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Weed Control Methods Used in Agriculture

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ABSTRACT

One of the most challenging duties in an agricultural field is weed control. Weed control is a major problem for peasant farmers everywhere. This paper's objectives are to review and report the weed management practices utilized in Ethiopian agriculture and to recommend the viability of mechanizing weeding operations for the further research. In agriculture, three weed management techniques are frequently used. These are chemical, mechanical, and manual control. Farmers that are convinced of its benefits quickly adopt mechanical weed control. In addition to pulling weeds out from between the rows of crops, mechanical weed management maintains the soil's top loose, improving soil aeration and water absorption. Mechanical weeding saves time and labor while lowering labor costs also. Some weeding tools that are powered by animals are effective in terms of time and money savings. Herbicides are occasionally used by farmers; however, they are not often used in farming. In conclusion, weed control is one of the most essential and expensive operation in agriculture. Weeding by mechanical device reduces the cost of labour and also saves time than any other methods of weed control. Therefore, instead of manual weeding and using chemicals, the use of a mechanical weeding machine should be given priority.

INTRODUCTION

The Ethiopian economy is based primarily on agriculture, which directly and indirectly controls the national income. According to the central statistical agency (CSA, 2013) estimated that about 80% of the population's livelihood is based on this sector. One of the major reasons for decreased productivity of agricultural field crops in the country is due to lack of mechanization from sowing to harvesting, especially at critical stages such as weeding and intercultural operations. Weed is a common term to describe a plant that is considered undesirable (Gavali and Kulkarni, 2014). Weed losses exceed those caused by any other agricultural pest. In Ethiopia, crop yield losses due to weeds vary from season to season and from region to region, due to different biotic and abiotic factors, it is estimated that weeds reduce yield due to delay weeding from 15 to 62% (Kebede Desta, 2000). Weeds can be undesirable for some reasons; an essential one is they intrude on meals and fodder production in agriculture, which ought to be managed so that it will save you misplaced or faded crop yields (Gavali and Kulkarni, 2014). Weeding may be completed through the guide, chemical, and mechanical techniques. Due to excessive time consumption, much fewer paintings capability, and tediousness, chemical, and mechanical weed management techniques are possible options to guide weeding. The introduction of efficient mechanical weeding machines is expected to encourage farmers to be self-sufficient, which will lead to increased yields and thus reduced poverty (Olukunle & Oguntunde, 2006) for the soil, stimulating microbial activity in the soil, reducing soil moisture evaporation and facilitating rainwater infiltration (Hegazy et al., 2014). In developed countries, multi-

purpose machines have been developed and successfully implemented for weeding and intercultural operations. The use of such machines in the Ethiopian agricultural scenario is difficult as most of the Ethiopian farmers are small-scale farmers because the area they control is small. In the traditional method, weeding is done manually. Cutlass and hoe is a handy tool used for this purpose. It is the most widely used weed control method, but it is laborious, time-consuming, labor-intensive, cause's long-term health problems, and operating speed is one of the most important factors. In most of the highlands, crops are planted at the same time and weeding operation is performed at the same time. This results in shortages of labor during the peak seasons of weeding. The weeding labor bottleneck is especially problematic because some varieties are prone to weeding time; hence delayed weeding decreases crop yields. Using a mechanical weeder relieves stress and ensures a comfortable position for the farmer or operator during weeding. Pantage et al. (2015) found that the mechanical approach to weed control is best with little or no limitation due to its effectiveness. The main purpose of row farming is to improve the use of agricultural machinery to remove weeds from cropland. The effect of this method is to promote plant growth and give higher quality. However, the use of this type of machine is uncommon, and very rarely is a mechanical weeder available. Generally, to increase agricultural output and reduce the time and cost of weeding operations, it is imperative to develop and promote mechanical operated weeding technology. Hence, this paper is studying and reporting on the method of weed control in agricultural improvement and assessing the possibility of mechanization of weeding operation.

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LITERATURE REVIEW

Overview of weed control methods

In Ethiopia, weeds are controlled mainly by manual weeding, but also by good agricultural practices such as repeated deep plowing, late sowing, and crop rotation. Some mechanical weeding methods are also practiced, using simple traditional tools. All of which is neither adequate nor timely. Hence, it is imperative to develop an efficient and economical way of managing weeds through the use of herbicides (Kebede Desta, 2000).

Chemical weed management results in better crop growth and often improved yields compared to manual and mechanical methods by eliminating mechanical damage to the crop and reducing moisture loss (Atiq et al., 2009). In addition, the authors found that chemical weed management was much quicker and less labor-intensive, allowing for the covering of large areas in a short time with limited work. Though, manual weeding is a traditional and common practice for managing weeds in potatoes, marginalities of labor and the prevalence of frequent rains many times prevent the timely management of weeds at critical periods of crop growth.

Weed control includes a variety of techniques used to limit weed entry and minimize competition. These techniques attempt to strike a balance between control costs and crop yield loss, but weed control is used only after the problem exists; it is not prevention. Weed control techniques have been widely adopted because control is the easiest to do and often effective. The problem is known and visible, and actions can be tailored to the observed problem. Control techniques can be selected to meet short-term agricultural and economic planning objectives (Lopez, 2011).

Duff and Orcino (2001) reported that the timing rather than the frequency of weeding was a major determinant of effective weed control for crops. Recommendations have been made for the first weeding to be done 2 up to 3 weeks after sowing, followed by a second weeding three weeks later and if necessary a third one.

Ofor et al., (2009) reported that weeds as pests highly reduce the production of the crops. They extract nutrients, water, and moisture available in the soil and also compete for light and air and negatively affect the crop. Critical crop growth periods are very much important in all crops at which weed competition for nutrient and water resources plays a significant effect on yield. It varies from crop to crop. It is shown between 30- 60 days in a wheat crop after sowing (Ahmad and Shaikh, 2003)

Kebede (2000) found that Ethiopian farmers often lose up to 40% of their crops to weeds. Since crops are usually not grown in rows, weeding is a time-consuming undertaking, up to 140 h/ha. Weeds are controlled mainly by manual weeding, but also by good agricultural practices such as increased tillage, delayed sowing, and crop rotation. He also reported that machine weeding was also carried out, using simple traditional tools and some modern tools. Weeding is one of the important steps in the growing process and affects the yield and quality of output.

Verma and Victor (2003) reported that the percentage yield loss due to weed competition during the first month, two months, and the entire growing season were 23.7%, 35.4%, and 35.4 percent, respectively. 40.8%.

Thorat et al. (2014) reported that weed competition is a serious problem in most wet season crops, resulting in yield losses of 9-60% or more.

Most Ethiopian farmers do not weed their fields in time due to a lack of labor. Therefore, weeds are one of the major constraints on the country's agricultural production. Research conducted by agricultural research institutes across the country investigated the effect of delayed weeding on crop yields.

Weed control methods

Weed management is as old as agriculture, but weed control methods and concepts have changed over the years. Current weed control practices in Ethiopia are chemical, mechanical, and biological. The mechanical method is characterized by heavy use of manual labor and animal strength. Both are rare and are becoming increasingly unprofitable. Manual weeding, in addition to being laborious, is inefficient (not on time in most cases) and is not feasible due to poor soil conditions. Weeds compete more with plants in the early stages of growth (2-6 weeks after planting). Weed control during this period is essential to achieving maximum crop yields. For this reason, chemical weed control is rapidly gaining traction in the country, which, on the other hand, raises several environmental concerns. With increasing public awareness of environmental pollution, the development of environmentally friendly weed management technologies will be emphasized.

Weed control is one of the most difficult tasks in agriculture, accounting for a significant portion of the cost of agricultural production. Weeds compete with crops for nutrients and other growth factors, and without effective control measures, weeds will consume 30 to 40 percent of the applied nutrients, resulting in reduced considerable productivity. Weeding with hand tools takes a lot of work. A mechanical weeder makes it possible to get your weeding job done on time and at a lower cost. Environmental pollution due to chemicals is also reduced by using a mechanical weeder (Sirmour and Verma, 2018) Babu & Rao (2017) studied weed management and concluded that weed management is one of the tedious activities in agricultural production. Due to the cost of labor, time, and completely manual weeding, this is not convenient. Therefore, efforts are being made to design efficient agricultural equipment to perform weeding without a power supply. The design and key features of the design are based on simulation and the advantages of using it to design the drive mechanism of a three-row weeding device have been discussed. Weeding and tilling are usually done 15 to 20 days after sowing. It is necessary to control and eliminate weeds at an early stage. Depending on weed density, grain yield loss of 20 to 30 percent is quite common, which can increase up

to 80 percent if proper crop management practices are not followed. Rice and peanuts are susceptible to weeds. Competition at the start of growth and failure to control weeds in the first three weeks after sowing reduces yields by 50%.

Kebede (2000) found that Ethiopian farmers often lose up to 40% of their crops to weed infestations. Since crops are usually not grown in rows, weeding is a time-consuming undertaking, up to 140 h/ha. Weeds are controlled mainly by manual weeding, but also by good agricultural practices such as increased tillage, delayed sowing, and crop rotation. Machine weeding is also done, using simple traditional tools and some modern tools. Some weeding systems that use animals effectively save time and money. Some farmers also use herbicides, but these methods are not very suitable. He also reported that 35% of wheat yield loss was due to delayed weeding.

Olaoye and Adekanye (2012) has studied that weed control is one of the most difficult tasks in agriculture, accounting for a significant portion of the costs associated with agricultural production. Chemical weed control is more important than manual and mechanical methods. However, its harmful effects on the environment cause farmers to consider and accept mechanical methods of weed control. Hand weeding is popular in developing countries. This is the most commonly used weed control method, but it is laborious. The use of a mechanical weeder reduces strain and ensures a comfortable position for the farmer or operator during weeding.

Machine weeding is one of the commonly used methods of weeding in agricultural fields. Research has been done on economical weed control methods that do not harm the crop. Weeding machines are developed to be used for specific crops such as tomatoes, corn, and rice. These machines are mainly in-row weeders that remove weeds in several rows of crops at once (Cordill and Grift, 2011)

Manual methods of weed control

Sirmour (2016) reported that weeding is traditionally done using indigenous hand tools. These involve considerable time and labor. Hand weeding is very common on wheat and vegetable crops. In the manual method, weeds are pulled by hand.

Verma and Prabhat (2015) found that the manual weeder has the limitation of working width and required more time to cover an area between crops and a tractor-drawn cultivator was evaluated for weeding operation and found successful for weeding in large row spaced crops

Kebede (2000) studied that the traditional animal-drawn weeding method known as Shilshalo involves growing cows in sorghum or maize planted broadcast or in rows at 50–70 cm spacing. Traditional animal traction plows are used for inter-row farming. This breaks down the soil crust, reduces runoff, and speeds infiltration into the soil, in addition to controlling weeds and thinning crops to an appropriate level. However, since most farmers do not practice Shilshalo at the correct stage of crop growth, severe plant damage (stem breakage and uprooting) often

occurs, resulting in low yields. A series of trials have been carried out to improve existing traditional practices by determining the optimal timing of livestock operations to increase yields of sorghum and maize. Shilshalo is effective at the 6-8 leaf stage for sorghum and the 4-6 leaf stage for maize.

Mechanical weed control method

Singh (2001) points out that mechanized farming is still the most important method used for weed control and is generally still the most economical method, recommended from an environmental pollution point of view. The author also found that operating costs of rotary weeders and weeding costs are 63% higher than that of a hand wheel hoe and 72% lower than chemical control. Thorat & Sahoo (2014) researched and reported that machine weeding is highly effective because it reduces the effort of manual weeding, kills weeds, and also keeps the soil surface loose by providing soil aeration level and water absorption capacity. The availability and cost of labor for weed control are limiting its progress, and the development of an appropriate mechanized weeding method is imperative. The cost of weeding by mechanical weeding is about one-third that of manual weeding.

Guru et al. (2018) reported that mechanical weeding is one of the most conventional weeding methods most important. Although this is one of the older weed control methods, recent advances have made it an innovative weed control technique. Mechanical weeding has many advantages over chemical weeding, i.e. weeding is retarded and has no adverse effect on plant growth.

Piyush et al. (2018) found that controlling weeds in shoots was difficult and in these crops, weeds were removed only once by manual labor. As a result, weeding is inefficient and operations are stalled, behind schedule, and lost in productivity. For row crops, this problem does not arise because mechanical weeders and cart-powered tools can be used to effectively and promptly control weeds. Furthermore, the author concludes that tillage depth has no significant effect on rice yield. There is growing interest in using weeders between rows due to concerns about environmental degradation and growing demand for organically produced foods.

Weeding is an important but equally laborious farm unit operation. There is growing interest in the use of mechanical weeders in the row due to concerns about environmental degradation and the growing demand for organically produced foods. Today, the agricultural industry requires weed control without using chemicals to ensure food safety. Consumers demand high-quality food products and are particularly concerned about food safety. Through the engineering development of physical weed control mechanisms, such as precision weeding between rows and within rows, it is possible to control weeds in a way that meets consumer and environmental needs (Kurstjens & Perdok., 2000).

Quadri (2010) reported that the mechanical weeder consists of two auxiliary tools, namely, a primary blade in

the front for loose soil at the top and a secondary blade at the rear for cutting and lifting the grass. The weeding efficiency of the manual weeding machine on loamy soil is 81.14%, clay soil is 93.75% and sandy soil is 94.29%. The overall field efficiency of the machine is 98.67%.

Chemical method of weed control

Weeding is one of the main activities of agriculture. Chemical weed control is more important than manual and mechanical methods. However, its harmful effects on the environment cause farmers to consider and accept mechanical methods of weed control. Chemical weed control is the most widely used weed control method. But these chemicals used to control weeds are harmful to living organisms and are toxic.

Kebede (2000) reported that some farmers have started using herbicides to control weeds, especially in double-cropping areas. However, herbicides are less effective than manual weeding, as they require specific conditions that can be more restrictive than other control methods. Chemical weed control can quickly become unpopular because it is not environmentally friendly. Indeed, chemical weed control has been found to introduce a toxic substance into the environment. Herbicides seem to be out of pocket and even uneconomical for small farmers. Herbicide production itself is a high-tech process and requires a very reliable linkage (Manuwa et al., 2009).

Chemical weed control is more important than manual and mechanical methods. However, its harmful effects on the environment cause farmers to consider and accept mechanical methods of weed control. Chemical weed control is the most widely used weed control method (Olaoye and Adekanye, 2012).

Current weed control practices

Since crops are usually not grown in rows, weeding is a time-consuming undertaking, up to 140 h/ha. Ethiopian farmers use a variety of strategies to reduce or avoid weed invasion in their fields. Current weed control methods are reviewed below.

Hand weeding

Manual weeding is the most common weed control method used by smallholders. It usually doesn't require any upfront payments. This is a great advantage when cash is not readily available and labor is provided by the farming family directly or through a non-monetary exchange. This may be the only viable method of weeding on flies when herbicides are not available. Manual weeding is intensive farming. Hand weeding is time-consuming, labor-intensive, back-breaking, and often costlier than other methods of weed control.

The oldest and simplest technology is manual weeding. Manual weed control begins with farmers pulling weeds with their hands. Later, this technology evolved into hand tools, moving from the use of a stick to the use of a hand pickaxe. Cordilla and Grift (2011) report that manual weeding is labor-intensive, accounting for about 80% of

the total labor required to produce food. Farmers who use only hand-hoes for weeding will struggle to escape poverty, as this level of technology tends to perpetuate human toil, risk, and mystery. The use of a sorting hoe is effective and is the most widely used weed control method.



Figure 1: Hand weeding methods

Animal-drawn weeding implements

Kebede (2000) also reported that the three-tine cultivator with a reversible narrow shovel is attached to the frame by movable clamps, bolts, and nuts, designed to achieve width and depth. This includes a frame capable of adapting to different weeding attachments, two wheels for maneuverability, and provision for lifting and lowering tillage elements. The author has also studied a practice known as Shilshalo that involves growing burdock in sorghum grown in rows or rows. Traditional animal traction plows are used for inter-row farming. This breaks down the soil crust, reduces runoff, and speeds infiltration into the soil, in addition to controlling weeds and thinning crops to an appropriate level. However, since most farmers do not practice Shilshalo at the correct stage of crop growth, severe plant damage (stem breakage and uprooting) often occurs, resulting in low yields. A series of trials have been carried out to improve existing traditional practices by determining the optimal timing of livestock operations to increase yields of sorghum and maize.

Mechanical weeding implements

Much effort has been made to design and develop convenient and practical mechanical weeding methods using simple tools and instruments. Mechanical

equipment can save time during peak times, resulting in higher output per worker and reduced weeding costs. This mechanical device can be pulled by hand or by an animal.

Kankal (2013) has researched the design and development of self-propelled weeding machines for field crops. The machine is useful in row crops, horticulture, and vegetables for weeding and seedbed preparation. It consists of a 4.1 kW diesel engine mounted on the chassis of the electric tiller, a drivetrain, two MS wheels, a frame, and a rotary tiller. Power from the motor is transmitted to the rotor by belt and chain and through a gear transmission to the ground wheels. A disconnect device is provided to connect or disconnect the power to the rotating system. The lug wheels are provided for traction. The speed of the electric lawn mower ranges from 2.3 to 2.5 km/h with an effective working width of 550 mm for a field yield of 0.10 to 0.13 ha/h. The cost of a self-propelled weeding machine is around Rs 40,000/ha and the average weeding cost is Rs 1000/ha. The device saves 90% of operating time and 30% of weeding costs compared to manual weeding.

Machine weeding not only pulls weeds between rows of plants, but also keeps the soil surface loose, creates better aeration of the soil and increases water absorption, and the machine weeder does the job at the same time. Weeding and hoeing can reduce weeding time, the cost of weeding, and the arduousness of manual weeding (Shakya et al., 2016).

Sirmour and Verma (2018) evaluated the performance of the developed electric lawn mower. It has been tested based on field capacity, field efficiency, weeding efficiency, activity index, energy consumption, and operating cost. Therefore, the following conclusions can be drawn. The performance of the rice weeding machine is rated as excellent in wet conditions, the working width of the developed machine is expected to be adjustable between 140-250mm, and the forward speed is 2.48 km. / h and operating depth from 3 to 4.2 cm, with fuel consumption of 0.55 l / h. The effective yield is 0.054 ha/h. Weeding efficiency is 82.92%, operating cost of rotary weeding machine and manual weeding machine is Rs 980/ha and Rs 2300/ha respectively. Weeding cost saving is 60% and time-saving is 65% compared to manual weeding.

Verma and Victor (2003) report that the rotary weeder reduces strain and ensures a comfortable posture of the operator when weeding and increases yields because of the field productivity and weeding efficiency of the machine was 0.0712 ha/h and 73%, respectively.

Kishore et al. (2018) studied and evaluated the activity of mechanical weeds in dry soil conditions. Three weeds were evaluated initially on dry land maize with plots of 20 m × 10 m with row spacing of 60 cm. The actual productivity of electric weeders, rotary hoes, and star weeders are 0.0494 ha/h, 0.022 ha/h, and 0.021 ha/h, respectively. The field efficiency of electric weeders, hoes, and star weeder were 82.33%, 73.66%, and 80.76%, respectively. The electric weeder is more efficient in the

field than the other two weeders. The weeding efficiency of electric weeders, wheel hoe, and star weeders are 78.4%, 74.0%, and 75.4%, respectively. The hoe has lower efficiency and lower operating costs than the three types of weeders. Since weeding is more labor-intensive than other grasses, weeding may be given less priority than electric and star weeders.

Padole (2007) studied the comparison in-field performance between rotary power weeder and bullock drawn blade hoe. It was reported that effective field capacity of 0.14 ha/h (40% more than a bullock-drawn blade hoe), and field efficiency of 90% (34.1% more than that of a bullock-drawn blade hoe were obtained). The cost of operation was found to be Rs 798.46 compared to 894.87 per ha by bullock-drawn blade hoe. Hence, it was more economical and effective than bullock-drawn blade hoe as it saved 10.77% weeding cost; reduced plant damage up to 54.23%, and achieved weeding efficiency up to 92.76%.

Manuwa et al., (2009) designed and developed a power weeding machine with a working width of 0.24 m for weeding in row plantations. The effective field capacity, fuel consumption, and field efficiency of the machine are 0.53 ha/h, 0.7 l/h, and 95% respectively.

Alizadeh (2011) studied the performance of 4 types of mechanical rice weeders including single row cone weeders (W1), double row cone weeders (W2), rotary weeders (W3), and power weeders (W4) compared with manual weeders (W5). Two local rice varieties and improved transplanted rice, Hashemi and Lai respectively, were selected for this study. The results showed that among the mechanized grasses, the highest weeding efficiency (84.33%) was with W4 and Hybrid varieties, and the lowest value (72.80%) was measured with W3 and Hashemi varieties. Plants damaged by mechanical weeding were 3.83% compared with 0.13% for manual weeding. The highest effective field yields of 0.082 and 0.087 ha/h was measured with W4 and the lowest values of 0.0084 and 0.0088 ha/h was obtained with W5 respectively for the Hashemi and Hybrid. Weeding costs decreased by 15.70, 38.51, 22.32, and 48.70% respectively for W1, W2, W3, and W4 compared to W5.

Chanakyan and Mohanty (2017) conducted a study to evaluate the performance of mechanical power weeders. The weeding was done 35 days after transplanting in sandy loam soil. The various mean performance parameters such as speed of operation, effective field capacity, field efficiency, weeding efficiency, plant damage, and fuel consumption were observed to be 1.65 km/h, 0.065 ha/h, 78.9%, 84.8%, 4.12%, and 16.9 l/hr respectively.

Mechanical weeding is very effective because it reduces manual weeding, kills' weeds, and also keeps the soil surface loose by providing aeration and water absorption to the soil. The availability and cost of labor for weed control are limiting its progress, and the development of an appropriate mechanized weeding method is imperative. The cost of weeding by mechanical weeding is about one-third that of manual weeding (Thorat et al., 2014).



Figure 2: Mechanical weeding Machine

Manual weeding

Commonly used manual weeders consist of a hoe (pull-and-push weeder) consisting of a steel blade (cultivator) mounted on a long wooden handle. These weeders are most useful when weeds are small and the soil is not too hard.

Attanda et al. (2013) developed and evaluated a hand-push mechanical weeder to determine its performance indicators. Field performance was compared with that of a traditional hand hoe in multiple TZPB-SR maize fields. The mean values of forwarding rate, actual field capacity, and weeding efficiency were 0.092 m/s, 0.028 ha/h and 75.17% for weed growth compared to 0.013 m/s, respectively, 0.0059 ha / h and 77.98% for hand hoe.

According to Bhavin et al. (2016) to evaluate the field performance of manual weeding machines developed which performed for various performance parameters such as weeding capacity, efficiency weeding, draft requirements, and the welder's performance index were taken into account during the tests. The weeding machine developed has a field yield of 0.0285 ha/h and the highest weeding efficiency (ie up to 80.42%). The required draft was 34.4 kg for a weed width of 20 cm and the obtained weed activity index was 1210.53.

Nkakini et al. (2010) studied the field performance evaluation of manual gasoline-powered weeders for the tropics. According to the report, the theoretical yield of the rotor weeding machine is 0.047 ha/h with an effective capacity of 0.34 ha/h, which is about 20 times higher than manual weeding. The operating index is 1700 and the fuel consumption is 3.2 liters in 8 hours. Rotary weeders have a weeding efficiency of 71% at removing weeds with shallow roots. This suggests that motorized weeders can be useful equipment in agricultural modernization

for smallholder farmers. Mechanical weeding is an environmentally friendly method of weed control.

Bhavin et al. (2016) reported that mechanical methods are by far the most widely used means of weed control for many years to come. Furthermore, the author points out that mechanical weeding is potentially more sustainable than chemical weeding because it is less risky (financial, health, and environmental) and easier to maintain with current skills and facilities.

Mechanical weeding is very effective because it reduces manual weeding, kill's weeds, and also keeps the soil surface loose by providing aeration and water absorption to the soil. The availability and cost of labor for weed control are limiting its progress and therefore the development of a suitable mechanized weeding method is urgent. The cost of weeding with a motorized weeder is about one-third that of manual weeding (Guru et al., 2018).

Mechanical methods of weed control are widely used in many developing countries because agricultural labor is cheap and readily available. Mechanical weed control methods are simple for farmers. Weed control tools and instruments are mainly hand and animal-operated. Mechanical weed control involves the use of human labor, animal-drawn, or tractor-powered weeders, self-propelled weeders, or electric weeders (Sirmour, 2016).

Attanda et al. (2013) developed a mechanical weeder consisting of two sets of conical propellers, an adjustable main frame, and an afloat. The weeder has an effective capacity of 0.357 ha/hr, a draft of 64.87 N, and overall width and depth of cut of 180 mm and 20 mm, respectively. With one cut between rows in the field at 40.8% soil moisture, the optimal weed control efficiency was 84.5% while the weed control efficiency at 10.5% soil moisture was 53.1%. Therefore, the highest plant damage of 8.33% was recorded at soil moisture of 10.5%. 0.058 hp is the power required for one person to push the prototype grass.

Alizadeh (2011) reported that manual weeding removed only 65-85% of weeds for cotton production, mainly because workers confused weeds with crops or lacked weeds. It has also been reported that manual weeding with a long-handled hoe will damage crops and miss some weeds. Digging is also time-consuming and can lead to back injuries for workers.

Chemical weed controls

Chemical control involves the use of herbicides. Herbicides control weeds by accelerating, stopping, or altering the normal growth patterns of crops; by drying the leaves or stems; or by making them drop their leaves. Chemical control with the application of herbicides can provide the most effective and fastest method of weed management. Many herbicides are available for effective weed control and are selective so that weeds are not harmed. Weeding is one of the main activities of agriculture

Chemical weed control is becoming popular day by day

in developing countries. Some farmers have begun to use herbicides to control weeds, especially in double-cropping areas. However, herbicides are less effective than manual weeding, as they require specific conditions that can be more restrictive than other control methods. For example, the right herbicide must be selected for the specific spectrum of crops and weeds present. It must be applied at a specific rate, at the right time, and only under specific environmental conditions (Kebede, 2000).

Fagade (2008) reported that the cost of applying herbicides to control weeds is half that of manual weeding. Chemical methods give promising results in the eradication of weeds but are limited due to their harmful effects on humans and the environment. Singh (2001) states that herbicides can significantly reduce the need for labor, but there is a contradiction in their performance. Inconsistencies include herbicide cost versus labor, and farmers' lack of knowledge about application rates, timing, and methods. In addition, the lack of availability of herbicides and sprayers is one of the main factors limiting the use of herbicides by smallholder farmers. These limitations make mechanical weed control a priority over the use of herbicides.

CONCLUSIONS

The main objective of this paper is to gain insight into the various aspects or limitations of different weeding techniques in order to reduce the efforts that farmers have spent in terms of money, labor, time, and money. Weed control is one of the most difficult tasks in agriculture, accounting for a significant portion of agricultural production. Weed losses exceed those caused by any other agricultural pest. Three methods of weed control are commonly known in agriculture. Here's how to weed by machine, manually and chemically. Machine weeding is easily adopted by farmers once they believe in its benefits. Mechanical weeding not only removes weeds between rows of crops but also keeps the soil surface loose, ensuring better aeration and water absorption. Weeds are also controlled mainly by manual weeding. Manual weeding is the most efficient weeding method, but it is not suitable due to the time-consuming operations and labor-intensive costs. Chemical methods give promising results in the eradication of weeds but are limited due to their harmful effects on humans and the environment. In general, weeding is one of the most essential and costly activities in agriculture. Mechanized weeding reduces labor costs and also saves time compared to any other weeding method. In summary, weeding is one of the most essential and costly activities in agriculture. Mechanized weeding reduces labor costs and also saves time compared to any other weeding method. Therefore, instead of manual and chemical weeding, the use of a mechanical weeding machine should be most preferable.

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