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Wheat Production as Affected by Weed Diversity and Other Crop Management Practices in Ethiopia

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Abstract: *Wheat is one of staple and major food security crops which can be cultivated from small to large scale farms in Ethiopia. Therefore, the aim is to determine influence of weed and other abiotic stresses on wheat production under rain fed and irrigated areas. It was rich sources of different nutrients which contain higher percentage of starch followed by protein and other types of nutrients. Traditionally, the crop is used for making bread, Dabokolo, porridge, Kinche and other types of foods. The straw is good source for animal feed and also used for thatching roofs in rural areas. Wheat production was limited due to various biotic and abiotic factors. Many varieties of wheat were released by agricultural research institute in Ethiopia that were suited for different soil types and climatic conditions. The crop competes with weeds for various growth resources like nutrient, light, Carbon dioxide, space, moisture etc. during its growth. The competition can be intra and inter specific completion. Planting densities can determine plant population in the field. Planting fewer seeds below the recommendation in the plots may exert severe competition of weeds but planting of higher seed rates created problem of lodging, disease infestation and rat damage. Increased plant density per unit area achieved by higher seed rates probably caused smothering of weeds and consequently reduced their dry matter. Weed competition is most serious when the crop is young and at active growth stage. Weed losses in wheat may occur from initial stages to the last stage of maturity, harvest, threshing, winnowing and storing of wheat grains. Weeds can be controlled by different methods but chemical weed control in wheat was best in producing higher grain yield than hand weeding. A wide variety of herbicides are available for both annual grassy and broadleaf weed control in wheat. Application of grassy and broad leaf herbicides increased grain yield and yield components of wheat. Several investigations were made for the management of weeds in wheat fields. Studies on annual weeds control in wheat was done by many researchers in Ethiopia as well as outside the country but still there is yield gaps. Therefore , further study on weed management in wheat will be needed for various weed flora throughout the country.*

Keywords: *competition; crop; plant; weed; wheat*

1. Introduction

Wheat belongs to the family Poaceae and the genus *Triticum*. The global annual wheat production is 731.6 million metric tons from an area of 215.87 million hectares giving an average yield of 3.39 metric tons ha^{-1}(USDA,2019).In Ethiopia, it is one of the major staple and strategic food security crop with an average annual production and productivity of 4.64 million tones and 2.73 tons ha^{-1} respectively (CSA,2018)**.**Wheat has great nutritional value and contains starch (60-90%),protein (11-16.5%),fat (1.5-2%),inorganic ions(1.2-2%) and vitamins (Ali *et al*., 2014). Bread wheat is known to be a major source of energy and protein. Traditionally the crop is used for making bread, *Dabokolo,* porridge, *Kinche* and other types of foods. The straw is good source for animal feed and is also used for thatching roofs (Mathewos *et al*.,2012).

Although wheat has a great nutritional and economic importance, its productivity has been constrained due to various biotic and abiotic factors(Haidar *et al*.,2014).Among the biotic factors weeds are one of the major constraints in wheat production as they reduce productivity due to competition, allelopathy and by providing habitats for pathogens as well as serving as alternate host for various insects, fungi and increase harvest cost (Abbas *et al*.,2009).Studies indicated that crop losses due to weed competition throughout the world are greater than those resulting from combined effects of insect pests and diseases (Amare *et al*.,2014).The yield loss caused by weed infestations in wheat ranges from 10- 65%

depending up on the weed species, their density and environmental factors(Gezu and Soboka,2001;Oerke and Dehne,2004). .

In Ethiopia, where wheat is cultivated, poor weed management and indefinite and below optimum plant population used by the farmers appear to be the major limiting factors resulting in low productivity of wheat (Zegeye *et al*.,2001).In most cases, wheat is grown in the country without appropriate seed rate, sometimes farmers use below optimum seed rate that resulted in poor stand establishment encouraging growth of weeds. On the other hand, higher seeding rate may exacerbate problems like lodging, insect and disease infestation and rat damage that harm crop yield (Bibi *et al*., 2008;Abbas *et al*.,2009).Therefore the aim of this article is to determine influence of weed and other abiotic stresses on wheat production under rain fed and irrigated areas.

2. WHEAT PRODUCTION CONSTRAINTS

2.1. Wheat Production and Ecology

In Ethiopia, wheat was planted to 13.38% (1,696,907.05 hectares) of the grain crop area in 2018/19 cropping season (CSA,2018).The production obtained from wheat was 15.17% (46,429,657.12 quintals) of the grain production and yield of 2.73 t ha^{-1} (CSA, 2018).Some of the common bread wheat varieties under production in Ethiopia includes: *Dendea, Digelu, Kekeba, Galema, Alidoro, Hidassie, Kubsa, Batu, Mitike, Wabe, Simba, Hawi, Warera, Dure, Dodota, Meraro, Abolla, Pavon, Dashen, Kenya -1, Densa, Simbo, Megal, Enkoy and Laketch* (HAR,2019).

Table1. *Wheat production regions of Ethiopia under private peasant holdings for 2018/19 Meher Season (CSA,2018).*

Regions	No of holders	Area of production (ha)	Production ton/ha	Yield ton/ha
Tigray	312708	107929.86	214003.14	1.98
Afar	-	-	-	-
Amhara	1645432	554661.74	1404707.481	2.53
Oromia	1713504	898682.57	2669917.77	2.97
Somali	-	-	-	-
BenishangulGumuz	8455	2455.71	5908.35	2.41
SNNP	525386	127246.59	34919.60	2.67
Gambella	-	-	-	-
Harari	3405	-	-	-

Wheat can be cultivated in a wide range of agricultural environments (Farooq *et al.*, 2009). It can grow over a wide range of elevations, climatic conditions, and soil fertility conditions. The crop is grown at an altitude ranging from 1500 to 3000 meters above sea level (m.a.s.l.) between 6-16°N latitude and 35-42°E longitude in Ethiopia. The most suitable agro-ecological zones, however, fall between 1900 and 2700 m.a.s.l. (Bekele *et al*., 2000). Even though the optimal growing temperature is 25°C, it can be grown in temperatures ranging from 3 to 32°C. The ideal daily temperature for different stages of wheat development varies from 20-25°C for germination, 16-20°C for good tillering and 20-26°C for proper plant development. The optimal rainfall for wheat is between 900-1100 mm throughout the growing season, but wheat can be grown in xerophytic to littoral moisture regimes with average annual rainfall between 250 to 1750 mm. Wheat can be grown under different soil types but well-drained fertile loamy to sandy loam soil with a P^H of 6 to 7.5 is suitable for its growth (Tana *et al*., 2018).

2.2. Common Weed Species Associated with Wheat

Wheat field infested by variety of weed species belonging to different families.The weed flora composition assessment in wheat fields in Ethiopia showed that *Avena abyssinica* L., *Avena fatua* L., *Bromus pectinatus* L., *Lolium temulentum* L., *Phalaris paradoxa* L., *Setaria pumila* L., and *Snowdenia polystachya* L. are the major problematic weed species in wheat growing regions (Birhanu, 1985; Rezene, 1985; Tanner and Grief, 1991).

The most widely spread and distributed broadleaved weeds and most problematic weeds in wheat crop weeds include: *Amaranthus hybridus* L., *Argemone mexicana* L., *Bidens pilosa* L., *Commelina africana* L., and *Chenopodium album* L. *Convolvulus arvensis* L.,*Datura stramonium* L.,*Galinsoga parviflora*

Cav., *Guizotia scabra* (Vis) Chiov, *Medicago polymorpha* L., *Polygonum nepalense* L., *Plantago lanceolata* L. and *Scorpiurus muricatus* L. (Rezene, 1985; Tanner and Giref, 1991).

2.3. Weed-Crop Competitions for Growth Resources

The word competition comes from the Latin word compete, which means to ask or sue for the same thing another does. Competition in biology, ecology and sociology is a contest between organisms, animals, individuals, groups, etc., for territory, a niche or a location of resources, for resources, mates, for prestige, recognition, awards or group or social status for leadership. According to Thompson, and Grime (1979) competition is established when neighboring plants use the same resources and success in competition is strongly determined by the plant capacity to capture these resources. Thus, a good competitor has a high relative growth rate and can use the available resources quickly. However, Tilman (1980) claims that competitive success is the ability to extract scarce resources and to tolerate this lack of resources – essentially to be more efficient in extracting and using a given resource. Competition between plants is different from the competition between animals. Due to the lack of mobility, the Competition among plants apparently is passive, not being visible at the beginning of the development (Munch *et al*., 2008). It is known, however, that crops in general terms do not present high competitive ability against weed species due to the genetic refinement they were submitted to increase the occurrence of desired productive features in detriment of aggressiveness (Ainsworth and Rogers, 2007). Therefore, in theory, a good competitor could be the species with least resource requirement (Radosevich *et al*., 2007).

In agricultural systems, both the crop and weeds grow together in the same area. As both groups usually demand similar environmental factors as water, light, nutrients and CO2, and usually these resources are not enough even for the crops, the competition is established. Under this situation, any strange plant which emerges at this area will share these limited resources, causing a reduction both in the volume produced by the crops, as well as in the quality of the harvested product (Munch *et al*., 2008). Radosevich *et al*. (2007) classified the environmental factors which determine plant growth in resources and conditions. Resources are the consumed factors such as water, CO2, nutrients and light, and the response of plants usually follows a standard curve: it is small if the resource is less available and maximum at the saturation point, usually declining again in case of excessive availability of the resource (e.g. toxicity due to excessive zinc availability in the soil). Conditions are factors not directly consumed, such as P^H and soil density, although they influence directly plant ability in exploring the resources. However, plant competition will only be established when the demand of a given resource by a plant community surpasses the ability of the environment in supplying the demanded level of the given resource (Munch *et al*., 2008).

2.4. Effects of Weed Competition on Growth and Yield of Wheat

Weeds are plant which compete for nutrients, space, light and exerts lot of harmful effects by reducing the quality as well as quantity of the crop if the weed populations are left uncontrolled (Alemaw and Agegnehu ,2019).Weeds cause diseases in crops and support the insect pests. In agricultural term weeds are called pests because they cause damage to the crop. Weeds may reduce about 40-50% grain yield in wheat crop .Among the factors, which adversely affect the yield of wheat crop, weed infestation is the most harmful one but less noticeable. Weeds comprise the most undesirable, aggressive and troublesome element of world's vegetation. Weeds are plants, which grow out of their proper places and whose virtue has not yet been discovered. Weeds also act as reservoir for multitude of pest and diseases, which use them as alternate hosts for food and shelter during the off season period. Weed density under both rained as well as irrigated conditions were studied for yield losses due to various densities of *Melilotus indica* L.(Oad *et al*., 2007)

Wheat is attacked by different agricultural pests, but weeds remained the major problem play the main role. Weed losses in wheat may occur from initial stages to the last stage of maturity, harvest, threshing, winnowing and storing of wheat grains. Weed plants are more resistant, hardy and making faster growth than wheat and cause great growth and yield loss due to competition before crop harvest. Generally weeds reduce wheat yield by30-50%.Losses may reach 100% depending on weed species and density (Tessema and Tanner, 1997). However, different workers reported different estimations of wheat yield losses depending on the infesting weed species, crop cultivar and their densities and the agricultural practices employed.

2.5. Critical Period of Crop-Weed Competition in Wheat

Critical period of crop-weed competition (CPC) represents the time interval between two separately measured components; the maximum weed-infested period or the length of time that weeds which have emerged with the crop can remain before they begin to interfere with crop growth, and the minimum weed-free period or length of time a crop must be weed-free after planting in order to prevent yield loss. Competition may be interspecific between two or more plants belonging to different species of weeds or crops or intraspecific between plants of the same species which may be crop or weed species (Tana *et al*., 2018).Weed competition is most serious when the crop is young and at active growth stage.It is essential in reducing weed control expenses. Weeds at this period must be removed by any mean or in economic language it is the shortest time span in the ontogeny of crop growth when weeding result in the highest economic returns.It is determined by crop species and cultivars, weed species and density, agricultural practices employed and prevailing environmental conditions.

Terefe *et al*. (2016) reported that the critical periods of weed competition in wheat ranges between 15-45 days after sowing (DAS) and also the critical weed competition period in wheat is 30 to 60 days after sowing. It occurs between 32 to 40 days after sowing and between 30-50 days after sowing (Chaudhary*et al.*,2008).The critical period of weed-crop competition generally lies approximately between equal to the first one-third to one-half of the life cycle of the crop. Therefore, weeds that are present before or emerge after this period do not cause significant yield losses. Thus, crop yield obtained by weeding during critical period of weed competition is almost similar to that obtained by the full season weed–free conditions (Tana *et al*., 2018).

2.6. Effects of Seed Rates on Weed Management and Productivity of Wheat

Optimum seeding rate is essential in determining the size of weed infestation in the field. This rate means ideal number of wheat plants per unit area that allow highest yield and smothering of weed. It is well established that yield increased with seeding rate up to a certain rate level after which no more increase obtained per plant basis while increasing rate per unit area is greatly decreased or kept steady or unchanged after certain plant density. The concept was termed as "the constant final yield”. Optimum seeding rate minimize the space available between plants and rows which may be occupied by weeds. However, farmers should not exceed this rate in order to avoid any intraspecific competition effects of crop plants (Rao and Nagamani, 2010).

Planting fewer seeds may increase weed growth. GeneralIy, high seeding rates should be increased when seeding is delayed beyond the optimum dates to compensate for reduced tillering (Shah *et al*., 1994).Row spacing is in direct link with seeding rate and availability of water and nutrients. Under low soil moisture and fertility level planting distance between plants and rows may be increased to allow enough space to be exploited by individual crop plant. This however, opens the way for weed invasion and occupation of space available.

Weed control by hoe or herbicides should be implemented between rows. Wide rows associated with low seeding rate allows more crop tillering and facilitate mechanical weed control. Removed weeds vegetation may be laid into between rows (soil cover) to prevent any subsequent weed seed germination or growth. However,when moisture and nutrients are unlimited, narrow rows and increased crop density offer advantages for weed control. Emerged weed seedling strongly suffered from both shading and competition effects of tall growing wheat plants. Narrow + row spacing can improve weed control during the fallow periods because weeds are smaller and more easily controlled with herbicides than they are in wide row (Derksen *et al*., 2002).

Bhan *et al*. (1987) concluded that increasing seedling rate from 100 to150 kg ha^{-1} significantly reduced the dry matter of weeds and increased grain yield of wheat. Nazir *et al*. (1987) reported that 100 kg ha^{-1} was the most effective in producing taller plants and higher yield as compared to low seedling rate. Mennan and Zandstra (2005) reported that decreasing the seeding rate from 250-200 kg ha^{-1} decreased wheat yield in the presence of weed.

Sharma and Singh (2011) found that Weed population was significantly lower in crop sown at higher seed rates of 150 kg and 125 kg/ ha as compared to recommended seed rate of 100 kg seed/ha and lowest seed rate of 75 kg seed/ha though the differences between higher seed rates of 150 kg/ha and 125 kg/ha were statistically at par with each other. Increased plant density per unit area achieved by higher seed rates probably caused smothering of weeds and consequently reduced their dry matter. Further, successive increments of seed rate from 75 to 150 kg/ha significantly reduced dry matter accumulation of weeds. Seed rate of 150 kg/ha reduced 6.5, 13.6 and 30.3% in the first year and 3.2, 8.2 and 19.4% in the second year, dry matter of weeds compared to 125, 100 and 75 kg Seeds /ha, respectively.

Gill (2008) also observed that seed rate influenced the weeds dry matter effectively as the seed rates increased, the competition among crops increased which shows excellent smothering effect. Wheat seed rates significantly influenced grain and biomass yield, spike per unit area and kernel weight. Haile and Girma (2010) found that increasing seed rate over recommended (150 kg ha^{-1}) by 25 and 50% to 187.5 and 225 kg ha^{-1} increased wild oat control efficacy by 16.9 and 21.5% respectively. Similarly, maximum weed control efficiency under 150 kg/ha seed rate and minimum under 75 kg/ha seed rate .Sharma and Singh (2011) concluded that sowing at 125 kg seed/ha with post-emergence application of sulfosulfuron at 25 g/ha at 30 DAS is the most economical and efficient weed management practice for achieving high yield in wheat. Marwat *et al.* (2011) observed that integrating line sowing with higher seed rate (150 kg ha^{-1}) and herbicides (Buctril super) could suppress weeds.

2.7. Effects of Herbicide Application on Weed Management and Productivity of Wheat

Herbicides should be used in combination with good preventative, physical and cultural practices. A wide variety of herbicides are available for both annual grassy and broadleaf weed control in wheat. The effectiveness of the herbicide will depend upon a number of application and environmental factors. Most herbicides are recommended at a range of rates either to facilitate control of weeds in a window of growth stages or under differing densities. Weed control is always easier and less disruptive to the crop when done at an early growth stage on the weeds. Decreasing the water carrier volume can increase the danger of spray drift result in inadequate coverage of the weed species and cause yield damage. According to Tanner and Grief (1991) broadleaf herbicides in the first decade of research as the phenoxy compounds provided adequate control. Subsequent to the shift in the weed spectrum towards phenoxy-tolerant broadleaf species, broadleaf herbicide screening increased in the early 1980s.

On the other hand, reliance solely on chemical weed control involves excessive use of herbicides, resulting in pollution of the environment and inter and intra-specific shifts (Hassan and Marwat, 2001) due to the development of more competitive herbicide-resistant biotypes within a plant population or community (Shrestha *et al.*, 2010).In addition, herbicide use reduces N-uptake in wheat (Azad, 1997) leading to low growth and yields. This is especially true in the case of non-selective herbicides as reported by Malhi *et al*. (2007) who observed a significant reduction in plant N uptake in wheat by applying a mixture of non-selective (glyphosate) and selective (2,4-D) herbicides. For most infestations, the selective use of herbicides is necessary. However, the uses of herbicides in conjunction with cultural and mechanical control methods usually result in the most effective management of weeds (Egan *et al*., 1993).

Ahmad *et al*. (1993) observed that herbicides application decreased dry weight of weeds significantly compared to dry weight in non-treated plots. Chemical weed control in wheat was best in producing higher grain yield than hand weeding. Akhtar *et al*. (1991) found that application of grassy and broad leaf herbicides increased grain yield and yield components of wheat.

Several investigations were made for the management of weeds in wheat fields. Studies on annual weeds control was done by many researchers in Ethiopia as well as outside the country. Accordingly, Dawit *et al*. (2014) was found that Pallas 45 OD had better weed control efficiency of broad spectrum especially for controlling serious weeds like *G. palviflora* , *G. scabra* and from grassy weeds *Avena fatua* L., *P. paradoxa* and *Phalaris minor* L. which were serious at Babicho and Faate. Move over, the highest weed suppression were from the combination of Pallas 45 OD with 2, 4-D and twice hand weeding followed by Derby +Pallas 45 OD and the highest was from weedy check and single herbicide application either for grass or broad leaf purposes (Zahara and Shigute,2017). The results of the present investigations we conclude that: annual weed species like *Amaranthus hybridus* L.*, Argemon Mexicana* L.*, Bindens pilosa* L.*, Commelina benghalensis* L.*, Datura stramonium* L.,*G. parviflora* , *G. scabra* , *P. lanceolata* and *Xanthium strumarium* L. were highly managed by these sequential herbicides application (Zahara and Shigute,2017). Megersa *et al*. (2017) observed various weed species such as *G. scabra* , *P. nepalense* ,*S. arvensis*, *R. raphanistrum*, *Achyranthes aspera*, *A. fatua* and *S. pumila* were effectively controlled by the application of Pallas 45 OD. It was also found that Pallas 45 OD decreased weed density by 79.8% and 81.8% at Shambo and Gedo, respectively. Pallas 45 OD was more effective on controlling broadleaved weeds which reduced the weed population as compared to 2, 4-D and also it can control serious grassy weeds on wheat (Bekele *et al*., 2018). In addition to this, the application of 2, 4-D EE¼ ha^{-1}+1/4 lha^{-1} Pallas 45 OD has better herbicide efficacy could be the best option for weed management for wheat production. The grain yield of the Pyroxulam treatment was higher than the hand weeding treatment in all districts which could be due to the effectiveness of the herbicide in reducing weed competition at all stage of the crop. Wild oat control efficacy was varied highly among the herbicide rates and application timings. It was found that application of Topic 1 L ha^{-1} is more effective in controlling the target weed species.

3. Conclusion

Wheat is one of the major staple and strategic food security crops in Ethiopia. It can be grown over a wide range of elevations, climatic conditions, and soil fertility conditions. Among the biotic factors weeds are one of the major constraints in wheat production as they reduce productivity due to competition, allelopathy and by providing habitats for pathogens as well as serving as alternate host for various insects, fungi and increase harvest cost .The yield loss caused by weed infestations in wheat ranges from 10- 65% depending up on the weed species, their density and environmental factors. Wheat field infested by variety of weed species belonging to different families. Weeds compete with crop for various resources. Competition is established when neighboring plants use the same resources and success in competition is strongly determined by the plant capacity to capture these resources. Weeds may reduce about 40-50% grain yield in wheat crop .Among the factors which adversely affect the yield of wheat crop, weed infestation is the most harmful one but less noticeable. Critical weed competition period in wheat is 30 to 60 days after sowing. Optimum seeding rate is essential in determining the size of weed infestation in the field. Increasing seedling rate from 100 to 150 kg ha^{-1} significantly reduced the dry matter of weeds and increased grain yield of wheat. Weed can be controlled by different methods but chemical weed control in wheat was best in producing higher grain yield than hand weeding. A wide variety of herbicides are available for both annual grassy and broadleaf weed control in wheat. Application of grassy and broad leaf herbicides increased grain yield and yield components of wheat. Several investigations were made for the management of weeds in wheat fields. Studies on annual weeds control in wheat was done by many researchers in Ethiopia as well as outside the country but still there is yield gaps .Therefore, further study on weed management in wheat will be needed for various weed flora throughout the world.

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