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Original Research Article

Determination of Critical Weed Competition Period in Chamomile (*Matricaria chamomilla* L.) Production at Wondo Genet, Southern Ethiopia

Ano Wariyo Negaso[1*], Desta Abayechaw[1], Negasu Guteta Bayisa[1]
[1]Wondo Genet Agricultural Research Center, EIAR, P.O.BOX. 198, Shashemene, Ethiopia

***Corresponding Author**
Ano Wariyo Negaso
Wondo Genet Agricultural Research Center, EIAR, P.O.BOX. 198, Shashemene, Ethiopia

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Abstract: The study was carried out at Wondo Genet to determine the critical weed competition period for growth, yield, and yield components of the chamomile plant. The weed competition duration had a significant influence on plant height, the number of primary branches/plants, fresh stem yield/plant, fresh leaves yield/plant, fresh and dry flower/plant, fresh and dry flower yield/ha, essential oil content (v/w) and yield kg/ha. The highest fresh and dried flower yield (3780.10 kg/ha) and (798.32 kg/ha) was recorded from weed-free check followed by weed-free for 60 DACE (Days After Crop Emergence) (3652.10 kg/ha) and (789.43 kg/ha), respectively. The maximum essential oil content and yield were recorded from the weed-free check (0.79v/w) and (6.25 kg/ha) whereas the minimum was in the weedy-check (0.10 v/w) and (0.15kg/ha), respectively. The yield losses of chamomile were estimated based on the fresh and dry flower and essential oil yield per hectare. Thus, the highest fresh and dry flower yield losses were recorded from the weedy-check (83.58%) and (81.05%) while the lowest was from weed-free check (0.00%), respectively. The highest essential oil yield loss was also recorded from the weedy for 60DACE (97.92%) followed by weedy-check (97.60%). To determine the beginning and the end of the critical period of crop-weed competition 5 and 0% acceptable yield loss levels were used. Therefore, to reduce the yield losses of chamomile by more than 10% and higher economic return, plants must be kept weed-free within 40 to 60DACE to reduce the risk of economic yield losses as it is the critical period of weed-crop competition in chamomile plants.

Keywords: Critical period, essential oil content, yield, flower yield, weed species, yield losses.

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INTRODUCTION

Chamomile is an annual medicinal and aromatic herb that belongs to the family Asteraceae often referred to as the “star among medicinal species” is native to southern and eastern Europe (Shams *et al.,* 2012; Salamon, 1992). It is cultivated commercially in Europe, the Former USSR, North Africa Asia, North and South America, and New Zealand (Salamon, 2004). Chamomile is among the widely used aromatic and medicinal plants throughout the world (Baghalian, 2000). It has been used in herbal remedies for thousands of years, known in ancient Egypt, Greece, and Rome (Issac, 1989). It is an ingredient of several traditional, Unani, and homeopathy medicinal preparations (Kumar *et al.,* 2001; Lawrence BM., 1987; Mann and Staba, 1986). The flowers of chamomile contain blue essential oil from 0.2 to 1.9% which finds a variety of uses (Bradley, 1992; Mann and Staba, 2002). Chamomile is used mainly as an anti-inflammatory and antiseptic, also antispasmodic and mildly sudorific (Mericli, 1990).

Many factors influence agronomic characters, biomass, and essential oil yield of medicinal and aromatic plants. Among these, weed management is a major constraint. As with all commonly grown crops, also in medicinal and aromatic plants, weeds function as crop competitors, create problems for mechanized harvest, and may alter the end quality when mixed with the harvested product. The well-known interference of weeds takes additional relevance for medicinal and aromatic plants for several reasons. Firstly, the synthesis of secondary metabolites in plants is linked to many genetic and environmental factors (Sangwan *et al*., 2001). Buyers often grade such plants according to their specific quality features, which are primarily determined by their content in essential oils or other secondary metabolites, which in turn can be reduced in the presence of weeds (Carrubba and Catalano, 2009). It was reported that weed removal in chamomile plants during 5–11 weeks after planting was necessary to obtain a higher yield of the flower and oil (Singh, 1997). The uncontrolled weed growth caused a 34.4% reduction in the dry flower yield as compared with the weed-free condition.

Some experiments carried out on the suitability of medicinal and aromatic plants to field conditions have confirmed the importance of weed competition. De La Fuente *et al.,* (2003) demonstrated that on coriander, especially under poor soil conditions, weeding had a greater effect than did N fertilization. In Ethiopia, there exist diverse ecological conditions (NMSA, 1996; Kebebew, 2003; Andargachew, 2007). Hence, it is a prerequisite to determine the critical period of weed control for chamomile for its agronomic and chemical characters to get optimum yields. However, there is no crucial period during which weed infestation is particularly harmful to chamomile plants. Thus, for sound integrated weed management in its cultivation, it is necessary to determine when it will be the most and least affected by weeds.

The concept of critical periods of weed competition, during which weeds have the greatest impact on crop growth, was verified by Nieto *et al.,* (1968). It is a specific minimum period during which the crop must be free of weeds to prevent loss in yield and represents the overlap of two separate components (Weaver and Tan, 1983). The first component is the length of time weeds can remain in a crop before interference begins. The second component is the length of time that weed emergence must be prevented so that subsequent weed growth does not reduce crop yield. The critical period is the prime period most suitable for conducting weeding operations considering the following factors: the environment (climate and soil), the period of weed infestation in the field, the weed species, the cultural practices including crop rotation, fertilization, density, and methods of seeding (broadcast, hill seeding or transplanting), and the relative growth rates of the crop and its associated weeds. For example, according to Le Bourgeois and Marnotte (2002), the critical period is generally located between 15 and 60 days after seeding (DAS) for short-cycle annual crops (cotton, corn, sorghum, rice, etc.) and between 30 and 90 DAS for long-cycle crops (yams, cassava, sugarcane, etc.).

Despite diverse potential uses of chamomile plants, increasing interest of farmers and investors for its cultivation in Ethiopia, and the existence of diverse ecological conditions in the country, there exists scanty information about the weed management system at an appropriate time. Because of the differences in climatic conditions and weed populations, the result of studies conducted in different environments or on different crops may not apply to other systems (Bukun, 2004; Evans *et al.,* 2003; Knezevic *et al.,* 2003; Van Acker *et al.,* 1993). The critical period for weed control in the chamomile plant has not been determined in our country. This could help chamomile producers to improve the efficacy of their current weed management systems and reduce yield loss resulting from weed competition. The objective of this study was, therefore, to determine the critical period for weed control in chamomile under rainfed conditions found at Wondogenet and to investigate the effect of weed interferences on chamomile yield.

MATERIALS AND METHODS

The experiment was carried out at Wondo Genet Agricultural Research Center experimental site during the 2017 to 2018 cropping seasons. Wondo Genet is located between 7°19' N latitude and 38°38' E longitude which is found at an altitude of 1780 m.a.s.l (meter above sea level). It receives mean annual rainfall of 1128 mm with minimum and maximum temperatures of 11 °C and 26 °C, respectively. The soil textural class is sandy loam with a pH of 6.4 (Abayneh *et al*., 2006). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications having plot size measuring 2.4 × 1.8 m. The crop was sown in July 2017 and 2018 with 30 *40cm space between rows and plants, respectively. Distance between plants was maintained by thinning extra plants at an early growth stage and German chamomile, genotype was used. The experimental treatments consisted of a quantitative series of both the increasing duration of weed interference and the length of the weed-free period. The timing of weed removal was based on the number of days after crop emergence. Weeds were removed manually with a hand hoe from respective plots after a prescribed duration and kept weed-free till harvest.

To determine the beginning of the CPWC (Crop Period Weed Competition), the first component, increasing length of weed-free period, was established by maintaining weed-free condition for 10, 20, 30, 40,50, and 60 days after crop emergence (referred to as weed-free plots) before allowing subsequent emerging weeds to compete for the remainder of the growing season. To evaluate the end of the critical period of the CPWC, the second component, increasing duration of weed interference, was established by allowing the weeds to compete with the chamomile for 10, 20, 30, 40, 50, and 60DACE (referred to as weedy plots) after which, plots were maintained weed-free until harvest. In addition, season-long weedy and weed-free checks were included as controls.

Weed flora: Data on weed flora present in the experimental fields were recorded during the experimental period. The weed species found within the sample quadrats were identified and classified into their respective groups. Weed density: The weed density was recorded by throwing a quadrat (0.25 m×0.25 m) randomly at four places in each plot at the time of weed removal for early competition and about 10 days interval before the expected harvest time in the case of late competition to avoid possible foliage and seed shading. The weed species found within the sampling quadrat were identified, counted, and expressed in m^{-2}. Weed aboveground dry biomass (g): For aboveground weed dry biomass, the weeds falling within the quadrat were cut near the soil surface immediately after recording data on weed count and placed into paper bags separately treatment-wise. The samples were sun-dried for 3-4 days and thereafter were placed into an oven at 65°C temperatures till a constant weight and, subsequently, their dry weight was measured. The dry weight was expressed in g m^{-2}. Four plants per plot were selected at random to record plant height, the number of primary branches per plant, fresh stem and leaf weight per plant, fresh and dry flower weight per plant, fresh and dry flower per hectare, essential oil, and essential oil yield per hectare. Data collected on growth and yield parameters of the crop were analyzed statistically by using Fisher's analysis of variance technique. The least significant difference (LSD) test at 0.05 probability levels was employed to compare the treatment means (Steel *et al*., 1997). On the other hand, to analyze the critical period of weed control, the relative chamomile yields (Y) of each treatment were computed as followed.

Y = (*M. chamomilla* (L.) Rydb) ▯▯ yield in treatment / (*M. chamomilla* (L.) Rydb) ▯▯ yield in weed-free check x 100

$$\text{Yield losses (\%)} = \left[1 - \frac{\text{M. chamomilla L fa} \quad \textit{in weedy check}}{\text{M. chamomilla L fa yield in weed free check}}\right] x100$$

Determination of yields losses of chamomile to the maximum level due to weed.

RESULTS AND DISCUSSION

Weed data

There were 20 main weed species belonging to 9 families that were identified in which the greater number was broadleaf species with lower numbers of grass and sedge weeds. By grouping weeds according to their methods of reproduction and dispersal determining their life cycle, the following groups were distinguished annual (grasses, broadleaved species, and sedges) and perennial (grasses, broadleaved species, and sedges) (Table 1). Thus, the annual weeds that complete their life cycle within one year or less were the most common group during the two years of study while perennial weeds were found as the second group. Most of the weed species identified in the present study were in line with Bayisa and Hundesa (2017) who reported that the weed species were composed of a wide range of annual, biennial, and perennial broad-leaved, grasses and sedges weeds with differences in frequency, abundance, and dominance.

Total weed density increased significantly with the increase in competition duration and an increase was significant at each increase in duration period. The maximum (89.26) and minimum (0.00) total weed density was obtained in plots with weed-infested season long (weedy check) and weed-free season long (weed-free check), respectively (Figure 1 and 2). A weedy check showed the maximum weed density because there was a longer period available for weeds to germinate and weeds continued to germinate throughout the growth period. These results agree with Tunio *et al.* (2004) who reported that weed-free plots showed minimum density because weeds were eradicated by repeated hand hoeing.

The dry weight of aboveground weed biomass was increased with the increase in competition period, being maximum (113.53) in weedy check and the minimum (0.00) was in weed-free check (Figure 1 and 2). The maximum dry weight of aboveground weed biomass in weedy check might have been due to higher weed density (Figure 1) and longer growth period resulting in more accumulation of photosynthates and a greater biomass. Thus, the result clearly showed that the weed-free condition at the early crop growth stage is more important than the weed-free condition at the later one. The result further indicated that the weeds emerging at the later growth stages offer less competition to crops as it accumulates lower weed biomass (Uremis *et al.,* 2009). Similarly, Akhtar *et al.,* (2000) found that increasing weed crop competition duration increased weed biomass.

Table 1: Major weed species during the main cropping seasons of 2017 and 2018

S/N	Scientific name	Family name	Category	Life cycle
1	*Oxalis corniculata* var.	Oxalidaceae	Broad leaf	Annual
2	*Bidens pilosa* L.	Asteraceae	Broad leaf	Perennial
3	*Commelina latifolia* Hochst.	Commelinaceae	Broad leaf	Perennial
4	*Guizotia scabra* (Vis.) Chiov	Asteraceae	Broad leaf	Perennial
5	*Ageratum conyzoides* L.	Asteraceae	Broad leaf	Annual
6	*Amaranthus hybridus* L.	Amaranthaceae	Broad leaf	Annual
7	*Amaranthus spinosus,* Khmer	Amaranthaceae	Broad leaf	Annual
8	*Galinsoga parviflora* Cav.	Asteraceae	Grass	Perennial
9	*Plantago lanceolate* L.	Plantaginaceae	Broad leaf	Perennial
10	*Cyperus esculentus* L.	Cyperaceae	Sedge	Perennial
11	*Cyperus rotundus* L.	Cyperaceae	Sedge	Perennial
12	*Datura stramonium* L.	Solanaceae	Broad leaf	Annual
13	*Xanthium strumarium* L.	Asteraceae	Broad leaf	Annual
14	*Digitaria abyssinica* (A. Rich.) stapf	Poaceae	Grass	Annual
15	*Digitariasanguinalis* (L.) Scop.	Poaceae	Grass	Annual
16	*Portulaca oleracea* –Gourmet Sleuth	Portulacaceae	Broad leaf	Annual
17	*Commelina benghalensis* L.	Commelinaceae	Broad leaf	Perennial
18	*Anagallis arvensis* var. caerulea (L.) Gouan	Primulaceae	Grass	Perennial
19	*Rottboallia cochinchinesis* (Lour.) Clayton	Poaceae	Grass	Annual
20	*Nicandra physaloides* (L)Gaerth	Solanaceae	Broad leaf	Annual

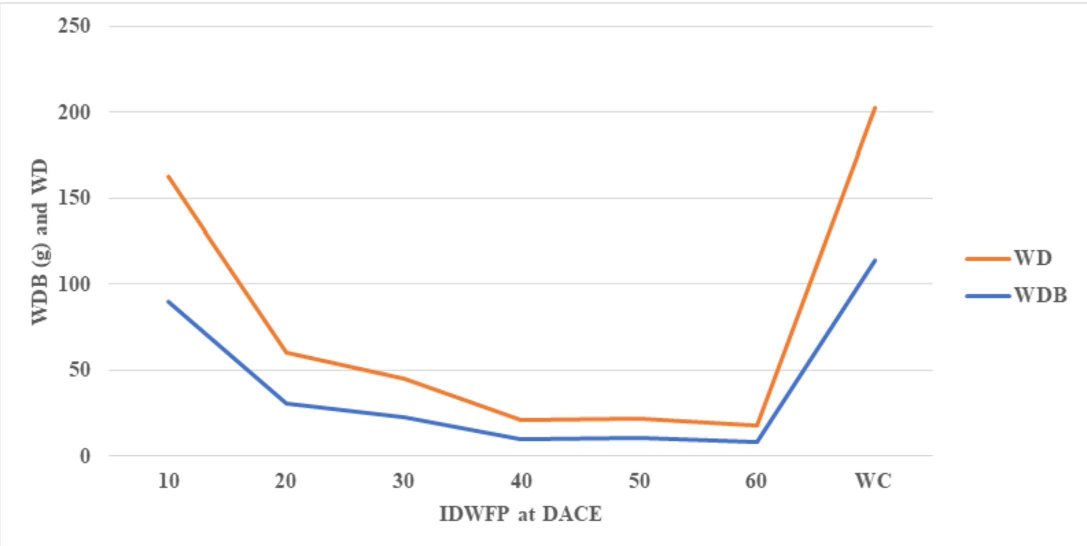

Figure 1: The effect of weed dry biomass (WDB) and weed density (WD) on chamomile plant in IDWFP (Increased Duration of Weed Free Period) at DACE

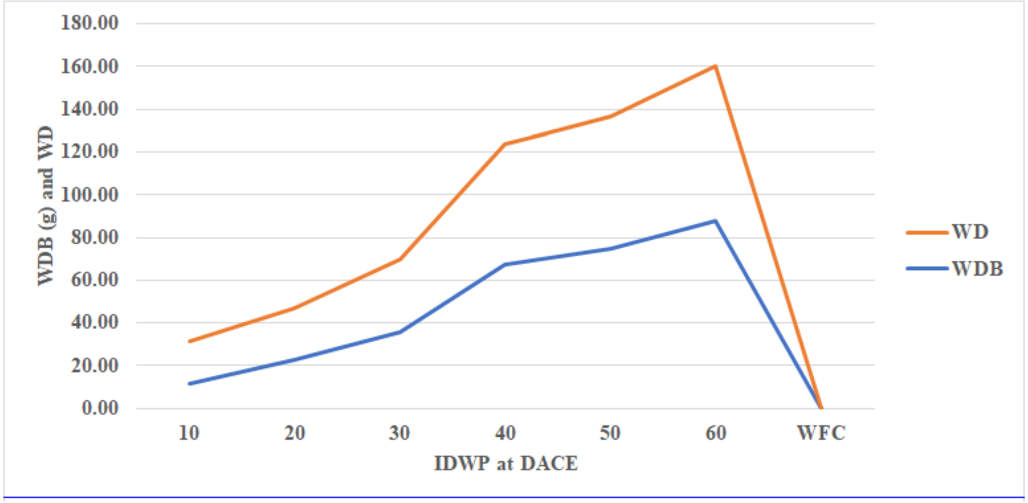

Figure 2: The effect of weed biomass and weed density on chamomile plant in IDWP (Increased Duration of Weedy Period) at DACE

Crop data

The present results revealed that the effect of different weed-crop competition durations on plant height was significantly (P<0.0001) varied. As the increased duration of weedy periods, the plant height becomes higher while in the increased duration of weed-free periods becomes decreased (Table 2). This could be due to weeds that were left to grow for longer periods and the weed plant population per unit area tended to increase which resulted in severe competition between crop and weed for light and space. Overall, in increasing weed-free periods, plant heights reached lower values while increasing duration of weedy periods reached the higher values. In agreement with the present study, Singh *et al.*, (2015) reported that the field pea plant height increased with an increase in the duration of weed interference and decreased with an increase in weed-free periods.

It is a significant (P<0.0001) effect of weed-crop competition durations on the number of primary branches per plant. A gradual and progressive decrease in the number of primary branches per plant was recorded with increasing competition duration. The highest number of primary branches (31.00) per plant was found in the weed-free check. This was statistically on par with the competition duration of 60 DACE and significantly different from the rest of the treatments (Table 2). This might be due to less time available for the competition of resources between the crop and weeds in a short competition duration for the higher number of primary branches per plant. Because weeds were removed and plants achieved good growth rate and maximum assimilates may be formed which allowed good vegetative growth and higher number of branches per plant in return while the minimum number of branches per plant was probably due to longer competition duration between crop and weeds and resources were not fully utilized by the crop. The results are in accordance with the findings of Singh *et al.* (2015) who also described that number of primary branches per plant in field pea increased when the weed-free days were prolonged.

The present study indicated that the weight of fresh and dry stem, leaves, and flower yield was significantly (P<0.0001) influenced by the duration of weed competition. The result revealed that the weed-free check followed by weed-free for 60DACE produce maximum fresh stem per plant (211.25g) and (210.35 g), respectively (Table 2). The minimum fresh stem per plant (18.28 g) was recorded in plots where competition was throughout the growing season (Table 3). Likewise, the maximum fresh leaves per plant were recorded in weed-free for 60DACE (77.62g). This was statistically on par with the weed-free check and competition duration of 50 and 40 DACE, respectively, and significantly different from the rest of the treatments (Table 2).

The maximum fresh flower yield (45.36 g/plant) and (3780.10kg/ha) was found in the weed-free check which was statistically on par with competition duration of 60, 50, and 40 DACE and significantly different from the rest of the treatments (Table 2). Similarly, the maximum dry flower yield (9.58g/plant) and (798.32 kg/ha) was found in the weed-free check which was statistically on par with competition duration of 60, 50, 40, and 30 DACE and significantly different from the rest of the treatments (Table 3). This could be due to the absence of weeds in being weed-free beyond 40 DACE which might have enabled the crop to make the best use of growth resources that resulted in a greater fresh and dry stem, leaves, and flower per given area. This was in line with Singh *et al.*, 2015 who reported that the yield attributes were highest in the season-long weed-free period and on par with weed-free for the initial 40 days or plots kept weedy only for the initial 20 days. The same authors also stated that yield attributes of field pea increased with an increase in weed-free duration and decrease in weedy periods.

Table 2: The effect of weed competition periods on chamomile yield components

Treatment	PH (cm)	NPB	FSWPP (g)	FLWPP (g)	FFWPP (g)	FFW (Kg/ha)
IDWFP at DACE						
10	62.50^{cde}	17.50^{e}	68.53^{f}	45.01^{d}	32.98^{c}	2748.30^{c}
20	63.67^{bcd}	20.67^{d}	145.74^{d}	58.64^{b}	39.49^{b}	3290.40^{b}
30	60.25^{de}	21.83^{cd}	161.58^{c}	59.25^{b}	39.49^{b}	3290.30^{b}
40	56.75^{defg}	23.50^{c}	203.34^{ab}	74.77^{a}	42.44^{ab}	3536.50^{ab}
50	52.46^{fgh}	26.17^{b}	197.96^{b}	74.97^{a}	43.39^{ab}	3615.60^{ab}
60	50.21^{gh}	29.50^{a}	210.35^{a}	77.62^{a}	43.83^{ab}	3652.10^{ab}
WC	73.33^{a}	5.33^{g}	18.28^{h}	11.17^{h}	7.45^{g}	620.80^{g}
IDWP at DACE						
10	56.58^{efg}	21.17^{d}	155.85^{cd}	51.04^{c}	27.39^{cd}	2282.30^{cd}
20	58.92^{def}	16.83^{e}	104.35^{e}	28.73^{e}	23.39^{de}	1949.40^{de}
30	62.46^{cde}	8.33^{f}	57.66^{f}	26.05^{ef}	17.87^{ef}	1488.80^{ef}
40	67.75^{abc}	6.67^{fg}	38.63^{g}	22.07^{f}	15.37^{f}	1280.90^{f}
50	67.79^{abc}	5.17^{g}	31.67^{g}	22.01^{f}	9.03^{g}	752.30^{g}
60	70.50^{ab}	4.67^{g}	29.03^{gh}	16.23^{g}	8.17^{g}	680.40^{g}
WFC	47.50^{h}	31.00^{a}	211.25^{a}	77.25^{a}	45.36^{a}	3780.10^{a}
$Lsd_{0.05}$	6.94	2.05	11.68	5.20	5.67	472.87
CV (%)	9.86	10.42	8.65	9.58	17.35	17.35

PH=Plant Height, NPB=Number of Primary Branches, FSWPP=Fresh Stem Weight Per Plant, FLWPP=Fresh Leaf Weight Per Plant, FFWPP=Fresh Flower Weight Per plant, FFW(Kg/ha) =Fresh Flower Weight per Hectare

Essential oil content and yield were significantly ($P<0.0001$) influenced by the duration of weed competition. The maximum essential oil content (0.79v/w) and (6.25kg/ha) was recorded from the weed-free check which was at parity with the treatments kept weed-free beyond 40DACE and the lowest was (0.10 v/w) and (0.15kg/ha) found in weedy for 60DACE (Table 3). The highest essential oil content and yield in the increasing duration of the weed-free period might be due to the accumulation of adequate dry matter by the crop through the utilization of available aboveground and belowground growth resources by the crop. The decrease in essential oil content and yield with increasing weed-crop competition duration was due to a decrease in the yield components like the number of branches per plant and fresh and dry flowers per plant. In general, essential oil content and yield of chamomile were inversely related to the increase in the duration of weedy periods and directly proportional to the increase in weed-free periods. In conformity with this result, Zuhal *et al.,* (2010) reported that the yield of faba bean significantly varied when weeds were allowed to grow for different durations and about 46% yield loss was recorded from weedy check plots.

Table 3: The effect of weed competition periods on chamomile yield and yield components

Treatment	DFWPP (g)	DFW (kg /ha)	EOC (v/w)	EOY (kg/ha)
IDWFP at DACE				
10	7.24^{bc}	603.20^{b}	0.43^{cd}	2.56^{cd}
20	7.40^{b}	617.00^{b}	0.47^{c}	2.93^{c}
30	8.87^{a}	739.23^{a}	0.58^{b}	4.27^{b}
40	8.99^{a}	749.48^{a}	0.78^{a}	5.89^{a}
50	9.17^{a}	763.89^{a}	0.76^{a}	5.84^{a}
60	9.47^{a}	789.43^{a}	0.76^{a}	5.91^{a}
WC	1.82^{f}	151.30^{f}	0.10^{g}	0.15^{h}
IDWP at DACE				
10	6.35^{cd}	528.72^{cd}	0.39^{cde}	2.06^{de}
20	5.54^{d}	461.69^{d}	0.34^{def}	1.55^{ef}
30	4.28^{e}	356.11^{e}	0.30^{ef}	1.04^{fg}
40	3.79^{e}	315.62^{e}	0.26^{f}	0.80^{gh}
50	2.16^{f}	179.67^{f}	0.12^{g}	0.21^{h}

Treatment	DFWPP (g)	DFW (kg /ha)	EOC (v/w)	EOY (kg/ha)
60	1.94[f]	161.64[f]	0.08[g]	0.13[h]
WFC	9.58[a]	798.32[a]	0.79[a]	6.25[a]
$Lsd_{0.05}$	0.99	82.66	0.10	0.74
CV (%)	13.86	13.86	19.67	22.46

DFWPP=Dry Flower Weight Per Plant, DFW(Kg/ha) =Dry Flower Weight per hectare, EOC=Essential Oil Content, EOY=Essential Oil Yield

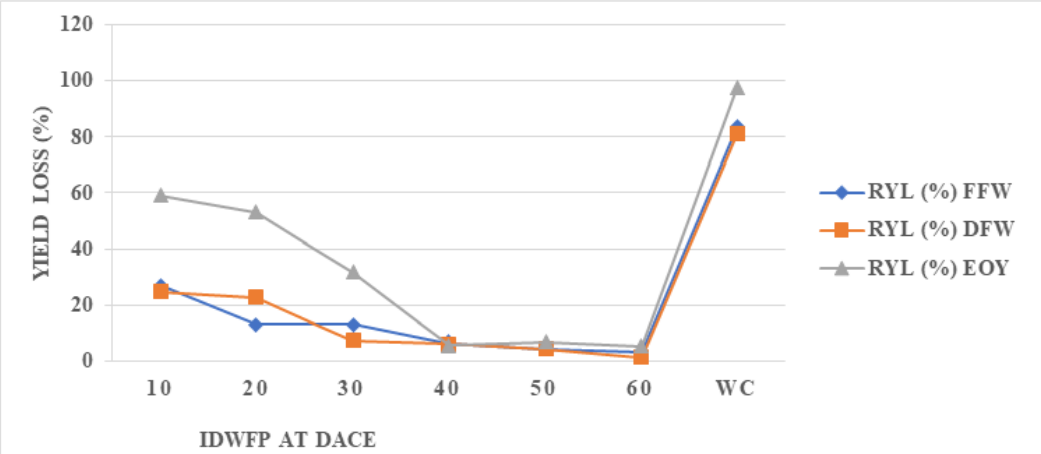

Figure 3: The effect of weeds on the yield losses of chamomile plant in IDWFP at DACE

RYL (%) FFW= Relative Yield Loss of Fresh Flower, RYL (%) DFW= Relative Yield Loss of Dry Flower, RYL (%) EOY= Relative Yield Loss of Essential Oil Yield

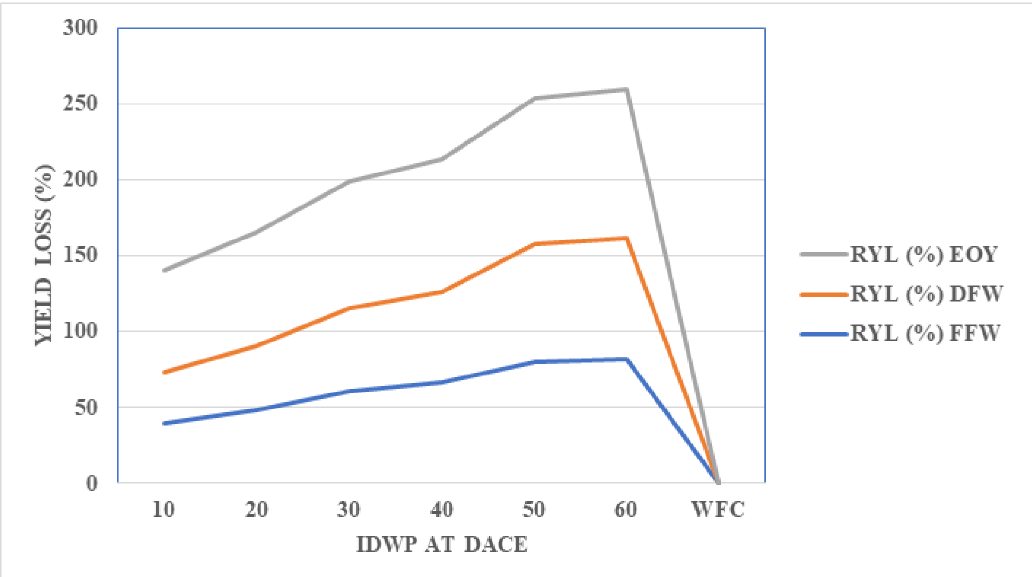

Figure 4: The effect of weeds on the yield losses of chamomile plant in IDWP at DACE

Yield losses

The losses that were shown due to each of the different weed competition periods were considered relative to the yield of weed-free checks compared with each of the treatments. The results in losses indicated that the fresh flower yield per hectare was higher beyond weedy for 40DACE compared to the WFC. The fresh flower yield losses ranged from (39.32 – 53.58 %) in increased duration of weedy periods while (0.00 – 27.30%) in increased duration of weed-free periods (Figure 4). Likewise, dry flower yield losses were higher in WC followed by weedy for 50 and 60DACE as compared to the WFC (Figure 3 and 4). In this case, the dry flower yield losses ranged from (33.77 – 81.05%) in increased duration of weedy periods while in increased duration of weed-free periods ranged from (0.00 - 24.44%) (Figure 3 and 4)). For essential oil yield, the maximum losses were found in weedy for 60DACE (97.92%) followed by weedy-check (97.60%) and weedy for 50DACE (96.64%) while the minimum was found in weed-free check that ranged from (67.04-97.92%) in increased duration of weedy periods and increased duration of weed-free periods (0.00-59.04%) (Figure 3 and 4). Thus, the losses come through the results of weed-crop competition regarding the nearby resources utilize in the growing period. The prolonged crop-weed competition resulted in reduced dry biomass accumulation which ultimately rendered the yields of parameters considered and higher yield losses for them. In conformity with Singh (1997) who reported that weed removal in chamomile plants during 5–11 weeks after planting was necessary to obtain a higher yield of the flour and oil. The uncontrolled weed growth caused a 34.4% reduction in the dry flower yield as compared with the weed-free condition.

The critical period of weed control

The critical period of weed control for chamomile was estimated based on the relative yields with between 5% and 10% as acceptable yield loss. The beginning of the critical periods of weed competition was obtained from the late weed-crop (from the increasing duration of weedy periods) competition while the end of the critical periods of weed control was obtained from the early crop weed competition (from the increasing duration of weed-free periods). Based on the current result of yield losses, the critical period of weed control for chamomile should be kept weed-free from 40 to 60 DACE. Thus, the weeds have to be managed during these periods through appropriate methods to prevent more than 10% yield loss of the crop. This critical period of weed control follows previous studies. Le Bourgeois and Marnotte (2002) located this critical period between 30 and 90 DAS for long-cycle crops (yams, cassava, sugarcane, etc.). This was in line with the finding of Zuhal *et al.,* (2010) who reported the critical period of weed control in faba bean started at 30 days and ends at 45 days after crop emergence with 10% acceptable yield loss.

CONCLUSION

There was an overall sensitivity of chamomile crops to the infestation of weeds, which demonstrates the need for weed control techniques. The highest weed biomass and density at harvest seemed to be associated with the lowest values of essential oil yield and yield-related components. From this study it can be concluded that to obtain a better yield of more than 90% yield, chamomile has to be weed-free. This period is between 40 to 60 days after the emergence of the crop as it is found to be the critical period of weed crop competition at Wondo genet and similar to the other agro-ecology areas. Hence, in integrated weed management (IWM) strategies not only herbicides or a single method is used for the control of weeds. However, various cultural practices are incompatible with other control methods as IWM is a very important method of weeds control in the crop fields when the critical weeding period is well known. So, this finding may be provided available information on the critical weeding period of this crop.

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