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Water loss by weeds: a review

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Abstract : Water losses caused by weeds were and remain important constraints, worldwide, in raising the plant productivity and crop production. Thus, the objectives of this paper are to review the water loss caused by weeds and to discuss the potential of some applications for cutting these losses. Depending on the available literature review it could concluded that weeds need more water than many crops and many weeds are known to be "water wasters". Therefore, proper weed control raises available soil water for crop production. Some common annual weeds growing with crops transpires about four times more water than a crop plant and use up to three times as much water to produce a pound of dry matter as do the crops. Under water stress condition weeds can cut crop yields more than 50% through moisture competition alone. The competition between weeds and crops are depending on weed density, the plant's physical characteristics rather than the aboveground biomass. So, perennial weeds can be less affected by drought than annual weeds. Evaporation from the soil accounts 25–50% of the total water used, therefore a layer of mulch can cut evaporation by as much as 75%. Any weed management measure that leads to cut the loss water is important for the sustainable agricultural development. Soil mulching raise soil water storage (up to 41%), raised grain water use efficiency by 14% and cut water loss from 0 to 30cm soil depth. Water saving under plastic mulching was more than 50% compared to herbicides or hoeing treatments and the benefits of mulching to crop performance are raised under water stress
Keywords: *Water Loss, Mulching, Evapotranspiration, Aquatic Weeds.*

Introduction

One of the biggest challenges in agriculture is the management of water, widely considered the greatest limiting resource for crops[1]. This limitation is especially important in the arid environments. In the field, the cultivated plants and weeds take share in influencing the water balance[2]. Agriculture is responsible for 70% of all water use globally and water use efficiency (WUE) in this sector is low, not exceeding 45%[3]. The annual freshwater withdrawals for agriculture in 2001 amounted to 83 percent[4]. In Egypt, agricultural sector consumes about 85% of Egypt's freshwater[5,6], the cultivated land area was 3,277 ha in August 2013 and many irrigation water applied to farm land is consumed by evapotranspiration (ET)[7].

Weeds compete for water, cut water availability, and contribute to crop water stress[8]. Knowledge of weed transpiration (T) is important in assessing the competition of weeds against cultivated plants[9].

Weeds directly compete with crops for water leading to less water available for crops, where weeds are potentially responsible for 34 percent of crop loss worldwide[10]. Weeds consume water intended for crops, cause water loss by seepage through root channels, transpire water, and cut water flow in irrigation ditches, leading to higher consumption by weeds and more evaporative water loss[8].

About 10% of all plant species are weeds, or a total of some 30,000 weed species. Of these, 1,800 cause serious economic losses in crop production, and about 300 species plague cultivated crops worldwide[11].

Weeds are a major competitor for available soil water in crops or during fallow periods[12]. Therefore, proper weed control raises available soil water for crop production.

Water extraction pattern of weeds are more close to the root zone volume of a species rather than the aboveground biomass[13]. Also, plants with a deeper rooting system are less affected by drought than plants with shallower rooting systems, because they can more readily explore soil profiles for water[14]. For this reason, perennial weeds can be less affected by drought than annual weeds.

Water conservation is defined as minimizing the loss or waste, care and protecting water resources and the efficient use of water. There are many ways to conserve water. A layer of mulch can cut down evaporation by as much as 75 percent[15].

Knowledge of weed transpiration is important in assessing the competition of weeds against cultivated plants[9].

Competition for water occurs below ground between roots. The ability to absorb water is is related to rooting volume. But, not only are the dimensions (breadth and depth) of rooting zones important: so is water extraction[16].

To produce a unit of dry matter, weeds transpire more water than do most of our crop plants. In weedy fields, the soil moisture may be exhausted by the time the crop reaches the fruiting stage, which is often the peak.

Water requirement for the growth of weeds is mainly of interest from the stand-point of competition with the crop plant for the available moisture[17]. Weeds, like other plants, consume large quantities of water, and most of it is lost by transpiration to the atmosphere. He came to conclusion that weeds are need more water than many crops[18,19]. Weed control is even more important during years of water shortage. When moisture is in short supply, weeds can cut crop yields more than 50% through moisture competition alone. Some common annual weeds growing with cultivated crops use up to three times as much water to produce a pound of dry matter as do the crops[19].

Weeds caused high evapotranspiration (ET) rates comparable with the ET rates of com during its early development stage[20].

Using some applications such as soil mulching with plant wastes which are excellent alternative to synthetic mulches, bed planting method, transplanting rather than direct seed sowing method, and so on, can be used as measures to cut the water losses in agriculture.

Therefore the present review has covered a great deal about the reduction of water losses caused by weeds and shows the potential of some agricultural practices for cutting the water losses. Further investigation and research are needed in this concern.

1. Weeds and Water

Many investigators have reported a great loss in the water caused by weed infestation from different parts of the world. Weeds are potentially responsible for 34 percent of crop losses worldwide[10]. Fourteen of the world's worst weeds are C_4 plants, while 76% of the harvested crop area is with C_3 crops[21]. In drought situations C_4 weeds might also have advantages over C_3 crops under elevated CO_2. Water requirement for the growth of weeds is mainly of interest from the stand-point of competition with the crop plant for the available moisture[17]. It was reported that wild mustard weed transpires about four times more water than a crop plant[18].

The amount of water used varies among plant species because of differences in root characteristics and distribution in the soil[22]. Many weeds are known to be water wasters[23]. These plants are less sensitive to the much available water and they transpire or use much water each day. Weeds are a major competitor for available soil water in crops or during fallow periods. Therefore, proper weed control raises available soil water for crop production.

Cutting unnecessary evaporation and unwanted transpiration, particularly by weeds and other non-cropped biomass in waterlogged parts of irrigated fields, along water supply ditches and canals and in and along irrigation drainage pathways could conserve water beyond the farm[24].

Some annual weeds can emerge and produce seeds in less than 6 weeks [25]. With regard to water retention, timely control is essential because weeds may daily use 5 mm of water from a soil[26].

During a normal growing season, evaporation from the soil surface may reach up to 50% of ET [27]. High proper evaporation to ET, roughly amounted by 50% in crops such as *Z. mays*[22]. The E/ET ratio was 40.7% in the growing period for the control, and it was only 17.8–25.0% for treatments mulched with sand and gravel. Soil evaporation with non-mulching was reduced by 78.0–93.7 mm when plastic film was mulched on the gravel surface and by 16.9–26.3 mm with gravel mulching only[28].

2. Competition between Weeds and Crops on Water

In the framework of phytocoenosis, the cultivated plants and weeds take share in influencing the water balance[2]. Some annual weeds can emerge and produce seeds in less than 6 weeks[25]. Several factors contribute to the water loss that occurs in water-limiting environments, including weed density, weed species, weed root structure, weed physiology, and duration of weed growth[12].

For example, the consumptive use of water for lambsquarters weed(*Chenopodium album*) was estimated by 550 mm against 479 mm for wheat crop. It is attributable to weed can remove moisture from deeper depth of soil than crops[16]. In another study, common lambsquarters requires 658 pounds of water to produce one pound of dry matter, common sunflower requires 623 pounds, and common ragweed 912 pounds, compared with 349 pounds for corn and 557 pounds for wheat[19].

The physiology of a weed also is important in WUE and thus total water loss from the soil system. C_3 plants (i.e., wheat, barley and mustards) are estimated to be half as water-use efficient as C4 plants (i.e., sorghum, corn, and shatercane) [29]. Plants of the C_4 category contain an extra carbon-fixing step in the leaves that allow it to close its stomata during times of few water supply[30]. By regulating stomata, plants conserve water internally and continue biomass production under water-limiting environments. Weed C_4 plants produce two to three times as much high dry matter production for unit of water used, compared to weed C_3 plants[8]. The same figures can be expressed in gallons of water required to produce one pound of dry matter. Lambsquarters requires nearly 79 gallons of water to produce one pound of dry matter, and ragweed 109 gallons as compared with only 42 gallons for corn and 67 for wheat[19].

Lambsquarters, if it were conserved through adequate weed control practices, could produce a new 1.9 tons for acre of corn and 1.2 tons for acre of wheat. One common mustard weed uses as much moisture as four wheat plants[19].

Researchers and growers experience clearly points out a good weed control program in all crops when adequate water is available. One can imagine the seriousness under meager irrigation water[19].

Table 1. Transpiration ratio (T: R1) of various Crops and weed species[31].

Crops	T:R1	Crops	T:R1	Crops	T:R1	Crops	T:R1
Sorghum	304	Cotton	568	Sugar beets	377	Wheat	528
Corn	349	Sunflower	630	Soybeans	646	Dry beans	700
Weeds	**T:R1**	**Weeds**	**T:R1**	**Weeds**	**T:R1**	**Weeds**	**T:R1**
Pigweed	287	Lambsquarters	801	Gumweed	608	Ragweed	948

T:R1: Pounds of water transpired per pound of above-ground dry matter produced. Water weighs 8.34 pounds $gallon^{-1}$.

Weeds caused high ET rates, as shown in Table (1), comparable with the ET rates of corn during its early development stage[20]. Also, there was a gain in water storage above field capacity when the ground surface was mulched or weeds covered, while important decrease in water storage occurred duringthe corn growing season[20].

3. Weeds and Water Losses under Dry Land Condition

Weed control was important under dry land condition. Under dry land conditions, weeds usually cause the most severe reduction in yield the first two or three weeks of crop growth. Good pre-plant or pre-emergence weed control and early post-emergence weed control seem to be essential for maintaining or increasing yields[19].

4. Plant Factors Affecting Water Use Efficiency

4.1. *Weed Density*

Weed density is important in depletion of soil moisture and has significant negative effects on the WUE of crops. Raising weed density decreases soil water and crop yields, the competitive ability of different weed species at similar densities may not have the same influence on water use[32].

The competition between Palmer amaranth (*Amaranthuspalmeri* S. Wats.) weed and irrigated corn were evaluated[33], and they found that total water use by *A.palmeri* continually rose as densities rose from 0 to 8 plants per meter of corn row[33]. Therefore, WUE of corn continued to decrease withraising*A.palmeri* density resulting in corn yield losses from 11 to 91% as densityraise from 0.5 to 8 plants per meter, respectively. Although raising weed density decreases soil water, the competitive ability of different weed species at similar densities may not have the same influence on water use. The similar found was recorded with *Solanumnigrum*L. when growing with tomatoes, it cut significantly the soil water, while*S.nigrum*at a density of 1.6 plants per square meter did not reduce soil water[34].

4.2. *Plants Physical Characteristics*

The ability of a specific weed species to affect crop yield under few soil water may depend on the plant's physical characteristics, such as rooting structure and depth[12]. Also, plants with a deeper rooting system are less affected by drought than plants with shallower rooting systems because they can more readily explore soil profiles for water[14]. For this reason, perennial weeds can be less affected by drought than annual weeds.

4.3. *Root Zone Volume*

Water extraction by weeds is more closely related of root zone volume of a species rather than the aboveground biomass[13].

5. Aquatic Weeds

Many problem weeds that occur on the canals have the potential to use excessive quantities of water through extensive root systems and high transpiration rates. Plants on canal banks that have extensive root systems and transpire continually will cut the water available for irrigation. Weeds present in the canals and ditches also can obstruct water flow[35]. The total length of Egyptian networks (canals and drains) exceeds 47000 km, 31000 km canals and 16000 km drains[36], and the total ratio of infested canals with all types of weeds was 86.9% and drains had a ratio of 73.6%[37]. Reducing flow rate caused by excessive growth of submerged weeds was determined by 80% in some small canals[37]. Also, in Egypt the total water loss by ET from water hyacinth infested areas was estimated to be 3.5 billion m^3per year. This amount is enough to irrigate about a further 432km^2 (43200 ha) every year[38].

Water hyacinth causes 4 billion m^3 losses of water every year in Egypt, enough to sustain Cairo with water[39]. The total infested area is estimated to be 487 km^2 covering most of the drainage and irrigation canals in different governorates of Egypt, and about 151 km^2 covering lakes. It was estimated, for example, that a pond infested with one hectare of water hyacinth will produce up to 1.8 tons of dry mass a day. That rate of reproduction alone makes the weed almost impossible to control[40]. Water hyacinths grow will in hot water and in hot climate[8].

5.1. *Aquatic Weeds in Cultivated Plants*

The rice crop suffers severely from competition when infested by aquatic weeds during the first stage of growth. The losses may range from 30 to 60%[41].

5.2. Evaporation or Transpiration is the Main Problem in Water Loss

The aquatic weeds pose a big problem in water loss because it have higher transpiration rate. Indeed, several recent studies have shown that such water losses are 2, 3 or even 6 times higher in reservoirs covered in weeds than they are in open waters[42]. The water loss (evapotranspiration) caused by water hyacinth weed was estimated by about to be 2.5 and 13 times evaporation from that of a free water surface and the flow of water in canals is reduced drastically was 40 to 90% .

6. Weed Control Management

Proper weed management can be used to cut the water losses in agriculture. Therefore, in this section we will discuss with a great deal the potential of some agricultural practices for cutting the water losses. Further investigation and research are needed in this concern.

6.1. Time of Weed Control Management

From the jointing to the milking stage of winter wheat, retaining definite amounts of weeds, no matter which tillage method was adopted, could significantly increase the 0-20 cm soil water content, suggesting the soil water conservation effect of retaining weeds[44].

6.2. Mulching

Mulching soil with plant wastes or synthetic mulches is one of the management practices for cuttingsoil evaporation, raises water retention, rising water use efficiency (WUE) and weed control in crop fields. Mulching soil with plant wastes or synthetic mulches cut soil evaporation loss and raised WUE of crops[45]. Mulching is one of the management practices for rising WUE and weed control in crop fields[46].

6.2.1. Soil mulching Effects on Water Conservation

Evaporation from the soil makes up 25–50% of the total quantity of water used[47]. So, soil mulching prevents soil water evaporation, and thus helps retain soil moisture, raising water use efficiency and weed control in crop fields[46,48]. Mulch raised grain yield by 17%, aboveground biomass by 19% and grain water use efficiency by 14% compared with bare soil treatments[49]. The amount of moisture stored in the profile to a soil depth of 90 cm was significantly greater under polythene and straw mulch over bare and chemically mulched soil [48]. Ramakrishna et al.[48] added that at 30 days after sowing, the polythene mulch plots contained more water (67 mm in autumn–winter and 47 mm in spring) than the un-mulched plots, while straw mulched plots recorded more profile water 43 mm in autumn–winter and 37 mm in spring. Use of vertical mulching substantially raised soil water storage (up to 41%) under some conditions [50].

Mulching treatments significantly cut water loss from 0 to 0.30 m soil depth [46]. Also soil salinity (0–0.30 m) gradually increased through accumulation of salts in the surface layer after sowing regardless of mulching, but not-mulched soil seemed to accumulate more salts than mulched soil. Mulching is more beneficial to crop performance when there is water stress[51]. The less moisture depletion under the mulches was a result of prevention of contact between the soil and dry air, which reduced water loss into the atmosphere through evaporation[51].

6.2.2. Effects of Mulch Type on Water Save

Several types of mulches such as rice straw or husk, grasses, sedges, banana leaves, pseudo stems, shrubs such as Lantana, weeds, soybean, black gram, rice husks, sawdust, wheat straw, plastic film, wood, sand and oil layer have shown to be beneficial in cutting the water losses by weeds.

6.2.3. Organic Mulches

Mulching soil with plant wastes or synthetic mulches is one of the management practices for cuttingsoil evaporation; rising water retention, WUE and weed control in crop fields [45,48,50,52,53,54]. This also ensures a more even moisture distribution throughout the soil profile, which further improves water use.Organic mulches also improve WUE indirectly. As the mulch decomposes, humus is added to the soil, which raised its water holding capacity[54]. A mulch layer prevents weed seedling growth by inhibiting light penetration to the soil surface. Lower weed prevalence significantly improves WUE[55].

Rice straw mulch raise WUE; where Zhang[45] observed that mulching with straw cut soil evaporation loss and raised WUE of winter wheat in northern China. They also showed remarkable higher grain yield of wheat when grown along with irrigation. Favorable soil environment, lower weed infestation and higher groundnut yield were got by using straw mulch compared to no mulched treatment in Vietnam [48].

In Egypt, soil mulching with rice straw was useful and not expensive especially if the material was available in the farm to cut transportation cost[52]. Although cost of weed control with plastic mulching is apparently high, about L.E 600 feddan^{-1}, against L.E 500 for herbicides and L.E 300 for hoeing, it can be used for two seasons if handled. Water saving is most important in the desert areas especially in the vineyards using drip irrigation from deep wells, and water becomes the most expensive factor of production in such areas. It could be recommended to use plastic mulching in the infected vineyards for its economy, control of weeds, to protect the environment from pollution and most important to save water and raised the net income of the grower[52].

6.2.4. Mulching with Sand and Gravel

Mulching with sand or gravel reduce the E/ET ratio, where the E/ET ratio was 40.7% in the growing period for the control, and it was only 17.8–25.0% for treatments mulched with sand and gravel[28]. At the size of gravel; a12 mm gravel mulch had greater effect on water savings, by preventing evaporation, than a 6 mm layer, but water conservation rose no further with a 25 mm layer [56]. Soil evaporation with non-mulching was reduced by 78.0–93.7 mm when plastic film was mulched on the gravel surface and by 16.9–26.3 mm with gravel mulching only[28].

6.2.5. Synthetic Mulch

Plastic films, which are probably the most commonly used mulching materials other than crop residues, are highly effective for controlling evaporation[50]. With a 100% plastic cover on soil to prevent evaporation and rainwater infiltration, grain sorghum yielded 6.3 Mg ha^{-1} with 178 mm water use from soil. Ungeret al.[50] concluded that plastic film mulches control evaporation and improve crop production.

Water saving under plastic mulching was more than 50% compared to herbicides or hoeing treatments[52].

Conserve soil moisture through mulching is one of the important purposes. When soil surface is covered with mulch helps to prevent weed growth, cut evaporation and raise infiltration of rain water during growing season. Plastic mulch helps prevent soil water loss during dry years and sheds excessive water away from the crop root zone during periods of excessive rain fall. This can reduce irrigation frequency and amount of water[58].

In 0- 10 cm soil depth, the transparent polythene mulch apparently showed highest moisture (21.1%), followed by black (20.4%) and blue (19.2%) polythene mulch[59]. The lowest moisture (14.6%) was recorded in the control plot. Increased moisture retention capacity caused by mulching with polythene could be attributed to less evaporation from the soil. Because of vapours, the water was further trapped in the mulches, resulting in fog which again dropped into the upper soil layer.

6.2.6. Effects of Mulch Thickness on Water Save

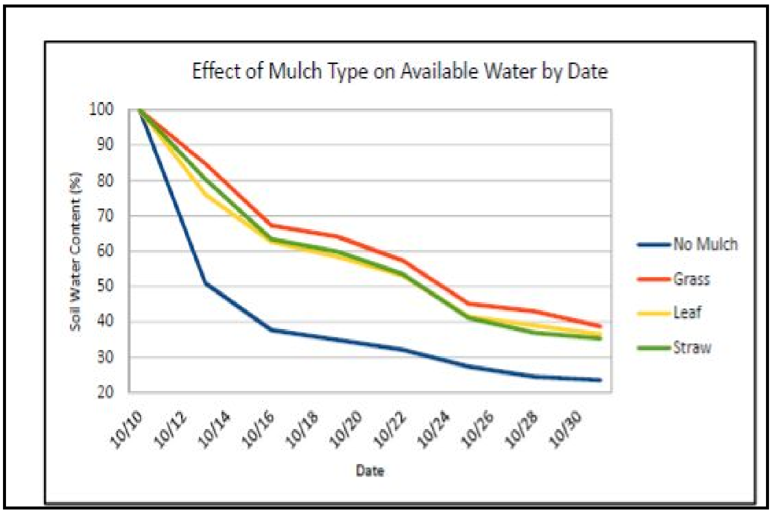

Figure 1.The effect of the three different mulch types on the soil water content[57].

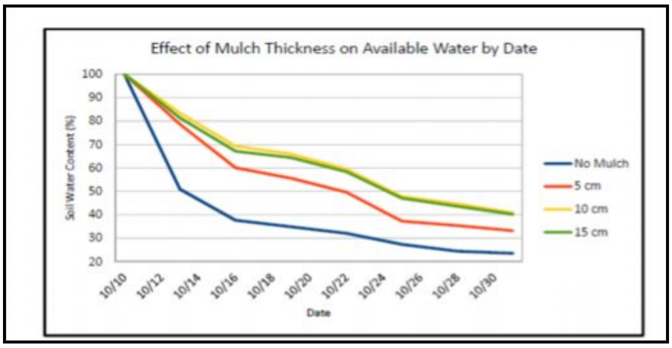

Figure 2.The effect of the three different mulch thicknesses on the soil water content[57].

Mulch thickness affected the water loss rate as shown in Figs. (1 and 2)[57], where doubling the mulching (Wheat straw, grass clippings, and leaf debris) rate from 5cm to 10 cm maintained soil moisture 10% higher. But, rising the mulch depth to 15 cm didn't significantly cut evaporation further[57]. They added that even a fairly thin layer of plant debris can conserve a considerable amount of water, especially right after an irrigation. In the first 3 days, bare soil lost half the moisture content, but soil covered with mulch layer of 5 cm lost only 20%.

That extra 30% would considerably improve the irrigation efficiency in a cropping situation, especially with shallow rooting plants such as vegetables and berries. Furthermore, the moisture is the soil is at a much lower tension, so it is much more easily absorbed by the crop.

The reduction in evaporation and maintains the humidity right at the soil surfacecaused by mulch may because of that mulch cut the amount of sunlight hitting the soil and prevents airflow which keeps the moisture in the soil [57].

The maximum mean percent soil moisture contents were observed at mulch treatment applied at 8 t ha^{-1} [60]as shownin Table (2). They added that rising the mulch rates from zero to 2, 4, 6 and 8 t/ha resulted in corresponding raises in dry stover yield by 19.0, 34.3, 63.4 and 83.5% respectively.

Table 2.Effect of mulch on average oil moisture content (%) in the top 0-15cm in experimental plots during 2007-2009 dry seasons [60].

Mulch treatments (t ha^{-1})	Soil moisture content (%)				Weed infestation (t ha^{-1})	Grain yield (t ha^{-1})
	3 WAS*	5 WAS	7 WAS	9 WAS		
0	12.5	7.6	10.1	11.9	2.09	2.16
2	14.8	9.5	13.0	12.9	1.01	3.48
4	16.4	10.9	14.1	14.0	0.89	4.05
6	19.3	13.1	17.8	15.2	0.31	5.52
8	21.9	14.8	19.6	16.8	0.18	5.69
LSD (0.05)	2.1	1.67	2.17	1.48	0.74	1.248

WAS: weeks after sowing.

6.3. Tillage

Tillage is common practice to control weeds, but tillage results in raises need for irrigation because of considerable water loss from the soil caused by evaporation from each tillage operation[61]. Thus, soil water content at plantings 50 percent higher in the herbicide plots compared to the tillage plots[62]. When tillage is used, exposing moist soil to the atmosphere may cause losses of 5 to 8 mm for each operation[63].

6.3.1. Tillage Effects on Water Conservation

Tillage practices that maintain crop residue on the soil surface were shown to raise maize yields in many studies and the yield raises were credited to raise water contents in the soil caused by cut evaporation [49].

Residue cuts evaporation of soil water mainly by shading the soil surface from the sun. Soils with stubble cover here cut wind velocities at the surface and temperatures, cutting evaporation from the soil surface.

Experiments at Akron, Colorado suggest that water losses were 1.5 times greater on bare soil compared to soils with 3,000 pounds of wheat straw[31]as shown in Table (3).

Table 3.Water losses from different operations 1 and 4 days after tillage[31].

Operation	1 day	4 days
	--- inches of water ---	
One way	0.33	0.51
Chisel	0.29	0.48
Sweep plow	0.09	0.14
Rod weeder	0.04	0.22

Tillage results in rising need for irrigation because of considerable water loss from the soil caused by evaporation from each tillage operation. Of the seven technologies, conservation tillage was the least costly through raising the cost per acre-foot of water saved. It is 80 times less costly than changing to irrigation equipment[62].

Raising conservation tillage practices yielded water savings of 2.0% of total irrigation water pumped[64]. Comparing moldboard, disk, rotary, sweep, and no-tillage treatments, soil water content rose during a fallow period following wheat averaged 3.50, 4.29, 3.35, 4.49 and 5.55 inches for the respective tillage treatments and averaged 3.82 and 4.65 inches for low and high residue treatments[65]. A water savings of 1.75 inches an acre per year was estimated from shifting an acre from conventional to conservation tillage with herbicide applications substituting for tillage operations. Raising conservation tillage from 50 percent of all irrigated acres in 2000 to 72 percent by 2060 was estimated to lead to a cumulative water savings over the 60 year period of 2.1 million acre-feet (682 billion gallons)[64].

6.3.2. No-Tillage

No-tillage considered one of agronomic practices used by farming for weed control and raising waterconservation. The ultimate conservation tillage system is *no-tillage*, which is a procedure so that a crop is planted directly into the soil with no primary or secondary tillage since harvest of the previous crop; usually a special planter is needed to prepare a narrow, shallow seedbed immediately surrounding the seed being planted[66]. The available soil water content in the soil 15- and 46-cm depths was greater each year in dryland grain sorghum [*Sorghum bicolor* (L.) Moench] with no-tillage compared to conventional tillage[67].

Shallow tillage had three advantages contained; control weeds and retain plant residues on the surface to protect the soil from erosion. A third goal was to retain surface residues to cut runoff, cut evaporative soil water losses, and conserve more water for the following crop[50].

6.4. Cultivar Selectivity

Use of aggressive cultivars one of the cultural practice for weed growth suppression [8,68]. Also some cultivars had a positive effect on water saving, however there is no available literature on the relationship between competitor cultivars with weeds and its potentiality to produce high yield with less water irrigation.

Depending on cultivar, SRI cultivar used 15–19% less water than CMP cultivar, a result of the system’s intermittent irrigation regime[69]. Short-duration cultivars require less irrigation, and the lowest water use under SRI was with NERICA 1 (783 mm), followed closely by S108 (785 mm) [69]. In CMP, these cultivars also had the lowest water use, though they received 170 and 195 mm more water, respectively, than in SRI.

6.5. Raised Bed Planting and Ridges Technique

Raised bed plantingand ridges systems have been used for weed control, increased WUE and plant productivity[70,71,72](Table 4). Raised bed planting helped in saving of 27% irrigation water and raising crop yield by 16.6% compared to flat planting under precision land leveling[67].

Table4.Effect of laser land leveling and planting techniques on water productivity of wheat[70].

Treatments	Average of total number of irrigations applied year^{-1}	Irrigation waterUse ($m^3 \cdot ha^{-1}$)	Irrigation water productivity ($kg \cdot grain \cdot m^{-3}$ water)
Precision leveling with raised bed planting*	4.5	2.403	2.15
Traditional leveling with raised beds *	4.5	3.103	1.57
Precision leveling with flat beds*	4.5	3.293	1.44
Traditional leveling with flat beds*	4.5	4.790	0.93
Traditional leveling with flat beds with o fertilizer as control	4.5	4.790	0.56
SE ±	—	13.88	0.04

* With recommended balanced nutrients (N120 + P26 + K50).

The minimum water use was observed in raised broad bed sowing[71]. In maize crop, after 4 years of experimental in farmers' fields, there were raises of 30%, 32% and 65% in grain yield, water saving and water productivity, respectively, under permanent raised beds compared to basins[71]. Similarly, permanent raised beds showed 13%, 36% and 50% higher grain yield, water saving and water productivity, respectively, for the wheat crop.

Weed infestation was also 24% and 31% lower for maize and wheat crops, respectively, under permanent raised beds, which maintained lower soil bulk density and high infiltration rates. Partial budgeting showed that raised beds generated 54% and 35% rose net benefit for maize and wheat, respectively. District farmers' experience with raised beds showed similar results, with 34% water saving, and 32% and 19% higher yields for maize and wheat, respectively. Raised bed and ridge sowing methods of wheat plantation saved 22.47 and 13.26% irrigation water, and significant higher wheat yield by 24.5 and 20.9%, respectively over flat sowing either by drilling or broadcasting[73]. The cost of cultivation was lower and net benefit cost ratio was higher in bed planting than conventional method of wheat plantation.

6.6. Role of Cover Crops in Weed Management and Water Quality

Some cover crops can improve weed control by raising mulch and allelopathically suppressing weed growth and may improve environmental quality, especially through protecting the surface water and groundwater, by cutting or in some cases ending the need for pre-emergence herbicides[74].

Cover crops are not classified as weeds, but they use water. Thus, their management about water retention is important, especially in drier regions where a delay in ending their growth may result in meager soil water retention for a following crop[75]. As a result, cover crops are not recommended for use under dry land conditions.

6.7. Effects of Chemical Weed Control on Water Conservation

Soil acting herbicides prevent some weed seeds from germinating and, therefore, cutout water use by such weeds, thus good water management contributed to lesser weed growth resulting in lesser weed density and biomass irrespective of treatment[76].

The soil water content at plantings 50 percent higher in the herbicide plots relative to the tillage plots[61,62]. Using herbicides to remove weeds without any tillageimproved soil water storage to 40 percent[61,62,77]. In minimum-tillage systems, herbicides are an important tool to control weeds and increase yields. Drier environments that rely on cut tillage systems to conserve water are often challenging environments in which to reach effective weed control[77].

With regard to water retention, timely control is essential because weeds may daily use 5 mm of water from a soil[26].

For the ET and water salvage (water available for other ecological operates), it was found that seasonal stand-level saltcedar water loss at an untreated control site ranged from 0.42 to 1.18 m/yr[78]. Seasonal water savings following application of imazapyr ranged from 31% 4 yr after treatment to 82% 2 yr after treatment.

Significant water savings may be reached by chemical saltcedar control, dependent on water use by replacement vegetation and saltcedar re-growth[78].

6.7.1. Disadvantages of Herbicides

Detectable residues of atrazine and alachlor in a small percentage were found in water wells[79]. Use of herbicides was effective in cutting the percentage of weeds but not recommended because environmental pollution and water loss from the barren soils is high. Repeated hoeing rose weed cover percentage, damage the fibrous roots and rose water loss[52]. With chemical weed control the need for tillage was cut and this resulted in accumulation of surface crop residues and leading to cut in soil erosion, raised conservation of water, and crop yields[80,81]. Weed populations are often cut in no-till systems because of less soil disturbance and more suppression of germination by accumulation of crop residues[80].

6.8. Pre-Planting Weed Management and Planting Date

Early planting of barley for forage can be an excellent addition to cropping systems as part of a multitactic approach for improved weed and water management[82]. Lenssen[82] added that early planting of zero tillage (ZT) barley resulted in excellent forage yields (7.3 kg ha^{-1}), small accumulation of weed biomass, averaging 76 kg ha^{-1}, and no weed seed production regardless of pre-plant weed management system. Early planting resulted in higher WU than delayed planting, averaging 289 and 221 mm, respectively.

7. Climatic Changes and water Loss by Weeds

Over the coming decades, global change will affect weeds. As mentioned before that 14 of the world's worst weeds are C_4 plants, while 76% of the harvested crop area is C_3 plants[21]. In drought situations C_4 weeds might also have advantages over C_3 crops under elevated CO_2. Elevated CO_2increase plant growth (above-and belowground) and improve plant water relations (reduces transpiration and increases WUE) [82]. Prior et al.[83] added that weeds often show greater growth responses to elevated CO_2 than do crop plants, which may be the result of weeds having greater genetic diversity and physiological plasticity than managed plants[84]. How rising CO_2 will impact weed management in horticultural systems is unknown. More knowledge in this area is required to develop best management strategies to deal with these potentially serious threats to productivity and profitability not only in horticulture, but for agriculture and forestry as well[82].

Conclusion

From the previous review it could be concluded that:

- The weeds are the major competitors for soil water with crops.
- The water amount used by an infestation of weed, if it were conserved through adequate weed control practices, could produce a more yield of each acre.
- Weed control is essential for water conservation purposes because weeds present before crop planting use soil water that could be later used by the crop.
- It is important to prevent or reduce unnecessary evaporation and unwanted transpiration by weeds in fields, irrigated fields, watercourse, canals and in and along irrigation drainage pathways.
- Improving water efficient use with using mulches that reduces evaporation and so conserves moisture for the crop. The organic mulches improve organic matter content and soil moistures status.
- Improving water efficient use through using bed planting techniques.
- Enhancing water flow in fields through sowing most crops (such as wheat) in holes on ridges.
- Adoption of nonchemical weed control application methods has been and will be an important part for improving water quality and the environment.
- Develop techniques for controlling the weeds before crop sowing or at early stage without using synthetic herbicides.

It might reasonably be argued that integration of approaches rather than single one could solve the water loss caused by weed infestation problem in substantially leading to satisfactory yield.

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