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Impact of forage clipping treatments on performance of winter wheat

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ABSTRACT. Farmers in northern parts of Pakistan face severe shortage of green forage for their livestock during the harsh winter season. Winter wheat has the potential to be used as a dual-purpose crop for forage plus grain production in these areas. Ten elite winter wheat lines from Oklahoma State University were evaluated at Hazara Research Station Abbottabad under unclipped and clipped treatment level during 2005-06. The material was planted in a randomized complete block design with three replications, with a row length of four meters and a row to row space of 25 cm. Data were recorded on green forage yield, plant height, spike length, spikelets/spike, days to maturity, spike weight, biological weight, and grain yield. Analysis of variance indicated significant differences among genotypes for all traits except spike length. Similarly all traits except spikelets/spike exhibited significant differences between unclipped and clipped treatment levels. Genotype x clipping interaction was non-significant for all traits except grain yield. Overall, winter wheat lines OK98G508W and OK00611W performed better for important traits such as early maturity, biological yield and grain yield, although over-environment testing is needed before recommendations can be made to the farmers.

Key words: Winter wheat; *Triticum aestivum*; G x E interactions; Clipping; Forage; Dual purpose

INTRODUCTION

Winter wheat (*Triticum aestivum* L.) has a unique property of dual purpose usage (forage + grain yield) because of the longer period required to complete its life cycle. It provides high-quality forage for grazing livestock during fall and winter (Horn, 1983). Earlier studies have revealed that winter wheat has an appreciable yield even after forage clipping in the earlier spring. Forage yield can be maximized by early plantation of winter wheat. However, grazing should be terminated in the early spring to get maximum grain yield. Numerous studies have investigated the effect of wheat grazing on grain yield (Redmon et al., 1995). Grazing tall winter wheat cultivars before culm elongation can produce a slight increase in grain yield as compared to non-grazed wheat because of reduced lodging. However, in semi-dwarf cultivars, net return is maximized when grazing is terminated at first hollow stem - a stage at which a hollow stem can first be identified above the crown (Redmon et al., 1996). Similarly, Krenzer Jr. et al. (1992) reported that differences in forage yield among winter wheat cultivars are sufficiently large to be of importance to wheat and cattle producers. Unfortunately, selecting a winter wheat cultivar on the basis of forage or grain yield alone seldom results in the greatest economic return, because higher grain-yielding cultivars are not always among the highest forage-yielding cultivars (Krenzer Jr. et al., 1996). In northern areas of Khyber Pakhtunkhwa, farmers face severe shortage of green forage for their livestock during harsh winter seasons due to extremely low temperatures. The forage plus grain production system has been practiced in many countries of the world, and if adopted in our country, this would have a direct impact on improving the living standards of our farmers as a whole and of northern areas in particular. The present study was thus an attempt to compare the performance of different exotic winter wheat lines with local check cultivar and investigate high-yielding winter wheat varieties for commercial cultivation in these regions.

MATERIAL AND METHODS

Ten elite winter wheat lines were planted in triplicate in a randomized complete block (RCB) design at Hazara Research Station (HRS) Abbottabad during 2005-06. Each experimental entry was assigned to a four-row plot with row length of four meters and row to row space of 25 cm. Data were obtained for green forage production (kg/ha), plant height (cm), spike length (cm), maturity (days), spikelets/spike, spike weight (g), biological weight (kg/ha) and grain yield (kg/ha). For data collection, ten plants were randomly selected in each replication and their mean values were used in statistical analysis. Data on green forage production was recorded by sickle harvesting the clipping treatments in early spring and then weighed with the help of a physical balance. Plant height was measured from base of the plant to the tip of last spikelet excluding awns. Similarly, spike length was measured from base of first spikelet to the tip of last spikelet excluding awns. Days to maturity were counted from date of sowing till date of harvesting. The harvested material was sun-dried for seven days for collecting data on biological yield. After threshing, the whole produce was weighed and then converted to grain yield (kg/ha). Data after compilation were statistically analyzed, and significant means were determined by the least significant difference (LSD) test.

RESULTS AND DISCUSSION

Green forage yield (kg/ha)

Statistical analysis of the data regarding green forage yield showed highly significant ($P \leq 0.01$) genetic variation among the winter wheat genotypes (Table 1). Green forage produced by winter wheat genotypes under study ranged from 5694.3 to 11,527.7 kg/ha, where the maximum was recorded in genotype OK99212 (11,527.7 kg/ha), closely followed by Intrada and OK00514 with each producing green forage of 11,389 kg/ha (Table 2). The lowest green forage of 5694.0 kg/ha was recorded for local check cultivar Ghaznavi-98.

Table 1. Mean squares for green forage production, plant height, days to maturity, spike length, spikelets/spike, spike weight, biological weight, and grain yield of 10 winter wheat lines evaluated under cliped and uncliped treatments at Hazara Research Station Abbottabad, in 2006.

Parameter	Replication	Genotype	Clip	Genotype x Clip	Error	CV (%)
d.f.	2	9	1	9	38 (18)$^{\$}$	-
Green forage	6672518^{NS}	1510013**	-	-	4029848	22.7
Plant height	74.1*	302.2**	1461.8**	10.5^{NS}	16.5	4.4
Days to maturity	7.9*	7.18**	109.3**	0.60^{NS}	1.7	0.76
Spikelets/spike	3.14^{NS}	15.17*	24.32^{NS}	6.57^{NS}	6.6	14.2
Spike length	4.1^{NS}	4.4^{NS}	19.04**	2.46^{NS}	2.21	14.8
Spike weight	0.93**	0.43**	3.12**	0.11^{NS}	0.10	16.43
Biological yield	5339166.6^{NS}	14277572.5**	518470186.25**	4194686.1^{NS}	4527835.38	17.47
Grain yield	4542.17^{NS}	1798170.16**	22052222.5**	559120.495*	193595.10	12.73

NS = non-significant; *,**Significant at 5 and 1% probability level, respectively; d.f. = degrees of freedom $^{\$}$d.f. in parenthesis pertains to green forage only.

Table 2. Means for green forage production, plant height, days to maturity, and spikelets/spike of 10 winter wheat lines evaluated under unclipped and clipped treatments at Hazara Research Station, Abbottabad during 2006.

Genotypes	Green forage (kg/ha)		Plant height (cm)		Days to maturity		Spikelets/spike	
	Unclipped	Clipped	Unclipped	Clipped	Unclipped	Clipped	Unclipped	Clipped
OK95616-56	-	7499.6	93.8	84.0	170.6	172.3	17.4	17.1
OK98G508W	-	10555.3	89.9	83.0	167.3	170.0	18.0	11.2
OK99212	-	11527.7	102.2	94.5	170.0	172.0	18.9	18.2
OK00421	-	8750.0	99.2	92.3	170.0	172.6	19.9	18.0
OK00514	-	11389.0	105.7	95.8	169.0	173.0	17.6	17.6
OK00608W	-	7777.6	97.2	87.8	168.6	171.3	18.4	17.2
OK00611W	-	6250.0	100.4	89.1	170.0	172.3	18.2	17.0
OK00618W	-	7222.3	98.7	87.2	169.6	172.6	19.9	19.6
Intrada	-	11389.0	100.3	84.5	168.6	171.6	17.8	18.4
Ghaznavi-98	-	5694.3	80.3	70.7	171.3	174.3	21.0	19.9
Average	-	8805.4	96.8	86.9	169.5	172.2	18.7	17.4
LSD (0.05)			4.75		1.52		3.01	

Plant height (cm)

Analysis of variance showed highly significant ($P \leq 0.01$) differences among genotypes as well as clipping treatments (Table 1). However, (genotype x clipping) interaction for plant height was non-significant showing similar performance of wheat lines between the two treatments.

There was a general reduction in plant height due to forage clipping. Plant height among wheat genotypes ranged from 70.7 to 95.8 cm in clipping *vs* 80.3 to 105.7 cm in no clipping treatments (Table 2). Short stature plants were observed in local check cultivar Ghaznavi-98 under both clipping and no clipping treatment. In contrast, wheat genotype OK00514 had the maximum plant height under both treatments. When averaged over the 10 wheat genotypes, mean plant height was 86.9 cm under clipping *vs* 96.8 cm under no clipping treatment, showing a net reduction of 9.9 cm or 10.2% in plant height due to forage clipping.

Days to maturity

Winter wheat genotypes and clipping treatments exhibited highly significant differences for days to maturity; however, the interaction (genotype x clipping) for maturity duration was found non-significant (Table 1). Generally, forage clipping during vegetative development stage of the crop delayed maturity in all wheat genotypes evaluated in the present trial at Abbottabad. Days to maturity ranged from 170.0 to 174.3 and 167.3 to 171.3 under clipping and no clipping treatment, respectively (Table 2). Genotype OK98G508W was consistently early in reaching maturity under both treatments. Surprisingly, local check (Ghaznavi-98) was late maturing compared to other genotypes, suggesting the possibility of adjustment of winter wheat lines in the current cropping pattern. When averaged over the 10 wheat genotypes, mean maturity period was 172.2 and 169.5 days under clipping and no clipping treatments, respectively, showing a net delay of 2.7 days in maturity due to green forage removal.

Spikelets/spike

Analysis regarding number of spikelets/spike showed significant ($P = 0.05$) differences among wheat genotypes (Table 1). However, main effect of clipping and interaction (genotype x clipping) was non-significant for spikelets/spike. Number of spikelets/spike ranged from 11.2 to 19.9 under clipping *vs* 17.4 to 21.0 under no clipping treatment (Table 2). Wheat genotype Intrada had more spikelets/spike under clipping than no clipping treatment, while OK00514 had the same number of spikelets under both treatments. The remaining seven wheat genotypes had fewer spikelets/spike under the clipping treatment. Averaged across wheat genotypes, mean spikelets/spike under clipping and no clipping treatments were 17.4 and 18.7, respectively.

Spike length (cm)

Genetic variation for spike length was not evident among the wheat lines, as well as the trend in genotype x clipping interaction (Table 1). However, the main effect due to clipping treatments was highly significant ($P \leq 0.01$). Spike length is an important yield component and generally has a strong positive relationship with ultimate yield per unit area. Spike length among the wheat genotypes ranged from 8.6 to 10.9 cm under clipping *vs* 9.9 to 11.6 cm under no clipping treatment (Table 3). Hence, there was a general reduction in spike length due to green forage removal. When averaged over clipping treatments, the local check cultivar (Ghaznavi-98) had longer spikes (11.1 cm) compared to the other genotypes evaluated. In contrast, wheat genotype OK00514 tended to have smaller spikes averaged over the two treatments (9.5 cm). When averaged over the 10 wheat genotypes, mean spike length was 9.4 cm with clipping *vs* 10.6 cm with no clipping treatment, indicating a net reduction of 1.2 cm in spike length.

Table 3. Means for spike length, spike weight, biological yield and grain yield of 10 winter wheat lines evaluated under unclipped and clipped treatments at Hazara Research Station, Abbottabad, 2006.

Genotypes	Spike length (cm)		Spike weight (g)		Biological yield (kg/ha)		Grain yield (kg/ha)	
	Unclipped	Clipped	Unclipped	Clipped	Unclipped	Clipped	Unclipped	Clipped
OK9561656	10.0	10.2	2.1	1.6	13611.10	10902.80	3875.00	3222.23
OK98G508W	10.3	8.6	2.1	1.3	16111.13	9722.23	4152.80	3430.57
OK99212	10.6	9.6	2.5	1.9	15972.20	11041.67	4236.13	3402.80
OK00421	11.6	10.1	2.7	1.8	14236.10	7916.67	3611.10	2236.10
OK00514	9.9	9.1	1.9	1.8	18055.57	9861.10	4861.13	2736.13
OK00608W	10.3	8.8	2.0	1.5	15000.03	10416.67	3791.67	2875.00
OK00611W	10.3	9.6	2.2	1.7	17611.10	9722.23	5277.80	3125.00
OK00618W	11.0	10.6	2.0	1.6	13888.90	8333.30	4375.00	2555.53
Intrada	10.2	9.3	1.8	1.5	15277.80	8055.53	3888.87	2958.33
Ghaznavi-98	11.3	10.9	2.6	2.4	11388.90	6388.90	2541.63	1944.47
Average	10.6	9.4	2.2	1.7	14090.28	9236.11	4061.11	2848.62
LSD (0.05)	1.73		0.38		2487		514.26	

Spike weight (g)

Highly significant genetic variations were evident among wheat genotypes and clipping treatments for single spike weight (Table 1). However, the interaction (genotype x clipping) was non-significant suggesting genotype consistency in spike weight under the two treatments.

There was a general reduction in spike weight in all wheat genotypes due to forage clipping. Single spike weight of wheat lines ranged from 1.3 to 2.4 g under clipping and 1.9 to 2.7 g under no clipping treatment in the experiment (Table 3). The lowest spike weight recorded, 1.3 g, was in genotype OK98G508W, while the highest (2.4 g) in the local check Ghaznavi-98 under clipping treatment. In contrast, the heaviest spikes were produced by OK00421 (2.7 g) followed by local check Ghaznavi-98 (2.6 g) under no clipping treatment. When averaged across 10 wheat genotypes, mean spike weight was 1.75 g under clipping and 2.21 g under no clipping treatment, indicating a highly significant net reduction of 0.46 g or 20.8% in spike weight due to green forage removal.

Biological yield (kg/ha)

Highly significant differences were observed among winter wheat genotypes as well as clipping treatments for biological yield (Table 1). However, interaction (genotype x clipping) effect for biological yield was non-significant, indicating a similar response of wheat genotypes to clipping and no clipping treatments. When averaged over all genotypes, mean biological yield ranged from 6388.9 to 11,041.67 and 11,388.9 to 18,055.57 kg/ha under clipping and no clipping treatment, respectively (Table 3). Maximum biological yield (11,041.67 kg/ha) under clipping treatment was recorded in wheat line OK99212, followed by OK98G508W and OK00611W (9722.23 kg/ha each). Similarly, wheat line OK00514 produced the maximum biological yield of 18,055.57 kg/ha under no clipping treatment. Minimum biological yields of 6388.9 and 11,388.9 kg/ha were recorded in check cultivar Ghaznavi-98 under both treatments, respectively.

Grain yield (kg/ha)

Grain yield was found highly significant for genotypes, clippings and genotype x clipping (Table 1). Significant genotype x clipping interaction indicated differential response of genotypes under both treatments. Maximum grain yield of 3431 and 5278 kg/ha were obtained by lines OK98G508W and OK00611W under clipping and no clipping treatments, respectively. These lines also produced maximum biological yield under both treatments. However, the check cultivar Ghaznavi-98 produced the minimum grain yield under clipping and no clipping treatment (1944.5 and 2541.6 kg/ha, respectively) (Table 3). These results are in accordance with the earlier findings of Dunphy et al. (1982) and Winter and Thompson (1987) who also reported reduction in grain yield due to forage clipping or cattle grazing. A net reduction of 23 and 48% in grain yield due to forage removal has been previously reported by Khalil et al. (2002, 2008). However, these losses in grain yield can be minimized by applying better management practices, such as optimum date of planting, appropriate stage of clipping and applying N fertilizer after forage clipping (Carver et al., 2001).

CONCLUSION

All wheat genotypes experienced reduction in grain yield due to forage clipping in the earlier spring. However, most of the winter wheat lines displayed the potential to produce more grain yield than our national average yield even after forage clipping in early spring.

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