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Relationships Between Grain Yield, Organic Matter Digestibility, Crude Protein, Ash Concentration and Water Soluble Carbohydrates in Non-Irrigated Cereals Which are Used as Animal Feeds

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Abstract: The aim of this study was to examine how differences in grain yield, nutritive value, ensilability and harvesting losses of intensively managed some winter cereals (bread wheat, triticale and rye) harvested during the advancing stages of ripening. Three cereal crops (*Triticum aestivum* L., cv. Konya-2002, *Triticale* Wittmack. cv. Mikham-2002 and *Secale cerale* L., cv. Aslim-95) were assessed and Dry Matter concentration (DM), Organic Matter Digestibility (OMD), Crude Protein (CP), Ash Content (AC) and Water Soluble Carbon Hydrate (WSC) were evaluated in five date of harvesting. Dry matter yields changed relatively between harvest dates in three crops. Nutritive value, crude protein and organic matter were relatively small. There were no clear and consistent relationships between harvesting loss and stage of ripeness in current experiment. Loss of wheat yield was relatively high in 2 years. Loss of rye yield showed lower than other. Grain DM concentration increased by average of 9.5 g kg^{-1} (wheat), 9.2 g kg^{-1} (rye) and 10.1 g kg^{-1} (triticale) per day the interval.

Key words: Cereals, ripening, nutritive value, chemical composition, harvest, dry matter

INTRODUCTION

Farmers are considering about technologies based on harvesting and conserving grains at high moisture concentrations, they need to know the impact of the stage of ripeness at harvest on grain yield. An evaluation of the changes in grain yield, nutritive value, ensilability and harvesting losses of intensively managed winter cereals harvested during the advancing stages of ripening (Stacey *et al*., 2006). Loss *et al*. (1989) indicate that the growth pattern of modern varieties differ from that of older varieties. Most of studies showing the relative stability of grain DM yield and chemical composition of cereal grains after physiological maturity were reached (Lang and Holmes, 1969).

Stoyanova *et al*. (1976) investigated that the changes in the amounts of sterols in the lipids of wheat of the variety Mironovskaya 808 at various stages of development of plant. The presence in the mixture of sterols of β-sitosterol, brassicasterol, stigmasterol, ergosterol, lanosterol, 24-methylene-24, 25-dihydro-lanosterol and campesterol has been shown. It has been established that the main sterol of wheat lipids is β-sitosterol; however, in the beginning of waxy ripeness stage the amount of this sterol falls sharply. At this stage of development of the plant the function of the main sterol is fulfilled by brassicasterol.

Tashiro and Wardlaw (1990), indicated that Grain weight and grain length at maturity were most affected by the 10 days period of high temperature commencing 7-10 days after anthesis. However, if dry-matter accumulation between the start of a treatment and grain maturity was used as a base for comparison, the response was more uniform throughout development, with a peak in sensitivity 25 days after anthesis. Although grain position within an ear did not have a large effect on the response to temperature, grains from the basal spikelet's were more sensitive than those from the apex and the upper floret grains of a spikelet were more sensitive to high temperature than those at the base.

Stankiewicz *et al*. (2003) defined the effect of parent components of rye, wheat on the content of total protein and protein amino acid composition of grain of primary forms of octoploid triticale at the ripening stages. There was also determined the effect of crossing of the octoploid triticale forms obtained with hexaploid triticale CZR142/79 on the chemical characteristics (qualitative). The obtained results showed that primary forms of octoploid triticale contained more protein in grain than the parent plants. It can give a potential in further breeding work of giving high-protein and high-starch cultivars. Both forms of octoploid triticale showed a higher level of lysine. Also, the marked amino acids show that the biological value protein of triticale Liwilla x Donar was

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more similar to wheat protein, which points to a considerable effect of components derived from the basic form on the nutritional value.

Kobata and Uemuki (2004), explained that high temperatures during the Grain-Filling Period (GFP) of rice (*Oryza sativa* L.) increase the Grain dry matter Increase Rate (GIR), but this increase in GIR is insufficient to completely compensate for the concomitant reduced GFP and as a result, grain yield decreases. The shortfall in GIR as temperatures increase has been believed to signify a reduction of the potential GIR as a sink capacity.

While, wheat is being produced as a human food, triticale and rye are for livestock in Turkey and interest of triticale is increasing among farmers contemplating lower-input system. However, relatively little information exists on the changes in grain DM yield and chemical composition during advancing stages of ripening for triticale and rye compared to wheat. In this study, we aimed to find the changes in grain DM yield and chemical composition during advancing stages of ripening for wheat, rye and triticale.

MATERIALS AND METHODS

This study was carried out in 2005-2007 growing seasons at Bahri Dagdas International Agricultural Research Institute experimental areas in Konya, Turkey. *Triticum aestivum* L., cv. Konya-2002, *Triticale* Wittmack. cv. Mikham-2002 and *Secale cerale* L., cv. Aslim-95 cultivars were used as material for the study. These materials were improved by Bahri Dagdas International Agricultural Research Institute (BDIARI, 2002). For each cereal were arranged in a randomized complete block design with five harvests time (From H1-H5) and four replicate blocks. Plots were designed 1.6×5 m and 8 rows. As the crop approached maturity, grain DM concentration and chemical composition were measured frequently; harvested time were based 5 days intervals from 25th of June to 15th of July. Fertilizer was applied as 150 kg ha^{-1} DAP (Di Ammonium Phosphate 18-46). In harvest time, plots were harvested with a plot combine harvester. Harvests were done 5 days Intervals (from H1-H5). Total rainfall occurred 213 mm in growing period.

Harvested grains from each plot were sub-sampled and stored until chemical characteristics analysis finished. Sub-samples of grain from each plot were dried at 105°C for 24 h in an oven with air circulation to determine the DM concentration. Each sub-sample was analyzed for Organic Matter Digestibility (OMD), Crude Protein (CP), Ash (A) and Water Soluble Carbon hydrate (WSC).

The grain yield, harvest loss and composition data for each cereal crop were analyzed in a randomized complete block design using the General Linear Model option in SPSS with least significant differences being used to separate individual harvest time effects. The relationship between changes in grain yield, harvest losses, chemical composition and the number of days from Harvest 1 (H1-H5) were examined using quadratic regression functions in SPSS.

RESULTS AND DISCUSSION

Under non-irrigation and high evaporative demand conditions, dry matter appears to be main yield-limiting factor (Monneveux *et al*., 2004). In 2005-06 growing season, the grain DM concentration of wheat changed 556-756 g kg^{-1} and fresh yield values on successive harvest dates decreased progressively (Table 1). Grain DM yields were $p<0.05$ at H3 and H4 than at the other harvests. Crude protein, ash, WSC and OMD didn't change throughout the harvest period. In 2006-07 growing season, the grain DM concentration of wheat increased ($p<0.01$) from 518-726 g kg^{-1}, while fresh yields decreased ($p<0.01$), correspondingly. Crude protein decreased steadily. But OMD, Ash and WSC revealed different reaction. Grain WSC and OMD concentration were higher ($p<0.01$) at H2 compared to other harvesting time. None of the other yield and yield composition variable in Table 2 were significantly affected ($p<0.01$) by harvest time.

In 2005-06, the grain DM concentration of rye increased from 511-685 g kg^{-1} while fresh yield simultaneously decreased ($p<0.01$). Grain WSC values were higher ($p<0.01$) at H5 than at other harvest time. OMD was lower at H1 than the others. Neither ash concentration nor WSC concentration differed through five harvests. The grain DM concentration for rye in 2006-07 increased from 496-671 g kg^{-1} and fresh yield decreased regularly. Crude protein concentration was lower H5 than at other harvests and it decreased regularly from H1-H5. OMD and Ash concentration were lowest values at the H1 ($p<0.01$). The negative relationships between ash and grain yield was observed not only under rain-fed conditions, which is consistent with previous results in barley (Febrero *et al*., 1994; Voltas *et al*., 1998). However, in the results didn't show any positive and negative relations in all cereals. It can be argued that kernel ash is negatively correlated with grain yield, because of its negative dependence on kernel mass (Finney *et al*., 1987).

The grain DM concentration of triticale increased at successive harvest during this period (Table 2). The fresh yields and OMD of triticale decreased from H1-H5 ($p<0.01$). Crude protein decreased from H1-H5 regularly. Ash concentration was highest at H1. Second year, DM

Table 1: Grain yield, chemical composition and harvesting losses of cereals (2005-06)

		Wheat							
		Harvestable grain yield		Chemical composition					
Crop harvest	Harvest date	Fresh (t ha^{-1})	Dry (t ha^{-1})	DM (g kg^{-1})	CP (g kg^{-1} DM)	OMD (g kg^{-1})	A (g kg^{-1} DM)	WSC (g kg^{-1} DM)	Harvesting losses of grain DM (kg ha^{-1})
H1	25 June	11.7	6.4	556	106	742	17.5	48	48
H2	30 June	9.8	6.2	593	102	754	17.1	48	95
H3	05 July	8.6	6.1	645	96	739	17.4	50	132
H4	10 July	8.0	6.0	713	95	744	17.5	51	185
H5	15 July	7.4	5.9	756	95	738	17.3	49	227
Significant		**	**	**	**	**	NS	*	**
R^2		0.995	0.992	0.993	0.973	0.310	0.025	0.630	0.998
Rye									
H1	25 Jun	12.4	6.8	511	102	716	17.6	49	45
H2	30 Jun	11.5	6.4	544	102	728	17.5	48	69
H3	05 Jul	9.6	5.8	586	96	729	17.1	50	110
H4	10 Jul	8.7	5.8	612	95	725	17.6	50	154
H5	15 Jul	8.1	5.6	685	91	731	17.4	51	191
Significant		**	**	**	**	**	NS	*	**
R^2		0.979	0.963	0.985	0.933	0.673	0.255	0.747	0.996
Triticale									
H1	25 Jun	14.1	7.41	461	91	791	18.7	55	36
H2	30 Jun	12.0	6.94	512	89	786	18.2	55	72
H3	05 Jul	10.8	6.91	598	89	768	17.9	57	114
H4	10 Jul	9.7	6.89	654	86	765	17.9	58	158
H5	15 Jul	9.7	6.83	712	83	759	18.1	58	211
Significant		**	**	**	**	**	NS	*	**
R^2		0.996	0.297	0.994	0.966	0.948	0.998	0.888	0.999

Table 2: Grain yield, chemical composition and harvesting losses of cereals (2006-07)

		Wheat							
		Harvestable grain yield		Chemical composition					
Crop harvest	Harvest date	Fresh (t ha^{-1})	Dry (t ha^{-1})	DM (g kg^{-1})	CP (g kg^{-1} DM)	OMD (g kg^{-1})	A (g kg^{-1} DM)	WSC (g kg^{-1} DM)	Harvesting losses of grain DM (kg ha^{-1})
H1	25 Jun	12.1	6.5	518	103	723	17.2	48	45
H2	30 Jun	10.2	6.0	576	102	742	17.5	50	86
H3	05 Jul	9.1	6.0	642	96	751	17.3	51	124
H4	10 Jul	8.7	5.9	697	95	738	17.5	51	168
H5	15 Jul	7.6	5.8	726	94	738	17.1	52	198
Significant		**	**	**	**	**	NS	*	**
R^2		0.978	0.890	0.996	0.918	0.793	0.589	0.950	0.998
Rye									
H1	25 Jun	12.4	6.9	496	104	706	17.2	46	39
H2	30 Jun	12.0	6.5	513	101	712	17.2	48	59
H3	05 Jul	10.8	6.2	588	98	721	17.6	51	106
H4	10 Jul	9.1	6.0	623	98	713	17.3	51	142
H5	15 Jul	8.2	5.6	671	94	722	17.3	48	188
Significant		**	**	**	**	**	NS	*	**
R^2		0.979	0.989	0.975	0.945	0.657	0.407	0.902	0.994
Triticale									
H1	25 Jun	13.8	7.2	466	94	762	18.2	51	37
H2	30 Jun	12.6	7.0	496	91	752	17.9	50	66
H3	05 Jul	11.2	6.9	574	90	749	17.6	54	120
H4	10 Jul	10.0	6.8	612	88	742	18.0	54	148
H5	15 Jul	9.6	6.8	695	86	739	17.7	55	197
Significant		**	**	**	**	**	NS	*	**
R^2		0.991	0.994	0.978	0.982	0.981	0.508	0.766	0.991

increased from H1-H5, while fresh weight decreased simultaneously. OMD was lower at H1 than at others. Neither ash concentration nor WSC concentration differed from five harvests.

Harvesting losses of grain DM (kg) per ha were influenced by harvest date for all cereals in two seasons. Values of for all cereals increased from the lowest loss at H1 to the highest loss at H5 ($p<0.01$). Wheat had the highest losses, while triticale had the lowest losses. Correlation coefficient between grain DM concentration and fresh yield across the times of harvest were wheat r = -0.92 and -0.87 (in 2005-06 and 2006-07), rye r = -0.95 and -0.93 (in 2005-06 and 2006-07), triticale r = -0.91 and -0.94 (in 2005-06 and 2006-07), respectively.

Grain DM concentration increased linearly with advancing harvest data in 2 years and all cereals while fresh yield decreased linearly ($p<0.01$). Grain DM yield was directly related to the data of harvest. Ash concentration can not be related to the date of harvest directly. But, crude protein was directly related to harvest time. WSC increased in wheat and triticale relatively, while WSC concentration of rye changed during the date of harvest. Harvest loss was linearly and negatively related to harvest date for all cereals ($p<0.01$). This is supported by the following facts: appositive correlation has been found between stem dry mass and stem total non-structural carbohydrates (Ford *et al*., 1979; Blum *et al*., 1994); changes in the stem mass of wheat after anthesis are related to changes in stem water-soluble carbohydrate content (Blacklow *et al*., 1984; Blum *et al*., 1994; Wardlaw and Willenbrink, 1994; Stone *et al*., 1995) the internodes reach their maximum length a few days after anthesis (Evans *et al*., 1975) the amount of assimilate mobilized from the stems is unrelated to the stem length (Rawson and Evans, 1971).

The grain DM yields achieved were similar or better than the mean yields obtained with cereals on Turkey farmers. The yield of harvested DM of cereals relatively constant over the harvest date studied (Stacey *et al*., 2006). Harvest loss is a result of declining DM concentration in seeds. These declines were likely due to the loss of ripe grain following shattering from the ear prior to harvesting (Smith, 1960). Thus, it can be concluded that each of the crops had reached physiological maturity prior to their first harvest date (Hanft and Wych, 1982; Stacey *et al*., 2006). The high negative correlations between the reduction in fresh grain yield and the increase in grain DM concentration over successive harvest dates are indicative of the extend to which the reduction in fresh yield was due to water disappearance from the grain (Karadavut and Tozluca, 2005; Stacey *et al*., 2006). The higher values for cereals likely reflect the better growing conditions that resulted in higher DM yields (Jenner *et al*., 1991). OMD and crude protein was not reflected a similar profile. In general, changes among indicates of grain nutritive value during the advancing stages of ripening were absent, or most relatively modest in scale and did not follow a clear and consistent temporal pattern (Salo, 1985; Singh, 1999; Stacey *et al*., 2006).

CONCLUSION

There were no clear and consistent relationships between harvesting loss and stage of ripeness in current experiment. Loss of wheat yield was relatively high in two years. Loss of rye yield showed lower than other. Grain DM concentration increased by average of 9.5 g kg^{-1} (wheat), 9.2 g kg^{-1} (rye) and 10.1 g kg^{-1} (triticale) per day the interval. Studies show the relative stability of grain DM yield and chemical composition of cereal grains after physiological maturity were reached. Therefore, ripening stages take part to determinate chemical composition. Ripening stages should be investigated in the future as different aspects.

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