Integrated Effect of Seeding Rate, Herbicide Dosage and Application Timing on Durum Wheat *(Triticum Turgidum L. Var Durum)* Yield, Yield Components and Wild Oat (*Avena Fatua L.*) Control in South Eastern Ethiopia

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ABSTRACT

Knowledge of optimal combinations of crop densities, herbicide dose and time of application could improve the effectiveness and net benefit of commonly used herbicides. A study was conducted at two locations in SARC on-station and farmer's field, South Eastern Ethiopia for two years from 2007 to 2008. The experimental design was randomized complete block (RCB) design with split-plot arrangement. Durum wheat *(Triticum turgidum)* seeding rates (recommended, 25% and 50% plus recommended rate) were arranged in the main plot. Four wild oat *(Avena fatua)* herbicide, Topik, doses (0, 25, 50 and 100 % of the recommended dose) and three timing of applications (14 DA, 32 DAE and 50 DAE) were used as sub-plot treatments. The treatments were compared to determine their effect on durum wheat yield, yield components wild oat densities and control efficacies. Durum wheat seeding rates significantly influenced grain and biomass yield, spike per unit area and kernel weight. Seeding rate of 225 kg ha^{-1} produced highest grain yield (3810.4 kg ha^{-1}) while 150 kg ha^{-1} recorded the lowest. Mean wild oat density count before herbicide application timings varied over the two locations averaging 37 and 87 seedlings m^{-2}. Increasing seed rate by 25 and 50% increased wild oat control efficacy by 16.9 and 21.5% respectively. Spraying the herbicide at later growth stages caused greater wild oat seedling density and reduced wheat yield at both locations. The highest efficacy (94.04%) was obtained in the second time of application (30 DAE) of 1 l lit ha^{-1}. The highest reduction in population density was occurred in 100% herbicide rate. There was a general decline in wild oat density in the early application and as the herbicide dose increased, but the effect of seeding rate varied very slightly. In contrast to the wild oat control efficacy the highest grain yield ha^{-1} was obtained in the first application date (14 DAE). Durum wheat yield losses in the absence of herbicide application were increased by about 16%. Maximum yield (3870.73 kg ha^{-1}) was obtained at 100% of the herbicide dose very closely followed by 50 and 25% of the recommended rate reducing durum wheat yield only by about 1.6 and 2% respectively. Durum wheat seeding rate, herbicide dosage and application timing had statistically no significant interaction effect**.**

Key words: Durum wheat, Wild oat, Herbicide dose, Seeding rate, Application timing.

1. INTRODUCTION

Wild oat (*Avena fatua* L.) is one of the most widespread and harmful grass weeds in wheat (*Triticum estivum* L.) worldwide. It infests more than fifty countries and is considered one of the most important weeds in the world (Holm et al., 1977; Simpson, 1990). Wild oat is also one of the most troublesome weeds which constrain wheat production in Ethiopia because of the continuous monocropping of wheat and barley in the large and small scale farming systems of the high lands (Rezene and Yohannes, 2003). Wild oat is one of the most dominant and frequently observed weed species in wheat fields and is becoming an increasingly serious constraint of wheat production in Bale highlands (Kedir et al., 1999). *Avena species* are highly competitive, resulting in greater reduction of wheat grain yield, i.e., 85% at 320 seedlings/m2 (Taye and Tanner, 1997). Tanner et al. (1995) have reported grain yield reductions of 26 to 63% across four bread wheat cultivars at 90 weed seedlings m^{-2} in Ethiopia.

Before herbicides were widely available, farmers employed cultural measures to manage weed population. Wild oat management systems have evolved to the point that producers rely on herbicides to the virtual exclusion of all other strategies (Liebman and Janke, 1990). Although herbicides are generally effective, wild oat is widely spreading and continues to reduce yields. Herbicide choice and timing are critical for wild oat control in many fields. Quality losses, due to contamination of cereal samples by wild oats, can be substantial, resulting in rejection for seed and milling.

Herbicide control is now the merely option in many situations because of the high level of infestation and the scarcity and cost of labour for hand rouging. Fortunately the wild oat herbicide range is now very effective particularly in the case of wheat. Topik is one of the products of choice on all varieties of durum and bread wheat for wild oat control and may be applied up to flag leaf stage. There is considerable scope for reducing rates of wild oat herbicides when applied at the early stages (Harker and Blackshaw, 2000).

However, herbicides are generally over used and the rather indiscriminant use of herbicides has led to health and environmental concerns. Using management practices that increase crop competitiveness may reduce the negative effects associated with the use of herbicides (Fernandez et al., 1987). Restricting weed seed production gives producers greater opportunities and latitude to practice integrated weed management. Because it has not yet possible to obtain sufficient control of wild oat with one control measure under current cropping system, it is important to explore the potential for an integrated management system (Barton et al., 1992).

Increasing the crop seeding rate improve weed control in an integrated weed management system (O'Donovan et al., 2000). The effects of wheat seeding rate on grain yield have been inconsistent in different studies. Sometimes, seeding rate does not affect grain yield (Kirkland et al., 2000). However in other experiments, higher seeding rates increased yields (Tompkins et al., 1991). The combination of high sowing densities of crops and low rates of herbicides is an effective weed management strategy for grasses (Harker and Blackshaw, 2000). Therefore, the aim of this study was to develop integrated weed management systems that reduce reliance on herbicide and also investigate whether wild oats can be controlled effectively in wheat using higher crop densities and lower herbicide rates.

2. MATERIALS AND METHODS

2.1. Experimental Sites

The experiment was conducted for two years (2007-2008 main cropping seasons) at two proxy sites; Sinana Agricultural Research Center (SARC) on-station and farmer's field (Selka area) in Bala, South Eastern Ethiopia. SARC is located at 7°7'N latitude, 40° 10' E longitude and 2400 m.a.s.l altitude in Bale Zone of Oromia Region. The soil at the experimental sites was sandy loam in nature with pH 7.5, organic carbon 0.34%, low in total nitrogen (0.041%), medium in phosphorus (50.88 kg ha^{-1}) and high in potassium (315.90 kg ha^{-1}). The area is characterized by bimodal rainfall pattern. Average annual rain fall, minimum and maximum temperatures during the experimental years were 1369.3 mm, 9.7°Cand 20.0°C, respectively. The amount of average rain fall in main cropping season of the experiment (August-December) was 610 mm. The pattern, onset and distribution of rain fall were sound in the areas for the entire seasons.

2.2. Experimental Design and Treatments

The experimental design was RCBD arranged in a split plot design with three replications. Three durum wheat seeding rates adjusted at a series of increasing (SR = recommended rate, SR = recommended rate +25% and SR = recommended rate + 50%) i.e. 150 kg/ha, 187.5 kg/ha and 225 kg/ha were arranged as the main plot treatment. Factorial combinations of four grass weed herbicide, Topik, rates (HR weedy check, HR =25% of recommended dose, HR =50% of recommended dose and HR =100% of recommended dose, 1 lit/ha) and three timing of applications, according to decimal code for the growth stages of cereals (Zadoks etal., 1974), i.e. two-three leaves unfolded seedling stage (14 DAE), two tillers or 4.5 leaves stage (32 DAE) and jointing stage when flag leaf is visible (50 DAE), were arranged as sub-plots. Plots of 3 by 4 m^2 spacing were sown at the same time. Topik was applied using knapsack sprayer.

2.3. Data Collection and Statistical Analysis

Wild oat density count was taken randomly from each treated and untreated plots before herbicide application and five weeks after each application by clipping all plants from two

0.25m quadrates and the density from treated plots compared with the untreated plots. The weed control efficiency (WCE) by number of weeds was calculated by using formula suggested by (Auskalnis and Kadzys, 2006).

$$WCE = \frac{NWC-NWT}{NWC} * 100\%$$

Where:

WCE = Weed (Wild Oat) Control Efficiency;

NWC = Number of Weeds m^{-2} from Control plots (weedy check) and

NW T = Number Weeds m^{-2} in plots Treated with Topik

Plant height was recorded as the average height of main tillers. Fertile spike count was taken randomly from each plot by clipping all fertile spikes from two 0.25m2 quadrates. Number of kernels per spike was counted as the average number of grains on single spike of main culm. Biomass yield, 100 kernels weight, Grain yield were also measured using a sensitive balance. Harvest index was calculated as the percent ratio of grain yield to the total above ground biomass. All data were analyzed using SAS GLM procedure (SAS, 1997). Comparisons among treatments with significant differences for measured and scored characters were computed based on LSD test.

3. RESULTS

The result of the data combined over the two years and two locations indicated that durum wheat seeding rates significantly influenced grain and biomass yield, spike per unit area and kernel weight. Seeding rate of 225 kg ha^{-1} produced higher grain yield (3810.4 kg ha^{-1}) and biomass yield (9185.0 kg ha^{-1}) (Table 1). It was found out that the highest number of spikes m^{-2} was recorded in the 225 kg ha^{-1}, while the lowest was recorded in 150 kg ha-1. On the other hand maximum number of seeds $spike^{-1}$ was recorded in 150 kg ha^{-1} (Table 1). Durum Wheat seeding rates had a significant impact on the 1000-grain weight. The highest 1000 grain weight was recorded in the lowest seed rate of 150 kg ha^{-1}. Increasing seed rate over recommended (150 kg ha^{-1}) by 25 and 50% to 187.5 and 225 kg ha^{-1} increased wild oat control efficacy by 16.9 and 21.5% respectively (Table 1). The highest weed count recorded in low seed rate treatment.

Since the experiment was sown in fields naturally well infested with the target weed, mean wild oat density count before each application timing was varied over the two years, averaging 37 and 87 seedlings m^{-2} at sinana on-station and Selka area respectively. However, population density count five weeks after spray varied considerably among the herbicide rates and application timing. Wild oat density count generally declined as herbicide dose increased. Conversely, density count was linearly increased with the application timing with minimum count at 14 DAE. On average over 59% of the declines in population density count occurred when the herbicide was applied in the early crop seedling stage at 14 DAE. The highest reduction in population density was occurred in 100% rate. Although herbicide rate, application timing and seeding rate interaction effect on wild oat survival was statistically not significant population density at each herbicide dose tended to decrease as seeding rate increased. A decline in the amount of wild oat population density in response to increased durum wheat seeding rate was more pronounced at the highest herbicide dose application in the tillering stage (32 days after emergence).

The result indicated that herbicide had the most consistent and significant effect on durum wheat seed yield at both locations. The effect of the herbicide on durum wheat yield was not influenced by crop seeding rate, as indicated by the lack of significant interactions with these factors. The greatest reduction in yield occurred when no herbicide was applied (Table 2). When compared to the recommended rate of 1lit/ha, yield losses in the absence of herbicide application increased by about 16%. Maximum durum wheat yield (3870.73 kg/ha) was obtained when Topik was applied at 100% of the recommended rate very closely followed by 50 and 25% of the recommended rate reducing durum wheat yield only by about 1.6 and 2% respectively. The highest spike per unit area was obtained from the highest application rate (1 l/ha) while kernel weight was not affected by herbicide application rate (Table 2). Similarly, significant differences observed in grain yield, plant height, spike per unit area and biomass with respect to herbicide application timing. These all parameters were found to be more influenced by the first application date (14 days after emergence).

There was also significant variation among the herbicide rates in controlling the target and most prevalent weed in the area, *Avena fatua*. Wild oat control efficacy was varied highly among the herbicide rates and application timings. It was found that application of 1 l ha^{-1} is more effective in controlling the target weed species. The highest efficacy (94.04%) was obtained in the second time of application (32 days after emergence) of 1 lit ha^{-1} Topik application. However, Topik rate of 0.5 lit ha^{-1} applied at 14 days after emergence recorded the highest grain yield (4108.68 kg ha^{-1}), followed by rate 0.25 lit ha^{-1} (4108.11 kg ha^{-1}) applied at same timing of application.

Various durum wheat seeding rates interactions with herbicide dosage and application timing had no significant effect on yield and yield component parameters. Yet statistically it is not significant maximum yield of durum wheat was obtained under the maximum seed rate of

225 kg ha^{-1} along with early application of Topik (14 days after emergence) at the rate of 1 liter ha^{-1}. Moreover, efficacy of lower Topik dose when applied in the early stages in combination with higher seed rate was efficient than when applied with higher seed rates in the latter stages. On the other hand, the lowest value of grain yield of wheat was recorded under seed rate of 187.5 kg ha^{-1} when there was no any attempt made for controlling weeds.

4. DISCUSSION

Durum wheat seeding densities influenced grain yield and important yield related traits. The highest fertile spike, grain and biomass yield were obtained in the highest seeding rate (225 kg ha^{-1}), however, the highest seeds per spike and kernel weight were recorded in the lowest seeding rate (150 kg ha^{-}1). The result indicated that the number of spikes per unit area has highly contributed than seeds per spike and kernel weight for the highest grain yield obtained in the highest seeding rate. This implies that increased crop density had strong and consistent negative effects on weed and positive effects on grain and biomass yield. Higher grain yield with higher seed rate was also reported by Olsen et al. (2005). In other studies it was also reported that weed competition in wheat reduces yield through decreases in spike numbers (Bell and Nalewaja, 1968; Cudney et al., 1989). Similar finding by Wilson et al. (1982) indicates that, in barley, competition in the higher seeding densities reduce yield through decrease in the number of grains per spike.

Increasing seed rate was highly contributed to wild oat control efficacy with the highest weed population reduction occurred in the highest seeding rate of 225 kg ha^{-1}. The efficacy was sharply increased when the seeding rate increases from 150 kg ha^{-1} to 187.5 kg ha^{-1}. A relative decrease in weed population or efficacy with higher seed rate might be due to competition from crop plants for space, nutrients, moisture and solar radiation. These findings are in agreement with the work of Justes et al. (1984), Taye et al. (1996a, 1996b) and Barton et al. (1992), who concluded the strong impact of crop seeding rates in wild oats management. In their wild oat and wheat competition study Carlson and Hill (1985) suggested that at relatively low seed rate, crop density would be naturally less, leaving a large amount of resources available for weeds and enabling them to establish quickly.

Wild oat control was highly effective at the highest herbicide application dose of 1 lit ha^{-1} in the tillering stage (32 days after emergence) in combination with higher durum wheat seeding rate. Similar findings by O'Donovan et al. (2001) indicated that at the lowest barley seeding rate, more wild oat density counted when the herbicide dose was reduced to 25 or 50% of the recommended rate. They concluded that at the highest seeding rate, there was little difference between applying wild oat herbicide at 50 or 100% of the recommended rate in terms of the amount of wild oat population density.

Maximum wheat yield was obtained when the herbicide was applied at 100% of the recommended rate. In other study, Belles et al. (2000), was found out that maximum wheat yields were obtained when wild oat herbicide, tralkoxydim, was applied at 70 to 85% of the recommended rate. In contrast, reducing the herbicide dose below the recommended rate decreased bread wheat (*Triticum aestivum* L.) yield by 7% (Stevenson et al., 2000). On the other hand, neither grain yield nor net return was affected when relatively low rates of several graminicides were applied to either barley or wheat (Spandl et al., 1997).

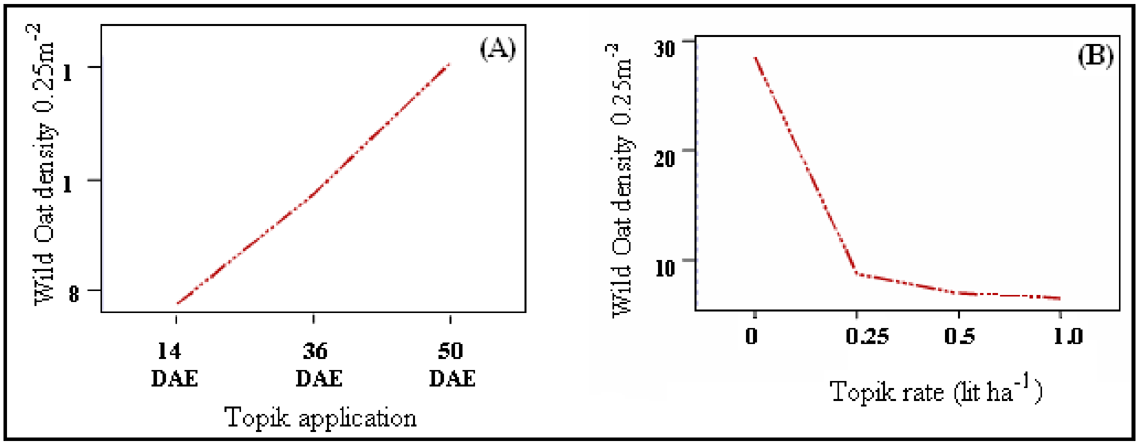

Figure.1 A). Effect of topic application timing on wild oat population density combined over locations and years; B). Effect of topic rate on wild oat population density combined over locations and years.

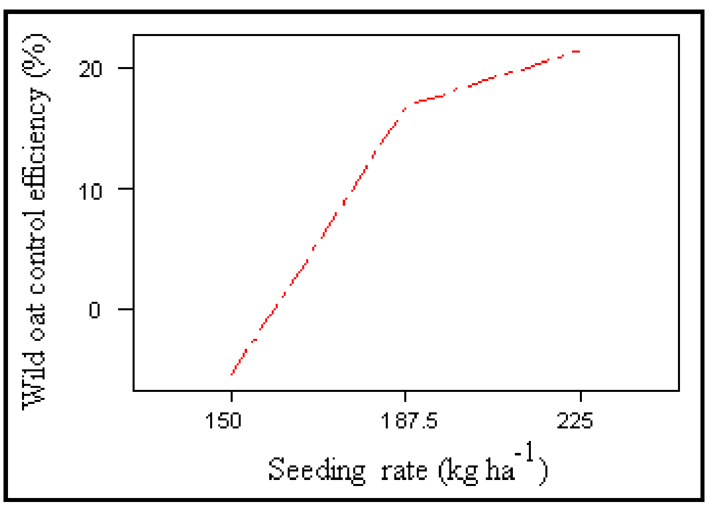

Figure 2. Effect of durum wheat seeding rate on wild oat population density combined over locations and years.

In the study it was also found that herbicide application in the early seedling stage (14 days after emergence) was highly influenced durum wheat yield and important yield related traits. It was indicated that controlling weeds in the early tiller initiation seedling stage has a yield advantage (about 4-12%) than late applications. There was a general decline in wild oat population density in the early application and as the herbicide dose increased (Fig. 1 A and B). The effect of increasing seeding rate on wild oat population reduction, however, was varied slightly between 187.5 and 225 kg ha^{-1} (Fig. 2).

The highest wild oat control efficacy (94.04%) was obtained in the application at two tillers leaves stage (32 DAE) of 1 lit ha^{-1} herbicide application. This could be because of the weed plants become woody in the late stage and are not likely to be killed easily by herbicide application. Efficacy of application in the early tiller initiation stage (14 days after emergence) was slightly lower than when the crop was in the tillering stage because late emerged weeds could not be killed in the first application. The result indicated that Topik application in the early tiller initiation stage (14 days after emergence), although it was not effective in controlling wild oats as application in the tillering stage (32 days after emergence), it has considerable effect in increasing grain yield. It was also evident that efficacy of lower herbicide dose when applied in the early stages in combination with higher seed rate was higher than when applied with higher seed rates in the latter stages. This might be because the lower dose of Topik might not be enough for controlling wild oats.

5. CONCLUSION

Durum wheat yield loss due to wild oat infestation was reduced by using higher than recommended seeding rates. Early application of reduced herbicide dosage was effective in increasing durum wheat yield through important yield components like number of spike per unit area and seeds per spike. Therefore, integrated use of crop seeding densities with early herbicide application can be used as the best strategy for controlling wild oats (*Avena fatua)* and improving durum wheat yield in the highly infested areas like southeastern Ethiopia. It can be recommended that 50% recommended rate (0.5 lit ha^{-1}) of the herbicide at these wild oat densities (37-87 seedlings m^{-2}) in the early application (14 DAE) used for better yield. Yet, care should be taken for the effective control of the weed too, especially at relatively higher infestations for unlikelihood of producing herbicide resistant biotypes. The relative success of 50% recommended rate of Topik in our study could be due to the initial wild oat population densities counted to 37-87 seedlings m^{-2}.

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Table 1. Effect of seeding rate on some important agronomic parameters of durum wheat and wild oat control.

Seed rate	***Grain Yield (kg/ha)***	***Spike/0.25 m² (No.)***	***Thousand Kernel Weight (gm)***	***Seeds/spike (No.)***	***Plant height (cm)***	***Spike length (cm)***	***Harvest Index (%)***	***Biomass(kg/ha)***	***WCE (%)***
SR_1	3718.6	249.1	47.1	45.3	89.9	6.2	41.8	8935.5	-5.4
SR_2	3595.9	263.9	46.3	42.5	88.7	6.1	40.9	8802.4	16.9
SR_3	3810.4	273.2	46.5	42.6	90.2	6.2	40.9	9185.0	21.5
Mean	***3708.30***	***262.07***	***46.63***	***43.47***	***89.60***	***6.17***	***41.20***	***8974.30***	**-**
LSD (P<0.05)	*******	*******	*******	***ns***	*******	***ns***	***ns***	*******	**-**
CV (%)	***23.06***	***23.50***	***5.38***	***21.54***	***3.36***	***6.04***	***9.26***	***24.25***	**-**

- *SR_1= Recommended (150 kg/ha), SR_2= Recommended + 25% (187.5 kg/ha) and SR_3= Recommended + 50% (225 kg/ha)*
- *WCE = Weed (Wild Oat) Control Efficiency*
- *ns= statistically non-significant*
- **= Significant at 5% level of significance*
- ***= Significant at 1% level of significance*
- ****= Significant at 0.1% level of significance*

Table 2. Effect of herbicide dosage and application timing on wild oat control and some important agronomic parameters of durum wheat.

Herbicide application Rate (HR)	***Herbicide application timing (HT)***															
	Efficacy of wild oat control				***Grain Yield (kg/ha)***				***Fertile Spike/0.25m² (No.)***				***Thousand Kernel weight (gm)***			
	HT_1	***HT_2***	***HT_3***	***Mean***	***HT_1***	***HT_2***	***HT_3***	***Mean***	***HT_1***	***HT_2***	***HT_3***	***Mean***	***HT_1***	***HT_2***	***HT_3***	***Mean***
HR_0	-1.32	-1.32	-1.32	***-1.32***	3339.93	3339.93	3339.93	***3339.93***	241.57	241.57	241.57	***241.57***	46.29	46.29	46.29	***46.29***
$HR_{0.25}$	76.36	88.16	28.99	***64.50***	4108.11	3803.86	3457.65	***3789.87***	269.89	261.17	240.6	***257.22***	46.59	46.62	46.64	***46.62***
$HR_{0.5}$	90.74	95.69	21.71	***69.38***	4108.68	3900.07	3425.10	***3811.28***	269.30	275.40	271.34	***272.01***	47.22	46.73	46.53	***46.83***
HR_1	93.45	99.58	33.28	***75.44***	4066.81	3913.05	3632.32	***3870.73***	285.00	285.72	258.89	***276.54***	46.45	45.98	47.44	***46.62***
Mean	***86.41***	***94.04***	***27.55***		***3905.88***	***3739.23***	***3463.75***		***266.44***	***265.97***	***253.10***		***46.64***	***46.41***	***46.73***	
LSD																
HR	***				***				***				***ns***			
T	***				***				*				***ns***			
RxT	***ns***				***				***ns***				***ns***			
CV (%)	-				***13.06***				***13.50***				***5.38***			

- *HR_0= control; $HR_{0.25}$= 25% of recommended rate; $HR_{0.5}$= 50% of recommended rate; HR_1= 100% of recommended rate (1 lit ha^{-1})*
- *HT_1=application at 14 DAE; HT_2= application at 30 DAE; HT_3= application at 50 DAE*
- *ns= statistically non-significant*
- **= Significant at 5% level of significance*
- ***= Significant at 1% level of significance*
- ****= Significant at 0.1% level of significance*
- *R_0= control; $R_{0.25}$= 25% of recommended rate; $R_{0.5}$= 50% of recommended rate; R_1= 100% of recommended rate (1 lit ha^{-1})*

- *HT_1=application at 14 DAE; HT_2= application at 30 DAE; HT_3= application at 50 DAE*
- *ns= statistically non-significant*
- **= Significant at 5% level of significance*
- ***= Significant at 1% level of significance*
- ****= Significant at 0.1% level of significance*

Table 3. Effect of Durum wheat seeding rate and herbicide application timing on wild oat control and some important agronomic parameters of durum wheat.

Durum Wheat Seeding Rate (SR)	Herbicide application timing (HT)															
	Efficacy of wild oat control				Grain Yield (kg/ha)				Fertile Spike/0.25m^2 (No.)				Thousand Kernel weight (gm)			
	HT_1	HT_2	HT_3	Mean	HT_1	HT_2	HT_3	Mean	HT_1	HT_2	HT_3	Mean	HT_1	HT_2	HT_3	Mean
SR_1	63.30	68.31	2.23	***44.61***	3897.78	3778.18	3496.37	***3724.11***	258.31	250.98	238.56	***249.28***	47.16	46.86	47.19	***47.07***
SR_2	73.63	66.12	28.49	***56.08***	3791.86	3583.68	3429.04	***3601.53***	255.83	265.77	248.27	***256.62***	46.21	46.57	46.65	***46.48***
SR_3	65.33	60.38	26.39	***50.70***	4068.94	3871.22	3492.50	***3810.89***	290.91	283.36	271.41	***281.89***	46.64	45.79	46.22	***46.22***
Mean	***67.42***	***64.94***	***19.04***		***3919.53***	***3744.36***	***3472.64***		***268.35***	***266.70***	***252.75***		***46.67***	***46.41***	***46.69***	
LSD																
SR	***Ns***				***				***				*			
HT	***				***				*				***ns***			
SRxHT	***Ns***				***ns***				***ns***				***ns***			
CV (%)	***-***				***13.06***				***13.5***				***5.38***			

Table 4. Effect of Durum wheat seeding rate and herbicide application rate on wild oat control and some important agronomic parameters of durum wheat

Durum Wheat Seeding Rate (SR)	***Herbicide application Rate (HR)***																			
	Efficacy of wild oat control					***Grain Yield (kg/ha)***					***Fertile Spike/0.25m² (No.)***					***Thousand Kernel weight (gm)***				
	HR_0	$HR_{0.25}$	$HR_{0.5}$	HR_1	***Mean***	HR_0	$HR_{0.25}$	$HR_{0.5}$	HR_1	***Mean***	HR_0	$HR_{0.25}$	$HR_{0.5}$	HR_1	***Mean***	HR_0	$HR_{0.25}$	$HR_{0.5}$	HR_1	***Mean***
SR_1	-26.51	68.33	64.76	71.87	***44.61***	3380.28	3759.10	3872.81	3870.56	***3720.69***	234.28	239.00	249.70	273.72	***249.18***	46.48	47.12	47.77	46.87	***47.06***
SR_2	9.86	63.81	71.38	79.28	***56.08***	3236.65	3684.85	3721.31	3758.36	***3600.29***	238.68	258.33	268.61	260.61	***256.56***	46.26	46.53	46.47	46.63	***46.47***
SR_3	-2.55	60.24	70.72	74.38	***50.70***	3418.82	3967.28	3872.86	3990.53	***3812.37***	252.67	276.67	300.32	297.64	***281.83***	46.11	46.17	46.23	46.38	***46.22***
Mean	***-6.40***	***64.13***	***68.95***	***75.18***		***3345.25***	***3803.74***	***3822.33***	***3873.15***		***241.88***	***258.00***	***272.88***	***277.32***		***46.28***	***46.61***	***46.82***	***46.63***	***46.28***
LSD																				
SR	*ns*					***					***					*				
HR	***					***					***					*ns*				
SRxHR	*ns*					*Ns*					*ns*					*ns*				
CV (%)	-					*7.3*					*1.97*					*6.29*				

- *SR_1= Recommended (150 kg/ha), SR_2= Recommended + 25% (187.5 kg/ha) and SR_3= Recommended + 50% (225 kg/ha)*
- *HR_0= control; $HR_{0.25}$= 25% of recommended rate; $HR_{0.5}$= 50% of recommended rate; HR_1= 100% of recommended rate (1 lit ha^{-1})*
- *ns= statistically non-significant*
- **= Significant at 5% level of significance*
- ***= Significant at 1% level of significance*
- ****= Significant at 0.1% level of significance*