BEHAVIOR AND ADAPTATION of BALBO AND TETRA PETKUS RYE

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Bulletin 307
January, 1960

The University of Tennessee
Agricultural Experiment Station
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Knoxville

SUMMARY

• Rye is an important winter pasture plant in Tennessee. Recent studies on the varieties—Balbo and Tetra Petkus—are reported in this bulletin.

• Balbo has been the leading variety of rye in this state since its introduction. It has rapid, erect growth in seedling stage resulting in earlier pasture and earlier seed maturity than other varieties. In fact, plants of Balbo are so responsive to warm spells in winter months that they change into the reproductive stage and are subject to killing unless grazed. Balbo has weak stems and may lodge. The plants have 14 chromosomes and this variety is a diploid.

• Tetra Petkus is a recent introduction in Tennessee. It has slow, prostrate growth in seedling stage resulting in later pasture and later maturity of seed than Balbo. It remains in vegetative stage longer and is less likely to be injured by spring freezes than Balbo. It has considerably stronger stems and is more resistant to lodging. It has larger and fewer seeds than Balbo so that yields of grain are about the same for both varieties. The plants of Tetra Petkus have 28 chromosomes and this variety is a tetraploid.

• Rye is a cross pollinated crop and the seed yields of both varieties are adversely affected when planted near each other, because their cells have different chromosome numbers.

• Growth rate of heads within the stems during early spring months will determine time when grazing should be discontinued, if seed harvest is contemplated. This measure applies to all small grain crops.

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ACKNOWLEDGMENTS

The authors acknowledge the contribution of Philip E. Hoskinson, assistant plant breeder, for checking calculations in the tables.

COVER PHOTO: This photo shows the prolific stooling habit of Balbo, left. and the upright growth of heads in Tetra Petkus, right.

Behavior and Adaptation of Balbo and Tetra Petkus Rye

by
N. I. Hancock and Joseph R. Overton

INTRODUCTION

Rye is considered an important crop in Europe and in Russia. This is because the grain is used largely for bread, and the winter varieties are more winter-hardy than those of oats, barley and wheat. In this country some rye is grown for bread grain.

In Tennessee, rye is used mainly for winter pasture, winter cover, and as a green manure crop. Rye is often seeded with crimson clover for pasture and with hairy vetch for seed, winter cover, or a green manure crop. On some farms rye seed is an important cash crop. Rye grain is seldom used for feeding because it is less palatable and more likely to cause digestive troubles than other grains. Rye is generally considered less palatable for grazing than the other small grains, but palatability is not critical when it is the only crop available to the animal.

Rye is used widely as a pasture plant for several reasons. Rye is more resistant to diseases in the seedling stage than other small grains and thus can be seeded early in the fall. In Tennessee the winter-hardy varieties can be seeded late. At Knoxville, in the period 1943-45, Balbo rye yielded as much forage in the fall as oats and barley and more than wheat; it yielded more forage in the spring than any other small grain, Washko (13). At Columbia in 1948 when nitrogen was applied at seeding time, Balbo yielded more dry forage and suffered less loss in grain yield after grazing where split applications of nitrogen were applied than any of the other small grains, Long and Ewing (8). In a 4-year study at Jackson, Balbo produced about as much total yield of forage as other annuals, higher than the perennials tall fescue and Ladino clover, Orchardgrass and Ladino clover, and higher yields in March than other annuals or the perennials (Table 1).

BALBO RYE

Balbo was released by the Tennessee Agricultural Experiment Station as an introduction in 1933, Mooers (9), and since then has

Table 1. Forage production of perennial and winter annual species at the West Tennessee Experiment Station, Jackson, on Lintonia silt loam. Average of 4 years (1952-1955)[1].

Forage grown	Yields/A of air-dry forage	Production by months as registered by clippings			Total production in 3 months
		February	March	April	
	Pounds	Percent			
Perennials					
Orchardgrass-Ladino	3310	0	16	21	37.0
Orchardgrass-Ladino	2900	0	9	19	28.0
Tall fescue-Ladino (30 lb. N/A)	3140	0	25	33	58.0
Tall fescue-Ladino	2810	0	14	36	50.0
Annuals					
Rye	3410	12	57	20	89.0
Rye-Crimson clover	3790	11	50	24	85.0
Ryegrass-Crimson clover	3640	7	29	35	71.0
Rye - Ryegrass-Crimson clover	3840	9	42	26	77.0

[1]/Planting dates
1951, August 29
1952, September 5
1953, August 18
1954, August 20—reseeded on October 8

spread over a wide area. Balbo is seeded as far north as Illinois, as far west as Kansas, and in many of the eastern states. Balbo is particularly adapted to Tennessee because it has a rapid, erect growth in the seedling stage and yet is winter-hardy. However, periods of high temperatures during the winter months may cause it to head and become subject to killing by subsequent freezes. It is resistant to many of the seedling diseases—the Anthracnoses, Helminthosporiums, and Septorias—which infect oats, barley, and wheat, especially in the early fall seedings. Although Balbo is susceptible to Hessian fly, no reports of severe fly injury on Balbo have been received in Tennessee. Balbo is a diploid; its plants have 14 chromosomes, 7 from the male gamete or sperm cell and 7 from the female gamete or egg cell.

TETRA PETKUS RYE

Tetra Petkus was developed by Dr. W. Laube of Germany, Morrison (11), by applying colchicine to Petkus, a diploid, winter-hardy variety widely grown in Europe. Resulting plants had 28 chromosomes, or 4 times (tetra) the usual number of 7 in each male and female gamete. Selection from these tetraploid plants resulted in the variety named Tetra Petkus.

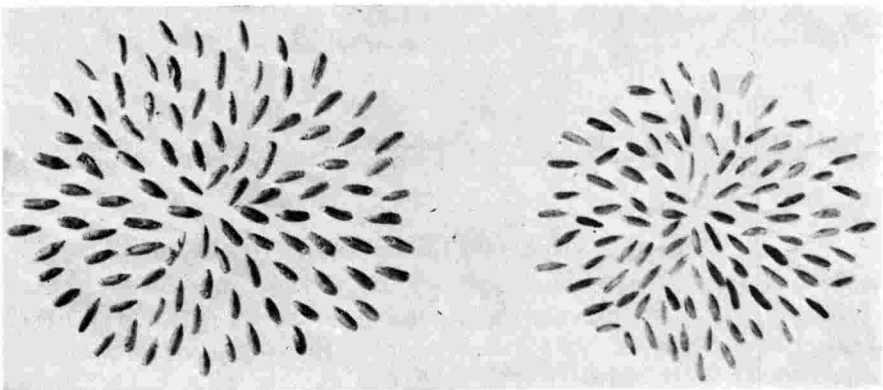
Tetra Petkus **Balbo**

Figure 1. Note the early, rapid seedling growth of Balbo.

This is the first variety of small grain crops resulting from the artificial doubling of chromosomes to attain commercial importance.

Tetra Petkus is winter-hardy and grows prostrate in the seedling stage (Fig. 1). It matures later than Balbo and its leaves are broader and bluish-green in color. The heads or spikes of Tetra Petkus are broader and shorter and the seeds are much larger than those of Balbo (see Fig. 2). One hundred seeds of Tetra Petkus weighed 4.6 grams compared with 2.5 grams for Balbo when samples of grain were harvested at Knoxville.

Several workers such as Cooper and Brink (2) and others (5, 6), have reported poor seed set of Tetra Petkus when pollinated by diploid plants. There is a reason for this. Rye is cross-pollinated with pollen that is scattered largely by the wind. Pollen grains falling on the stigma of the rye flower germinate and grow down to the egg cell, fertilizing it and giving rise to the seed. When Tetra Petkus rye is



Tetra Petkus **Balbo**

Figure 2. The seeds of Tetra Petkus are considerably larger than the seeds of Balbo.

grown next to diploid varieties, the pollen from each variety is scattered widely. If a Tetra Petkus flower is fertilized with pollen from a diploid plant, or vice versa, the seed aborts and does not develop. The seed set or fertility of Tetra Petkus grown next to a diploid variety such as Balbo will therefore be low, and the seed set of the diploid variety may likewise be reduced somewhat.

In 1954 at Knoxville, the fertility or seed set in an isolated plot of Tetra Petkus was 62 percent and seed set of an isolated plot of Balbo was 86 percent. These results are in line with those of Muntzing (10) and others.

Apparently Tetra Petkus is susceptible to Anthracnose. Many plants were severely infected with Anthracnose in Lawrence County in 1956, whereas Balbo in the same area was not affected so severely. Both varieties are susceptible to leaf and stem rusts in late spring, but no serious losses from rusts have been reported in Tennessee. Both varieties are resistant to the smuts which are rarely observed in rye varieties.

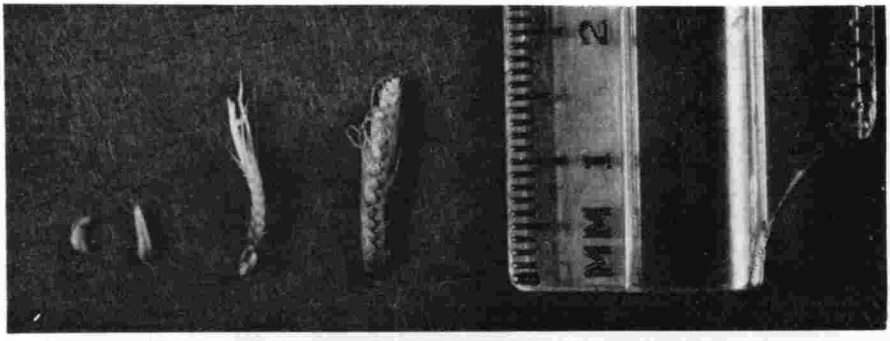


Figure 3. This is how Balbo heads appear when taken from the stem of Balbo at early through late stages of growth.

Relative Growth Characteristics

The heads of small grains begin growth at ground level within the stem (culm) and each stem can produce only one head (Fig. 3). The growth of the head is recognized by jointing or the number and length of internodes. Measurements show that the first joint of Balbo and Tetra Petkus varies from about 1 to 3½ inches in height when the plants begin to develop heads. At this stage the grower can see these small heads by splitting the stem above the first node. With practice one can feel the heads without splitting the stem (see Fig. 3). The time that varieties reach this reproductive stage determines their susceptibility to early spring freezes, and the period when grazing may severely reduce grain yields. Removing these heads reduces grain yields.

The data in Table 2 provide information on heading, height of heads, and effects of clipping for both varieties. Heads or spikes were observed on Balbo February 15, while no heads were seen on Tetra Petkus until March 12. Then heads of Balbo had reached a height of over 5 inches above ground level. This difference in growth habit is related to differences between the varieties in forage production in certain periods, and would affect pasture management. Heading of Balbo was delayed considerably by clipping in early February.

Table 2. Percentage of culms of Balbo and Tetra Petkus containing heads, and height of heads in the culm or stem—Knoxville, 1956.

Rye variety	No clipping					
	Culms with heads			Height above ground		
	Feb. 15	Mar. 1	Mar. 12	Feb. 15	Mar. 1	Mar. 12
	Percent			Inches		
Balbo	4.5	16.2	50.8	9/16	2-4/16	5-1/16
Tetra Petkus	0	0	2.1	0	0	2/16
	Clipped on February 5					
Balbo	0.6	8.2	40.1	2/16	8/16	1-3/16
Tetra Petkus	0	0	1.0	0	0	1/16

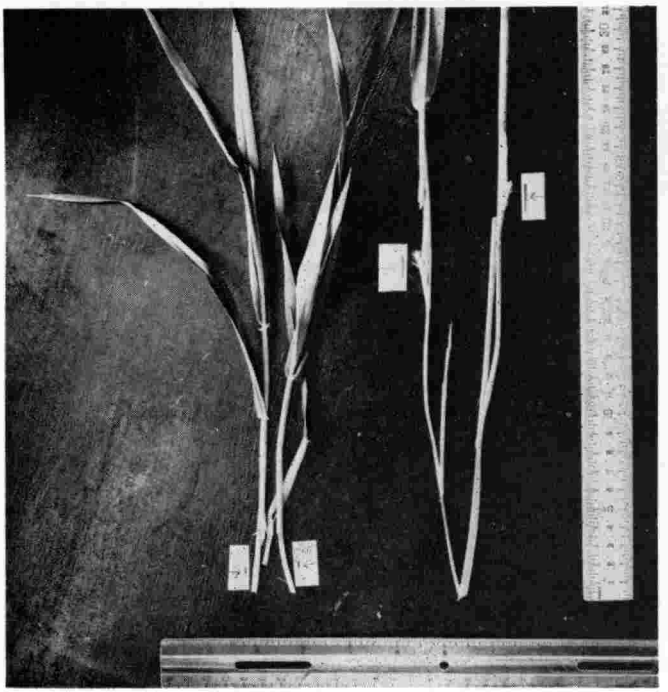


Figure 4. The block squares on the stem at right show the height heads have grown in the stem of Balbo after 4 weeks.

Tetra Petkus is outstanding for stiffness of stems. It stands up better than Balbo because the internodes between the joints on stems of Tetra Petkus have larger diameters and thicker walls than the corresponding internodes of Balbo (Table 3). The difference is proportionately greater in the lower internodes. Also, Tetra Petkus plants are not as tall as Balbo plants.

Table 3. Diameter and wall thickness of the culm internodes of Balbo and Tetra Petkus at maturity—Knoxville, 1957.

variety	Internode Number 1	2	3	4	5	6
	Diameter in millimeters					
Balbo	4.6	6.4	5.8	5.5	4.5	3.2
Tetra Petkus	7.1	8.6	7.8	7.4	6.5	4.7
	Wall thickness in millimeters					
Balbo	.61	.58	.48	.44	.35	.27
Tetra Petkus	.93	.87	.71	.56	.54	.38

A general summary of the characteristics of these two varieties is given in Table 4. Although both varieties are listed as very winter-hardy, they are not sufficiently winter-hardy to be seeded in the northern-most states. They are hardy enough to use in Tennessee for late seedings when necessary.

Table 4. Summary of characteristics, Balbo and Tetra Petkus varieties of rye.

Characteristic	Rye variety: Balbo	Tetra Petkus
Winter hardiness	Very good	Very good
Seedling growth	Erect	Prostrate
Dormancy	Semi-dormant	Very dormant
Maturity	Early	Late
Disease resistance	Good	Fair
Insect resistance	Good	Good
Pollination	Cross	Cross
Fertility—(Seed set)	Good	Fair
Stooling	Prolific	Fairly Prolific
Origin	Italy	Germany
Chromosome number	14 (Diploid)	28 (Tetraploid)
Size of spikes or heads	Long and narrow	Medium long and wide
Size of seed	Medium large	Very large
Stiffness of stem	Fairly stiff	Very stiff
Height of mature plant	Tall	Medium tall
Size of leaves	Narrow and long	Broad and medium long
Color of leaves	Dark green	Light bluish green

Table 5. Forage production of Balbo and Tetra Petkus rye at Jackson, 1955-56-57.

Planting date	Rye variety	Amount of air dry forage per acre (Av. of four replications) Mar. 11-27	Apr. 6-12	Apr. 22-May 5	Total
			Pounds		
1955:	Balbo	1205	474	429	2108
(Planted Nov. 8, 1954)	Tetra Petkus	184	2223	1073	3480
L. S. D. 5%					459
1956:	Balbo	916	878	1300	3094
(Planted Nov. 15, 1955)	Tetra Petkus	578	1075	1670	3323
L. S. D. 5%					N.S.
1957:	Balbo	2871	515	569	3955
(Planted Oct. 29, 1956)	Tetra Petkus	1287	1264	1109	3660
L. S. D. 5%					N.S.
3-year Average	Balbo	1664	622	766	3052
for 1955-56-57	Tetra Petkus	683	1521	1284	3488
L. S. D. 5%		535	343	263	

FORAGE YIELDS

Forage production was studied at the West Tennessee Experiment Station from 1955 through 1957. Plots 16 x 3 feet in size were seeded in three rows 12 inches apart. Plants were clipped at pasture stages, or at 10-inch heights or more except at last cuttings. In clipping, the cutter bar was allowed to slide on the ground so that a low cut was made. Composite samples were obtained to determine moisture content. Seedings were at the rate of 2.5 bushels per acre. There were four replications each year. Nitrogen was applied at the rate of 25 to 30 pounds per acre at seeding and again in February. High levels of phosphate and potash were maintained.

Forage yields of the two varieties are presented in Table 5. There is some difference in date of clipping from year to year because of seasonal variations. In general the separate harvests shown represent the cool season growth, recovery for mid-March to early April, and final growth. In 1955 a late freeze (15°F) occurred on March 26, followed by a 17°F temperature the next day. Rainfall was high in the winter and spring of 1957. These yields of forage were obtained from rather late plantings.

Total yields of these two varieties were not significantly different in 1956 and 1957. In 1955 the more advanced growth of Balbo gave a high yield of forage in March, but the freeze which followed soon after this cutting caused Balbo to make poor recovery. The two

Table 6. Forage production of Balbo and Tetra Petkus rye at two seeding dates at Jackson in 1957.

Planting date	Rye variety	Amount of air dry forage per acre (Av. of four replications) Mar. 14	Apr. 6	Apr. 27	Total
			Pounds		
September 24, 1956	Balbo	4044	542	622	5208
	Tetra Petkus	2726	1375	855	4956
October 29, 1956	Balbo	2871	515	569	3955
	Tetra Petkus	1287	1264	1109	3660
Av. of planting dates	Balbo	3458	529	596	4583
	Tetra Petkus	2007	1320	982	4309
L. S. D. 5%		535	299	245	

varieties differed considerably in total yield that year for this reason. Tetra Petkus was clipped several days after the freeze and made a good recovery.

Forage production of these varieties in certain periods was quite different. Balbo made twice as much forage as Tetra Petkus in March, but Tetra Petkus outyielded Balbo after March. This difference matters greatly to livestock producers, because pasture is very scarce in March, compared to April.

Yields obtained in 1957 from two planting dates are shown in Table 6. Both varieties produced more forage from the earlier planting date. The difference in vegetative growth was apparent in both plantings—Balbo yielding higher in March, and Tetra Petkus yielding higher after March. Neither seeding date provided fall pasture. Differences in total yield between varieties were not significant for either planting date.

Table 7. Forage production of Tetra Petkus rye and LeConte oats at Jackson in 1957.

Planting date	Small grain variety	Amount of air dry forage per acre (Av. of four replications) Mar. 14	Apr. 6	Apr. 27	Total
			Pounds		
September 24, 1956	Tetra Petkus rye	2662	1416	726	4804
	LeConte oats	2477	1141	723	4341
	L. S. D. 5%	N.S.	N.S.	N.S.	N.S.

Yields of air-dry forage from Tetra Petkus rye and LeConte oats are presented in Table 7. There was no significant difference within the three clippings or in the total yields. LeConte is very similar in dormancy to Tetra Petkus, but the seedling growth is not as prostrate. Their maturity is about the same.

GRAIN YIELDS

Work in Canada (15) showed that Tetra Petkus rye was adapted to climatic conditions in Ontario Province, but it was not winter-hardy enough to be grown in the western provinces. At the Ontario Agricultural College, Tetra Petkus greatly outyielded the local Horton in both grain and forage. In Indiana (14), Balbo showed higher yields of grain than Tetra Petkus on the sandy soils, while the differences in yields between varieties on silt loam soils were not significant. Balbo is recommended for Indiana. In Oklahoma Tetra Petkus did well on fertile soils, but high winds common to this state broke the stiff culms of Tetra Petkus (personal communication—Schlehuber).

Balbo **Tetra Petkus**

Figure 5. Note the more vigorous growth of Balbo at stooling stage.

As already mentioned, rye is largely cross-pollinated. Since Tetra Petkus seed set is adversely affected by pollen from diploid rye plants, a grain comparison on the same site is of no value. Accordingly, each variety was compared to Thorne wheat on separated

locations at Jackson in 1955. There were four replications at each location. The rye yields were expressed as percentages of the wheat yield. The wheat outyielded the rye at each site. On this basis the mean yield of Balbo was 66.4 percent of Thorne, and the mean yield of Tetra Petkus was 73.5 percent. Using the arcsin (Percentage)$^{1/2}$ transformation for statistical analysis, as shown in Table 8, these grain yields of the two rye varieties were found to be not different statistically at the 5% level. Snedecor (12).

Balbo rye is a more vigorous and prolific stooler than Tetra Petkus (Fig. 5). A 3-year average at Knoxville of culm counts at maturity showed 31 culms per linear foot for Balbo compared to 22 for Tetra Petkus. Grain in Tetra Petkus heads averaged about 20 percent heavier than grain in Balbo heads.

Table 8: Grain Yields of Balbo and Tetra Petkus as Mean Percentages of Thorne Wheat and as Mean Angles Corresponding to Percentages When Angle= Arcsin (Percentage.)$^{1/2}$

Mean Percentages of Thorne		Mean Angles of Thorne	
Balbo	Tetra Petkus	Balbo	Tetra Petkus
66.4	73.5	55.2	59.0
			NS

Note: Each rye variety was planted with Thorne as control in separate locations as given in text.

DISCUSSION

No data on forage yields from rye planted in August are reported in Tables 5, 6 or 7. However, Balbo rye and wheat varieties were seeded in forage tests at Knoxville on August 14 and 31 of 1959. Cuttings on October 14 gave forage yields of over 1,000 pounds dry weight for Balbo rye and some of the wheat varieties. Thus, the potential forage yield in the fall from early seedings of small grains under Tennessee conditions compares favorably with that of perennial grasses. However, if small grains are to be used in these early plantings, they must be highly resistant to diseases and insects.

When fall grazing is the objective, semi-erect to erect seedling growth is more desirable than prostrate seedling growth, provided the varieties contain the winter-hardiness character. As reported in Table 4, Balbo seedling growth is erect while Tetra Petkus is prostrate.

Varieties with the erect seedling growth tend to boot and to make heads during a period of warm weather in the fall or winter months.

In this stage, the growth of the varieties will be killed by freezes which may follow. It has been indicated in Table 2 that grazing can delay this reproductive phase.

Leaves of some small-grain varieties will top-kill during the winter months after a period of freezing weather and heavy frosts. At first the leaves have a white mildewed appearance, but later they die and are of no value for pasture. The leaves of Balbo and Tetra Petkus do not top-kill as much as leaves of oats, barley, and wheat.

For the past few years the production of Balbo rye seed in Tennessee has not been equal to the demand. As a result, some western rye mixtures represented as Balbo have been shipped into Tennessee.

Balbo rye seed is rather easily produced although in productive soils and under favorable conditions other grains often outyield it. On less productive soils, or when planted late, Balbo rye may produce more pounds of grain than the other small grains.

Seed production of small grain crops used for grazing may be increased by proper applications of nitrogen. This involves splitting nitrogen applications, using part of the nitrogen after grazing, and not grazing too late. Other suggested production practices for rye are given in the recent publication by Briggle titled "Growing Rye."[1]

The early maturity of Balbo favors its use for over seeding with lespedeza in early spring, or for preceding another pasture plant as Starr millet.

Since seed production of both Tetra Petkus and Balbo may be reduced when they are grown near enough to cross-pollinate, it is suggested that plantings for seed be isolated. If this is not possible, delaying the planting of Tetra Petkus two or more weeks after Balbo may decrease the overlap of pollinating periods somewhat. Both varieties tend to continue to tiller and produce pollen after seed heads begin to mature.

The Dairy Department at Knoxville has no record of milk flavor being affected by cows' grazing Balbo rye. Balbo rye has been found profitable for grazing of dairy cows at West Tennessee Experiment Station.

The low fertility or seed set in tetraploid rye greatly limits seed production. This problem has been studied by a number of workers:

[1]L. W. Briggle, U.S.D.A. Farmers Bulletin 2145, December, 1959.

East (3), Lewis (7), and many others listed by Elliott (4). Some factors causing poor seed set are: poor germination of pollen grains; failure of pollen tubes carrying male nucleus to penetrate full length of style and unite with female nucleus in embryo sac after the pollen grain germinates; disturbed relations of chromosome numbers between endosperm and embryo, or between endosperm and maternal tissue; and genes on the chromosomes that express these various kinds of incompatibility. Brenner and Brenner (1) increased the fertility of tetraploid plants around 15 percent by selecting plants which produced good seeds through several generations.

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