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Effect of Critical Period of Weed Competition and Its Management Option in Sweet Corn [*Zea mays* (L.) *var. saccharata strut*] Production: A Review

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ABSTRACT

Sweet corn [*Zea mays* (L.) *var. saccharata strut*] is the most important variety of maize with high sugar content. It contains a glossy sweetish endosperm and primarily grown for human food. It requires moderately high temperature from 22°C up to 33°C, high light intensity and adequate and well distributed rainfall of not less than 200mm during growing season. It can be grown on the wide range of soils. However, it performs best on neutral, well drained, well aerated and moderately heavy, deep fertile soils. Sweet corn is not so much competing with weeds like other crops. Avoid the influence of weed competition on the growth and development of sweet corn produce maximum yield and the economic importance of sweet corn used for conception and health benefits. By so far it is good in health and as medicinal uses it should be managed without affecting by weeds. The weed management option properly controls by the method of mechanical, biological, chemical and integrated weed management. In general, it is significant that properly controlling critical period weed competition in sweet corn reducing the competition of light, water, nutrient and space and maximizing the yield of sweet corn.

Key words: Critical period, Production, Sweet corn, Weed competition, Weed control.

Background and justification

Sweet corn [*Zea mays* (L.) *var. saccharata strut.*], is a type of maize which belongs to the grass family, Gramineae and is known as corn. Sweet corn first found in its niche in the preparation of Mexican and South American bear. Although field corn is generally harvested at the green immature stage and there is considerably interest in sweet corn for local fresh marketing and processing (Dechasa, 2010).

The production of high yield of acceptable quality ears of sweet corn is possible and profitable in Trinidad and Tobacco. However, development of disease resistant cultivars and weed control activities are required. Sweet corn is the most valuable of corn grown in the United States of America. It often referred to as "KING" of the grain crops because its production and value are greater than that of wheat, barley, oat, rye, rice and black wheat. Although corn is widely grown in the USA, the greatest production is an area of the mid-western state called the Corn Belt. Most sweet corn grown in the USA is fed to livestock (Knezevic and Datta, 2015). Sweetcorn has to allow fiber content, high in carbohydrate content and oils and most important palatable of cereals. The production cost of sweet corn is many areas of the world are attributed mainly to high labor input for harvesting and crop production practices including weed control. The identification of the effective weed control practice for sweet corn is very important since further weeding after the critical periods of weed competition only result in higher production cost (Chauhan and Johnson, 2011). In Ethiopia sweet corn is growth chiefly between

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elevation of 1500-2200 meters and requires large amount of rainfall to ensure good harvest. It is particularly important in south western of Ethiopia with oromiya region which producer the largest amount of yield. In our country the main growing season of sweet corn is from June up to October when there is high average rain fall is present and harvested period is from December up to February when average rain fall is very low or dry conditions (Mima and David, 2012).

The season-long weed competition caused considerable yield loss in Sweet corn (Khatam *et al*., 2013) weed reduce crop yield by competing for light, water, nutrient and carbon dioxide, interfere with harvesting and increase the cost involved in crop production (Shantveerayya and Agasimani, 2012). If weed growth is minimized during critical period of crop weed competition, the yield can be equivalent to that of weed free yield.

Sweet corn production suffers from a number of problems, include limited availability of hybrid seeds due to limited seed multiplication capacity; low profitability of the crop mainly arising from a combination of factors such as low fertilize efficiency, the use of poor agronomic practices low grain prices; and lack of irrigation system. One of the serious problems that is responsible for the reduction of sweet corn yield is weed infestation.

Objective

To review the effect of critical period of weed competition and its management option in sweet corn production.

Litererature review

Origin and botany of sweet corn

Sweet corn originated under warm, seasonally dry conditions of Meso America. The center of origin for Zea mays has been established as the Mesoamerican region, now Mexico and Central America of the south western United States, Mexico and Central America (CSA, 2013).

Sweet corn (*Zea mays*) is a thick-stemmed annual grass, usually with a single stem, one to four meters tall, with one or more tillers. It is monoecious and diclinous, with male and female inflorescences born separately on the same plant. Sweet corn is an annual grass plant ranging in height from 40 cm up to five meters with a diameter of between five and six centimeters. It is woody and filled with sweet corn pith and with nodes and internodes that can commonly be around 20 cm each (Steven *et al., 2*014).

Sweet corn has shallow, fibrous roots that grow to a maximum depth of only 50 cm. Aerial, adventitious roots also form at the nodes at the base of the stem. Sweet corn leaves are very large (up to 10 cm wide and 1 m long) and sheath-like (at their base they wrap round the stem) with a flat, extended blade in the shape of a strip with parallel veins. Under these leaves and close to the stems, the ears grow (Jean, 2003).

Production status of sweet corn

Sweet corn is a cereal crop which is cultivated widely throughout the world and has the highest production among all the cereals. The worldwide production of Sweet corn was more than 960 Million Metric Tonnes in 2013/14. It is an important food staple in many countries and is also used in animal feed and many industrial applications (Rosegrant *et al.,* 2008). Sweet corn is one of the most versatile crops having wider adaptability under varied agro-climatic conditions. Globally, Sweet corn is known as queen of cereals because it has the highest genetic yield potential among the cereals (FAOSTAT, 2010).

USA is the largest producer of Sweet corn and contributing nearly 35% of the total production in the world. States has a large Sweet corn surplus, which also makes it the largest Sweet corn exporter. Brazil, Ukraine and Argentina are the other key Sweet corn producing countries after USA. Sweet corn is by far the largest component of global coarse-grain trade. Most of the Sweet corn that is traded is used for feed; smaller amounts are traded for industrial and food uses. Japan has negligible Sweet corn production and has consistently been the top Sweet corn importer in the world (Olawale and Tontsa, 2015).

In large parts of Africa, Sweet corn is the principal staple crop; accounting for an average of 32% of consumed calories in Eastern and Southern Africa, rising to 5% in some countries.

Sweet corn is Ethiopia's largest cereal crop in terms of total production, area planted and number of farm holdings. Sweet Corn accounts for 20% of the total area covered by cereal and around 30% of the total cereal production. In addition to the highest total production per year and the highest per hectare yield, Sweet corn is also the single most important crop in terms of the number of farmers engaged in cultivation (Tefera *et al.,* 2014).

Importance of sweet corn

Sweet corn is a culture with a large number of varieties. Seed companies apply each year a great number of new varieties on variety lists. Selection is forwarded to enlarging harvest in ways to prolongation time of sugar converting into starch (Marton *et al.,* 2007) in order to maintain its quality longer in time. Exact optimal harvesting time considering quality examined by several authors (Dowd and Peter*,* 2002). However, quality increase has no direct effect on economic value. Therefore, it is necessary to determine varieties economic value before wide production use. Marketing aspects like sweet corn consumption reported by Ranum *et al*. (2014) for conventional production and by Najeeb *et al*. (2011) for organic production. Sweet corn as a farm product sells quite well at farmers' markets and other direct-to-consumer venues and a good-quality product is easily and rapidly sold out in most communities. Cooked sweet corn has significant anti-oxidant activity, which has been suggested to reduce the chances of heart diseases and cancer (Larsson *et al*., 2005). Although not has been definitively proven in practice. Most scientists measured the anti-oxidant ability of sweet corn to quench free radicals which cause damage to the body form oxidation.

Environmental requirements of sweet corn

Sweet corn requires moderately high temperature 22ºC up to 33°C. It can be grown under rain fed as well as irrigated condition. The amount of rain falls for the rain fed production is between 4500 mm-600 mm. In Ethiopia sweet corn is grown chiefly between elevation of 1500-2200 masl and it is particularly important in South Western of Ethiopia with Oromia Region which producer the largest amount of yield.

Critical periods of weed competition in sweet corn

Weeds are one of the limiting factors for crop growth and development and cause a significant yield loss when not controlled (Tefera *et al*., 2014). The weeds compete with the crops for resources (light, water and nutrients) and decrease resource availability for the crops. Corn is sdryland conditions (Sulewska *et al.,* 2012). According to Isik *et al*. (2006) weeds occurrence in corn causes significant yield losses with an average of more than 29% in case of no weed control and more than 12% despite weed control applications.

In crop competition, it is extremely difficult to determine the role which individual factors play in the injury to the crop. There is seldom only one factor involved, but more often there is complex interaction between factors. Yield reduction is occurring as the result of direct competition for limited resource or through allelopathic effects (Thomas, 2002). Many weed species have been found to occur in corn fields but four have been singled out as being serious or principal corn throughout the world. They include Cyperus rotundus, Echino chloacolonum, Eleusine indica and Digitaria sanguinalis (Dechasa, 2010). There are also some weeds are commonly found in sweet corn. They include *Amaranthus* spp., *Bracharia* spp., *Euphorbia* spp. *Cynodondactylon* (L.) pers, *Potulacaoleracea* (L.), *Sorghum halepense* (L.) pers and *etc.* (Dechasa, 2010).

Weeds compete with crops for environmental resources available in limited supply nutrient, water and light. Competition has been defined as the tendency of neighboring plants to utilize the same quantum of light, ions of mineral nutrient, molecules of water or volume space, as consequences weeds may significantly reduce the yield and impair crop quality, resulting in financial loss to the grower or farmer. Thus, has been estimated that global basis weeds considered being responsible for 10% reduction of crop. The critical useful in defining the crop growth stages most vulnerable to weed competition. In practice, the critical weed competition defined as a number of weeks after crop emergence during which a crop must be weed free in order to prevent yield loss less than 5 percent (AK Jha and Shrivastava 2013).

The beginning of the critical period was also defined as the crop stage or day after crop emergence when weed interference reduces the yield by a pre-determined level. The end of critical period defined as the crop stage or days after emergence until the crop must be free of weed in order to prevent a pre-determined level of yield loss. The length of critical period of weed competition varied between years and levels of chosen yield loss (Found Williams, 2002).

The critical period of weed competition has been defined as the time interval between the maximum weed infested period or the length of time that which emerge with the crop can remain uncontrolled before they begin to compete with crop must be free of weed after emergence. The critical period of weed competition is not necessarily the time of the most intense interference. Therefore, it may be better to use the term critical period for weed control instead of critical period of weed competition. The length of the critical period of weed control may vary depending on the acceptable yield loss (Gul *et al.,* 2011).

Sweet corn dry matter production significantly influenced by weed interference; the maximum dry matter obtained with full season weed control. The lost crop dry matter production was observed from the sweet corn plots that were left uncontrolled for the full season. Crop dry matter yield decrease as the length of period during which weed infestation elongated from 2 WAP to 10 WAP. However, as the length of the period when weeds were removed increased crop dry matter production was constantly increases (Cerrudo *et al*., 2012).

Found Williams (2002) reported that the total dry matter yield of sweet corn and weed per unit area held nearly equivalent to the dry matter of corn from the weed free plots *i.e*. the increased weed dry matter weight balanced the loss in corn and this indicated that the main factor affecting corn is the proportion of weeds which were strongly compete the corn for the same resources.

Impacts of weed on growth and yield of sweet corn

There is general agreement that the losses caused by weeds are greater than the combined losses from diseases and insect pests. Farmers are often concerned about crop damage from disease and insect pests probably because such damage is easier to visualize, unlike the effects of weed growth on the crop. The effect of weed interference with growth and yield in corn has been demonstrated by various researchers for example Ghanizadeh *et al*. (2009) and include reduced plant height leaf area index and yields (Dechasa, 2010).

The damaging effects of weeds on sweet corn growth and development have been reported in many studies. For instance, it has been reported that the competition between the corn and weeds reduced the total dry matter (Cox *et al*. 2006) reported a gradual decrease in the leaf area index (LAI) because of weed interference. (Sheibany *et al.,* 2009)stated a significant reduction in the LAI, crop growth rate (CGR) and total dry weight (TDW) of corn as a result of weed interference.

A quantification of the response of corn to weed interference can be provided by a comparative growth analysis of corn under weedy, compared to weed free, conditions. Differences between the crop and weed species in their relative capacity to capture growth limiting resources impute a variability in the crop's response to weed competition (Moechnig *et al*., 2003).

Weed competition has been shown to have an impact on various growth and yield components of corn. The most competitive weeds are those that emerge at about the same time as the crop. When and left to grow to maturity the average yield reduction in 30% (Ghanizadeh *et al*., 2009). Although fox tail seeded three weeks after the corn is planted produced 500 kg/ha dry matter, it did yield significantly. Hence, late removal of weeds has little beneficial effect on yield because the period of vegetative growth which essential for the crop yield has already passed (Knezevic and Datta, 2015). Weed competition reduced dry matter reproduction per plant, dry matter distribution to economic parts *i.e*. grains per cob and individual grain weight in corn. Reducing the dry weed weight improve the plant performance in terms of both biological yield (total dry matter production) and economic yield (seed yield).

The critical period has been repeated for many crops and not surs singly the result varies substantially between weed crop systems. Where weeds are not controlled until 30 or 40 days after emergence, but were adequately controlled thereafter, yields of corn reduced by 25 and 51 percent respectively as compared with the yield of plot kept weed free from emergence until harvest. In contrast, when the crop kept weed free for the first 30 or 40 days but no weed control practiced, thereafter, yield loss in corn respectively 7 and 5 per cent. These results illustrate, firstly the importance early weed control which the farmer is often unable to practice because of pressure of other work, secondly the ability of the crop to suppress weed growth once it has been given a good start with early weed control. It is concluded that maize (with vegetative cycle of 125 to 135 days) must be kept weed free for the first 30 days following germination (AK Jha and Shrivastava, 2013).

Methods of weed control in sweet corn

Mechanical method

Tillage is one management strategy that can impact the diversity of weed species present. The type of tillage practiced can affect crop and weed development (Hendrix *et al.,* 2004). Intensive tillage can be an effective weed management tool but may contribute to a decline in soil quality (Gallandt, 2006; Hobbs, 2007). Germination of weed seeds can be promoted or diminished by tillage events (Gallandt, 2006). For example, shallow tillage promoted the emergence of four broadleaf species, reduced the germination of a grass and did not affect the emergence of three other broadleaf species (Swanton *et al.,* 2008). When compared to other forms of tillage (disk, rotary tiller and chisel plow) mouldboard ploughing had a greater tendency to bring weed seeds to the soil surface as well as to bury weed seeds present on the soil surface. For this reason, mouldboard ploughing could serve as a useful method for the control of weed species with a short survival time in the soil (Mohler *et al*., 2006). There is a tendency for a shift to biennial and perennial weed species under reduced tillage systems (Swanton *et al.,* 2008). The shifts in weed populations under reduced tillage populations are a form of natural succession (Murphy *et al*., 2006). Species diversity can also be influenced by tillage, no-till tends to promote the highest species diversity and mouldboard plow the lowest. The weed species diversity seen in the chisel plow treatments was intermediate to that of conventional and no-tillage. (Murphy *et al*., 2006).

Mulches stop weed growth by restricting the penetration of sunlight to the soil surface and in the case of surface mulches of cover crops has the potential to release inhibitory (allelopathic) chemicals in to the soil environment that inhabit weed seedling growth. There has been considerable research investigating the use of living plants that are suppressed or kill with herbicide and then used as mulch prior to crop emergence. An example is the use of crown vetch (*Coronilla vetch*) as living mulch in corn. Herbicides are used to suppress, but not kill, the crown vetch to avoid competition with the corn. Crown vetches recover later in the season and the living mulch is maintained. The dense cover provided by crown vetch helps reduce weed growth (Gallandt, 2006).

Biological method

Biological control of weeds involves the use of any organisms or management practice using an organism to reduce, or eliminate the potential detrimental effects of weed population (Thomas, 2002). Classical biological control is associated with the use of insect, pathogens, herbivores or parasites that naturally attach weeds. There are two approaches used in the introduction of classical biological control agents in to a system. First one is inoculative approach which dispersion its own inhabit with the target weed. The second in undeceiver augmentative referred to as a bioherbicide or mycoherbicide which is used where an abundant supply of the agent is applied (Thomas, 2002).

Plant attaching insects are currently the most widely used biological control agent for weed control. They have a specific host range; can be mobile (which promotes their dispersion) and can destroy both vegetative and reproductive portion of weeds. Insect attacks can also predispose weed to attack by other factor such as disease, in fact researcher investigating a combination approach of insect as a disease vector for biological control (Kennedy, 2008).

The inoculums and inundactive are used for employing plant pathogens, primarily fungi, for biological control weeds. The mycoherbicide approach offers the best potential for extension of biological control weed control in to non-traditional disturbed areas. Extensive research is being conducted on many fungal pathogens and bacterial bio control agents as summarized by Kennedy (2008).

Chemical method

Chemical control is the last option method in controlling weed cultivated lands. After using mechanical, cultural and biological method then use chemical, is recommended in controlling a serious problem weed. 2-4-D was introduced in the mid 1940's to control broad leaf weeds in corn. Most corn herbicides are used to control annual weeds; however, some also control or suppress the growth of perennial weeds. Combination of two or more herbicides are often used as a tank mix or in sequential treatments to extend the period of control and/or broaden the spectrum of weeds controlled. In addition, corn cultivars are available that are tolerant to a certain herbicide that provide broad spectrum weed control (Vahedi *et al*., 2013).

Herbicide as selected primarily on the basis of weeds' species present, stage of crop growth and succeeding crop rotation. Corn has both susceptible and tolerant stages of development to 2-4-D. This herbicide is applied as an overall post emergence spray beginning at the three leaf stage until the corn is just less than 10 inches tall. Thereafter until tassel initiation directed sprays with drop nozzles are used. Corn is susceptible to 2-4-D injury during or after tasselling to dough stage (Price *et al*., 2011).

Integrated weed management

IWM is the application of many types of technology and supportive knowledge in the deliberate selection, integration and implementation of weed control strategies, with consideration of the economic, ecological and sociological consequences. It is to be successful if link he farmers' attitude, knowledge, performances and abilities with available tools that best fit each situation. The knowledge of the weed and cropping history of the site, knowledge of weed biology and ecology and knowledge of weed control methods are the most important in application of IWM. If farmers use these all knowledge to manage the system to obtain good high quality crop yields while minimizing and time reducing the harmful effects of weed IWM is effective economically and ecologically sound stresses integration of control to the larger picture of ecosystem *(*Knezevic *et al*., 2002).

The basic principles related to weed and IWM is understood and considered in designing and implementing an effective IWM system. Those principles include the factor like what is a weed, the basic resource that weeds and crop compete for factors affecting weed seed emergences, weed growth and reproduction length of infestation and general population biology of weed plants (Thomas, 2002).

Critical period for weed control in sweet corn

Critical period for weed control is defined as a period in the crop growth cycle during which weeds must be controlled to prevent yield losses (Knezevic *et al*., 2002). Controlling weeds base on CPWC lead to reduce costs and risks of intensive weed control. It also reduces the number of herbicide treatments as a result of better timing and efficiency which it leads to decrease the potential environmental contamination and the selection pressure for herbicide resistant weeds and help to optimize weed control methods (Bystro *et al*., 2012).

Determination of CPWC is based on characterizing functional relationships between two separately measured competition components: crop yield as a function of the duration of weed interference to identify the beginning of CPWC and crop yield as a function of the duration of the weed-free period to identify the end of CPWC. In theory, weed competition before or after the CPWC will not reduce crop yield below acceptable levels (Williams, 2006).

The length of the CPWC is dependent on site-specific factors, including climate variation; weed species composition and crop-specific production issues (Rajcan and Swanton, 2001). In a study which was conducted in Iran, critical period of weed control in corn was reported from 5 to 15-leaf stage to prevent yield losses of 5%. This period to prevent yield losses of 2.5, 10 and 20% was 4 to 17-leaf stage, 6 to 12-leaf stage and 8 to 9-leaf stage, respectively (Mahmoodi and Rahimi, 2009). Since, different studies in different regions showed various results of critical period for weed control, it is necessary to determine CPWC for a particular region in order to provide precise information. Therefore, the objectives of this study were to evaluate the effect of the timing of weed removal and the duration of weed interference on corn yield and determine the optimum timing for weed control in corn. The period during which weeds are removed from a crop was just reported as very important (Found Williams, 2002).

Generally critical period for weed control is the maximum period over which can be tolerated without affecting the final crop yield or the point after which growth does not affect the final yield. Cultivation on soils that become hard and complicated when dries in a dry year (Thomas, 2002).

CONCLUSION

Sweet corn [*Zea mays* (L.) *var. saccharata strut*] is the most valuable of corn grown in the United States of America and often referred to as "KING" of the grain crops because its production and value are greater than that of wheat, barley, oat, rye, rice and black wheat. Sweet corn is a monocot in the grass family, Gramineae. Cooked sweet corn has significant anti-oxidant activity, which has been suggested to reduce the chance of heart diseases and cancer. Weeds compete with crop plants for light, water, nutrient and space thereby reducing growth of yield and quality. The beginning of the critical period was defined as the crop stages or days after crop emergence when weed interference reduces the yield by a pre-determined level. Sweet corn dry matter production was significantly influenced by weed interference; the maximum dry matter was obtained with full season weed control. Late removal of weeds has little beneficial effect on yield because the period of vegetative growth which essential for the crop yield has already passed. The period of weed free maintains required after sweet corn emergence top produce maximum yield is achieved by using controlling measures like mechanical, cultural, biological, chemical and integrated weed management methods.

RECOMMENDATION

Even if Sweet corn is the most important high-quality crops, losses due to weeds have been one of the major limiting factors in Sweet corn production, where, weeds compete with Sweet corn for light, moisture and nutrients with early season competition, being the most critical. So, the following activities should be considered to reduce the impacts of weed in Sweet corn production.

- Combining weed control method can help keep weed damage before economic threshold levels and shall be performed rather than a separate control method.
- Create awareness about the practical understanding and combining weed control method strategy can result agronomically feasible, economically viable and environmentally sound sustainable crop production systems.
- Governments should take practical steps to promote weed control method to enhance the yield.
- Choice for selection of safe herbicides determines the success of weed control program. Herbicide also has a significant role in reducing the crop weed competition at the time of critical growth stages of the crop.

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