	21.88 ns	207.25**
	MT MS	5441.32**	1213.18*	33.44 ns	6.04*
	IM x MT x MS	2000.75*	115.72 ns	7.74 ns	1.95 ns

Note: TY= Tuber yield, ABY= Aboveground Biological Yield, PH= Plant Height, WP= Water Productivity, CV= Coefficient of Variation, LSD= Least Significant Difference, REP= Replication, IM= Irrigation Method, MS= Mean Square and MT= Mulch Type

Onion

Research conducted on onion crop in Debre zeit Agricultural research center (Ashebir *et al* 2021) reported that results on different types of furrow method had a significant difference ($p<0.01$) on onion yield. The maximum Onion yield (39.5 t/ha) were observed at conventional furrow irrigation water application method. The maximum marketable Onion yield obtained at conventional furrow irrigation was statistically superior to both alternate and fixed furrow irrigation. However, minimum marketable yield (28.9 t/ha) were obtained at fixed furrow irrigation method. Therefore, the highest marketable yield of onion obtained at conventional furrow irrigation method lead to an improvement of 27 % while alternative furrow was 16% than the fixed furrow irrigation method.

In addition to different furrow irrigation method the different types of mulch on onion yield had highly significant ($p < 0.01$). Therefore, maximum marketable yield of onion bulb (37.1 t/ha) were observed at straw mulching condition but the maximum bulb yield obtained at straw mulching condition was statistically similar with that of plastic mulch. Moreover, the minimum (29.5 t/ha) marketable yield obtained at no mulching condition was statistically significant different with both straw and plastic mulching. So, the highest marketable yield of onion bulb obtained at straw followed by plastic mulching showed an improvement of 20% and 18% respectively over the conventional non-mulching condition.

On the other hand, (Temesgen, T. (2018) who reported that the highest marketable yield were obtained through black plastic mulch followed by straw mulch in Onion crop. Interaction effect of deficit irrigation levels by mulching exhibited a highly significant ($P < 0.01$) influence on the marketable yield. The highest marketable yield (47.25 ton ha⁻¹) was obtained from combined application of treatment received 100% ETc and plastic mulch whereas the lowest marketable yield (15 tonha⁻¹) was obtained from treatment received 50% ETc and no mulch. Based on different research conducted finding results reported that different results and conclusions. Like Lindi *et al*, (2018) on Potato and Ashebir *et al* (2021) on onion those reported that yield of potato and onion result showed minimum on plastic mulch.

Table 3. Reviewed Paper on Interaction effect of deficit irrigation levels and mulching techniques on marketable bulb yield and water use efficiency (kg/m³) of Onion

Treatment	Marketable bulb yield (ton/ha)					WUE (kg/m ³) of Onion				
	Irrigation level									
Mulch	100%ETc	80%ETc	70%ETc	60%ETc	50%ETc	100%ETc	80%ETc	70%ETc	60%ETc	50%ETc
PM	40.8 ^a	33.2 ^d	30.9 ^c	25.4 ^h	20.8 ^k	7.93 ^c	8.05 ^{bc}	8.48 ^a	7.15 ^f	6.95 ^e
SM	37.2 ^b	31.4 ^a	30.0 ^f	20.6 ⁱ	16.4 ^l	7.24 ^{ef}	7.62 ^d	8.19 ^b	6.72 ^h	6.34 ^f
NM	35.7 ^c	29.9 ^f	28.4 ^e	20.0 ^j	15.0 ^m	6.95 ^e	7.36 ^f	7.36 ^c	6.49 ^f	6.11 ^j
Mean	37.9	31.5	29.8	22.0	17.3	7.37	7.64	8.01	6.79	6.47

Table 4. Reviewed Paper on combined analysis of MBY in (t/ha) and WUE (kg/m³) of Onion.

(Ashebir <i>et al</i> , 2021)	Marketable Bulb Yield of Onion (MBY)					Water Use Efficiency of Onion (WUE)					
	Furrow type	Mulch type				Mulch type					
		No mulch	Straw mulch	Plastic mulch	Mean	LSD(0.05)	No mulch	Straw mulch	Plastic mulch	Mean	LSD(0.05)
CFI		34.65	41.81	42.04	39.50 ^a	5.45	5.01	6.04	6.06	5.70 ^c	5.45
AFI		29.51	37.47	35.81	34.26 ^{ab}		8.45	10.91	10.20	9.86 ^a	
FFI		24.38	32.00	30.24	28.87 ^b		7.07	9.15	8.71	8.31 ^b	
Mean		29.51 ^b	37.09 ^a	36.01 ^a			6.84 ^b	8.7a	8.32a		
LSD (0.05)		1.98					1.98				
CV (%)		4.51					4.51				

N.B. Treatments with similar letter in the column & also in rows are not significantly different; CV: coefficient of variation; LSD: least significant difference; CFI: conventional furrow irrigation; AFI: alternate furrow irrigation; FFI: fixed furrow irrigation; WUE Water use Efficiency MBY; Marketable Bulb Yield.

Conclusions

Different Research findings on different mulch type and furrow irrigation method on different crop type at different parts of the country recommendation should be used for different irrigation conditions like fixed furrow irrigation method, alternative furrow irrigation method and different mulch type like plastic mulch, straw mulch and no mulch conditions. Research findings revealed that different mulch type under different irrigation condition significantly produced higher yield of diverse crops. Various crops under different agro-ecology and soil type were significantly different in response to mulch type. So, application of higher thickness and more soil moisture conserving mulch material like plastic mulch could be best for more yield production. Some of are recommended straw mulch are higher than the plastic mulch.

Based on different findings most of research conducted on mulch type and furrow irrigation methods are not considered cost benefit and economic analysis of mulch type and the water conserved by using mulch. In addition to this like Wed management system special in plastic mulch the wed controlling system is very difficult when the plastic covered fully the plot area. Disease controlling system on straw mulch, mulch material standards different research finding are not mention the mulch type and rate. So when researches are conducted on mulch type should be mention mulch type special straw mulch type and in plastic mulch the thickness and also color type white or black. Although different research conducted in different parts of the country especially

in research centers when proposed research activities on mulch the mulching system should be mention like all of the plot covered or only root zone of the crop and mulch materials only one crop type or local easily available any mulch materials. Moreover, more study on effect of different mulch type option and furrow irrigation method should be studied. The findings clearly indicated the interactive effect of the moisture content conservation and furrow irrigation method has significant yield advantage over almost all the control treatment on different crop types. Generally this review aims to contribute towards the research conducted in our country based on mulch type and integrated with furrow irrigation method could be documented and also filling this gap as listed above by focusing on the use of mulch in irrigated area as a best water-saving practice.

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