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MORPHOLOGY AND GROWTH OF WINTER WHEAT AS AFFECTED BY COMPETITION FROM ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM* L.)

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Abstract

Two addition series experiments were conducted at the Oregon State University's Hyslop Crop Science Field Laboratory (44° 37'N, 123° 13'W) near Corvallis, Oregon, USA, to investigate the dynamics in morphology and growth of winter wheat and Italian ryegrass during their life cycles. Experiment 1 was conducted during 1988-89 with six densities of each species and experiment 2 during 1989-90 with four densities of each species. Plants were destructively sampled from 100 plants/m^2 wheat monoculture, 100 plants/m^2 ryegrass monoculture, and 100 + 100 mixture of these species. Ryegrass plants were shorter than wheat plants up to 170 DAE. Whereafter Ryegrass plants became about 60 cm taller than wheat during reproductive stages during both the seasons. Wheat had more number of leaves, tiller, and leaf area per plant than ryegrass during vegetative stages but ryegrass had more number of leaves, tiller, and leaf area per plant during the reproductive stages. Ryegrass aborted fewer leaves and tillers per plant than wheat during their life cycles. The relative growth rate of ryegrass was also greater than wheat during reproductive stages. Results demonstrate that wheat was more competitive than ryegrass during vegetative stages but ryegrass became more competitive than wheat during reproductive stages. So, in predicting the competition of these two species, the shift in their competitive ability should be accounted for.

Key words : Morphology, Growth dynamics, Competition.

Introduction

Winter wheat (*Triticum aestivum* L.) is the most important cereal crop in Western Oregon, USA (Appleby *et al.*, 1976). Italian ryegrass (*Lolium multiflorum* L) is also a major grass seed crop in the Willamette Valley area, Oregon, USA. However, Italian ryegrass is a common and serious weed in the grain fields of Oregon and Washington (Appleby *et al.*, 1976; Burril *et al.*; 1988). Winter wheat and Italian ryegrass compete with each other for resources.

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Seed yield of winter wheat is reduced up to 60% by competition from ryegrass (Appleby *et al.*, 1976).

Growth analysis of plants are used as important tool to elucidate the mechanism of intra - and interspecific competition (Roush and Radosevich, 1985; Concannon, 1987; Roush, 1988; Poorter, 1989; Poorter and Remkes, 1990; Poorter, 1991). Time course study of other morphological characteristics viz., number of leaves, leaf area, tillers, senescence in tillers and leaves, plant height, etc. may also reveal mechanism in competion dynamics. Maximum relative growth rate (RGR), the weight increase per unit of biomass and per unit of time under optimal condition, may vary among species (Poorter and Remkes, 1990). The ecological advantages of RGR is that fast growth results in rapid preemption of greater resources. The rapid preemption of space is of great advantage to species to succeed in competitive situation (Grime and Hunt, 1975). So, a plant with greater RGR will acquire a larger share of resources in shorter time (Poorter, 1989).

Plant interaction involve complex factors of plant proximity viz., density, species proportion, and spatial arrangement (Radosevich, 1987; Roush, 1988). Considerable research has been conducted to measure the influence of proximity factors on the competition of crop and weed (Auld *et al.*, 1983; Medd *et al.*, 1985; Martin *et al.*, 1987; Roush, 1988). Few studies have directly addressed the role of plant growth and competition in weed population or community dynamics (Roush, 1988). Concannon (1987) related the growth of spring wheat and Italian ryegrass to their competition, using addition series experiments. The premise of this experiment was that plant growth was a mechanism for success in crop/weed system (Roush and Radosevich, 1985).

Based on the plant size during the vegetative stages, Concannon (1987) predicted that spring wheat was a greater competitor than Italian ryegrass. The seed yield of spring wheat was lower in mixture, however. Shift in competitiveness may occur during the life cycles of spring wheat or Italian ryegrass. So, prediction of the ultimate winner, based on the species competitiveness during the vegetative stage could be misleading in a crop/weed system. The objectives of these two experiments were, in part, to investigate the dynamics in morphology and growth of winter wheat and Italian ryegrass during their life cycles.

Materials and Methods

Experimental Technique

Two addition series experiments (Radosevich, 1987) were conducted from September to July during 1988-89 and 1989-90 at the Oregon State University's Hyslop Crop Science Field Laboratory (44° 37'N, 123° 13'W) near Corvallis, Oregon. Seeds of winter wheat were planted in a constant square arrangement in the last week of September each year using pre-marked template to maintain appropriate density. Ryegrass seeds were broadcast uniformly by hand. The unit plot size was 4 m^2 during 1988-89 and 4.4 m^2 during 1989-90. A factorial randomized complete block design with four blocks were used for both experiments. The crops were harvested for seed in the first week of July each year.

Addition series

The first experiment (Expt. 1) had six densities (0, 9, 25, 100, 400, 800 plants m^{-2}) of each species. The second experiment (Expt. 2) had four densities (0, 25, 100, 400 plants m^{-2}) for each species. Pair wise combinations of rows and columns gave the matrix of addition series in each experiment (Radosevich, 1987).

Growth analysis

Plants were destructively sampled from 100 plants/m2 wheat monoculture, 100 plants/ m2 ryegrass monoculture, and 100+100 mixture of these species. Four plants from each block were destructively harvested at 15 (first tillering) days after emergence (DAE), 90 DAE (maximum tillering), 170 DAE (spike primordia initiation), 225 DAE (heading) and 275 DAE (maturity) in Expt. 1 and at 15, 35, 50, 65, 85, 100, 170, 210, 225, and 270 DAE in Expt 2. Leaf area, plant height, number of green and dead tillers, number of green and dead leaves, green leaf area, and dry biomass per plant were recorded in both the experiments. Dead tillers per plant of ryegrass was not recorded in Expt 1. Plant growth was characterized by directly measured plants descriptors (plant weight, height, leaf area, leaf number, and tiller numbers) and by derived parameter (RGR).

Statistical analysis

Instantaneous RGR was estimated by a running refit (Hunt, 1982) of the curve for per-plant log-weight versus time and by getting the derivatives of the equation that best fitted the curve.

Results and Discussion

Plant height

Wheat plants in the monocultures and mixtures were equal in heights throughout their life cycles during 1989-90 (Figure 1). Height of ryegrass plants in monocultures and mixtures were equal up to 225 DAE (flowering stage) in both the years. During the ripening period, the ryegrass plants in mixtures became taller than those in the monoculture. This could be attributed to a greater degree of lodging of ryegrass plants in monoculture than in mixture during booting to flowering stages. In mixtures, ryegrass used lodging-tolerant wheat plants as support and stayed erect above the

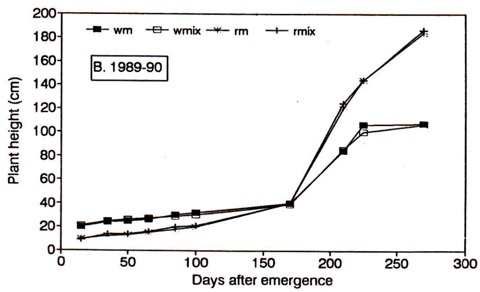


Fig. 1 Plant height of wheat and ryegrass over the growing season in monoculture and mixture in 1989-90. wm is wheat monoculture, wmix wheat mixture, rm ryegrass monoculture, and rmix ryegrass mixture. Results are on plants sampled from the density of 100 plants m^{-2} of wheat monoculture, 100 plant m^{-2} of ryegrass monoculture, and 100 + 100 mixture of wheat and ryegrass.

wheat plants. Greater lodging in monoculture probably reduced stem elongation of ryegrass. Wheat plants were taller than ryegrass up to 170 DAE. After 170 DAE, ryegrass plants were 40 to 80 cm taller than wheat plants. The plant height of the species exhibited similar results during 1988-89.

Leaf area

Wheat had greater leaf area per plant than ryegrass up to 170 DAE in both the years (Figure 2). After 170 DAE, ryegrass leaf area exceeded that of wheat. Wheat plants attained maximum leaf area at 170 DAE during 1988-89 and at 210 DAE during 1989-90 both in monoculture and mixtures. This is probably because of higher degree day heat unit accumulation in April, 1989 than 1990. Ryegrass reached maximum leaf area in monocultures and mixtures at 225 DAE i.e., 15 to 55 days later than wheat in both the years. Leaf area in both the species was lower in

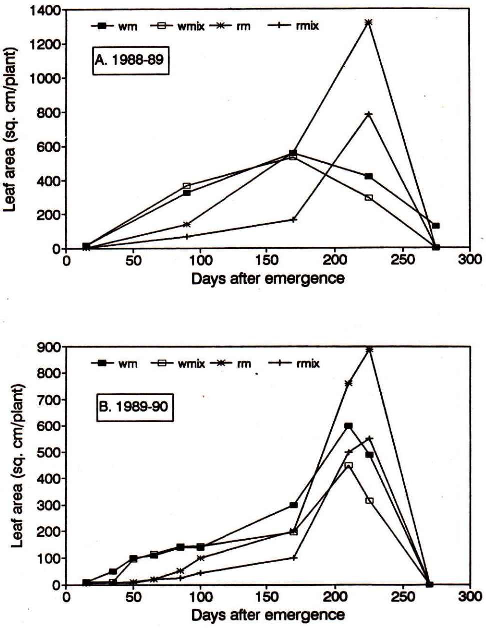


Fig. 2. Leaf area per plant of wheat and ryegrass over the growing season in monoculture and mixture in 1988-89 and 1989-90. wm is wheat monoculture, wmix wheat mixture, rm ryegrass monoculture, and rmix ryegrass mixture. Results are on plants sampled from the density of 100 plants m^{-2} of wheat monoculture, 100 plants m^{-2} of ryegrass monoculture, and 100 + 100 mixture of wheat and ryegrass.

mixtures than in monocultures. Ryegrass leaf area was more reduced in mixtures than was wheat leaf area although, leaf area of ryegrass was greater and duration of its leaf area was longer in mixtures than wheat. Greater per-plant leaf area and longer duration of leaf area of ryegrass should enhance the competitive ability over wheat in mixtures.

Leaf formation and senescence

The number of green leaves per plant in wheat increased progressively from 15 DAE and reached the maximum of 32 to 48 leaves/plant at 90 DAE (Fig. 3). The number of green leaves decreased to about 14 to 20 leaves at 225 DAE in monocultures and mixtures while number of dead leaves increased simultaneously. The number of green leaves were similar both in monocultures and mixtures until 85 DAE during 1988-89 and 1989-90. After 100 DAE, the number of green leaves in monocultures was higher than in mixtures in both the years. Dead leaves of wheat was first observed between 15 and 30 DAE. The number of dead leaves per plant of wheat was greater in 1988-89 than in 1989-90 (Fig. 3). This could

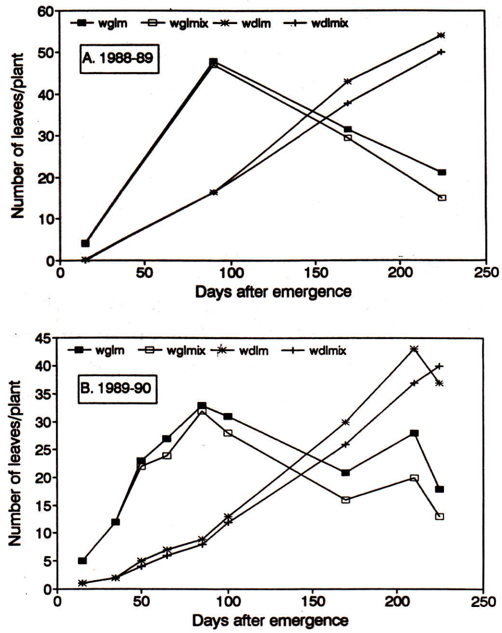


Fig. 3. Number of green and dead leaves per plant of wheat in monoculture and mixture over the growing season in 1988-89 and 1989-90. wglm is wheat green leaves in monoculture, wglmix wheat green leaves in mixture, wdlm wheat dead leaves in monoculture, and wdlmix wheat dead leaves in mixture. Results are on plants sampled from the density of 100 plants m^{-2} of wheat monoculture, 100 plants m^{-2} of ryegrass monoculture, and 100 + 100 mixture of wheat and ryegrass.

be attributed to the 250 mm snowfall during early February, 1989. The experimental plants remained under snow for two weeks. This caused substantial leaf senescence in both the species. However, the leaf senescence was about 40% greater in wheat than in ryegrass (data not shown).

The number of green leaves of ryegrass in monocultures increased gradually up to 70 in 1988-89 and 85 per plant in 1989-90 at 225 DAE (Figure 4). The number of dead leaves of ryegrass increased up to a maximum of 67 to 82 at 225 DAE. The number of green leaves of

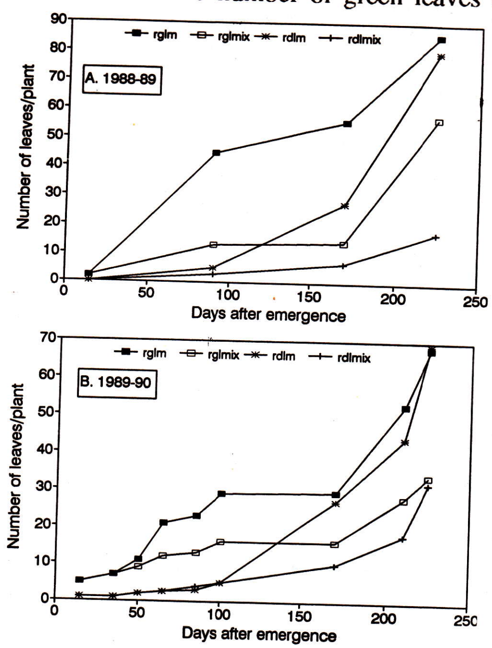


Fig. 4. Number of green and dead leaves per plant of ryegrass in monoculture and mixture over the growing season in 1988-89 and 1989-90. rglm is ryegrass green leaves in monoculture, rglmix ryegrass green leaves in mixture, rdlm ryegrass dead leaves in monoculture, and rdlmix ryegrass dead leaves in mixture. Results are on plants sampled from the density of 100 plants m^{-2} of wheat monoculture, 100 plants m^{-2} of ryegrass monoculture, and 100 + 100 mixture of wheat and ryegrass.

ryegrass in mixtures was lower than in monocultures over the growing seasons. Dead leaves in monocultures and mixtures remained similar up to 100 DAE whereafter dead leaves in monoculture became more than in mixtures. The number of green leaves in ryegrass during the reproductive stages were greater than in wheat but the reverse was true for dead leaves. These results demonstrate that leaf emergence as well as senescence was greater in monoculture than in mixtures of rygrass. Higher number of green leaves per plant of ryegrass during the reproductive stages contributed to its greater leaf area. A taller species with greater leaf area per plant than the other species planted at equal density in mixture will obviously intercept more solar radiation and consequently becomes more competitive. Higher leaf area of grass above the clover reduced the light intensity at the clover leaf canopy. Reduced light intensity at the clover leaf canopy caused a reduced growth of the clover in mixture (Stern and Donald, 1962; Coble *et al.*, 1981).

Tiller formation and abortion

The unmber of green tillers increased up to 85 to 90 DAE. After 85 or 90 DAF, wheat aborted tillers reducing the green tillers up to 5 to 7 per plant in the monocultures and about 4 to 7 per plant in the mixtures at its flowering stage (225 DAE). After flowering of wheat, the number of dead tillers equaled the green tillers in the mixtures during 1988-89 (Fig. 5). The number of green tillers per plant of ryegrass increased from 15 DAE up to 225 DAE in 1988-89 and up to 200 DAE in 1989-90. The number of green tillers of ryegrass was always higher in the monocultures than in mixtures after 35 DAE. Ryegrass aborted fewer tillers than did wheat. Tiller abortion in ryegrass began at 170 DAE (Fig. 6), as compared to 100 DAE in wheat. It is notable that ryegrass continued formation of primary tillers almost throughout

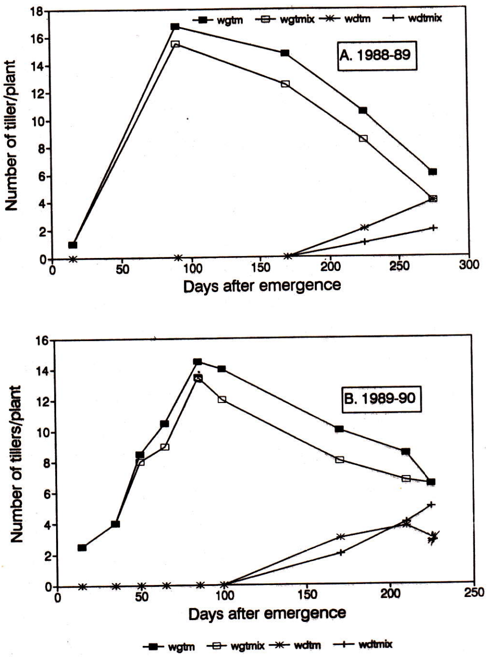


Fig. 5. Tiller dynamics of wheat in monoculture and mixture in 1988-89 and 1989-90. wgtm is wheat green tiller in monoculture, wdtm wheat dead tiller in monoculture, wgtmix wheat green tillers in mixture, and wdtmix wheat dead tiller in mixture. Results are on plants sampled from the density of 100 plants m^{-2} of wheat monoculture, 100 plants m^{-2} of ryegrass monoculture, and 100 + 100 mixture of wheat and ryegrass.

its life cycle while wheat terminated tiller formation around 85 DAE. Ryegrass also possessed secondary and tertiary tillers. These results demonstrate that ability of ryegrass to form tillers during reproductive stages would probably exert more demand on resources.

Relative growth rates and competition

The RGR of wheat and ryegrass decreased linearly with age of plants in 1988-89 (Fig. 7). Wheat in monoculture had greater RGR than in mixtures up to 225 DAE in 1988-89 and 1989-90. RGR of ryegrass was lower in mixtures than in monocultures in 1988-89. After 170 DAE, ryegrass in mixtures maintained greater RGR than in monocultures in 1988-89 (Fig. 7). The RGR of wheat remained unchanged in monocultures up to 50 DAE and that of ryegrass remained unchanged up to 65 DAE during 1989-90 (Fig. 7). The RGR of ryegrass was higher than wheat in both the experiments after 100 DAE. The RGR of wheat was greater in monoculture than in mixture at 225 DAE in both the experiments. The greater RGR of ryegrass after 100 DAE

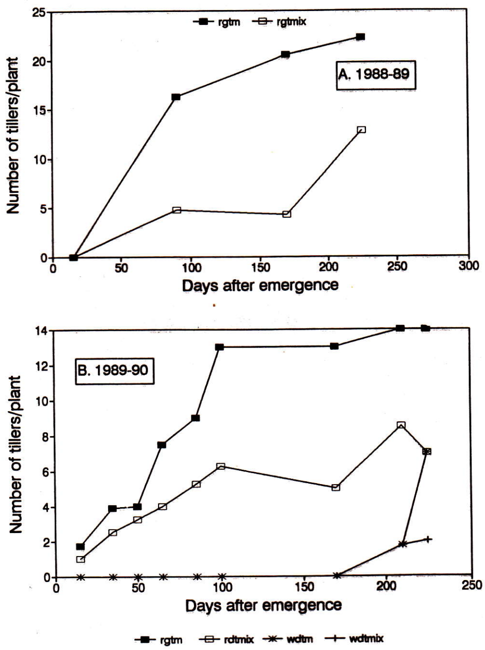
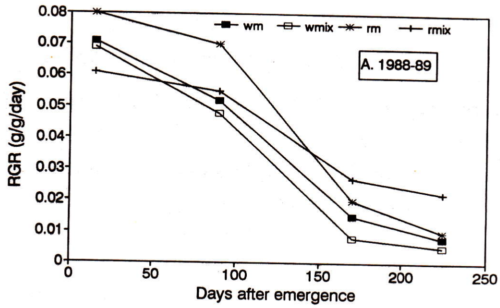


Fig. 6. Tiller dynamics of ryegrass in monoculture and mixture in 1988-89 and 1989-90. rgtm is ryegrass green tillers in monoculture, rdtm ryegrass dead tillers in monoculture, rgtmix ryegrass green tillers in mixture, and rdtmix ryegrass dead tillers in mixture. Results are on plants sampled from the density of 100 plants m^{-2} of wheat monoculture, 100 plants m^{-2} of ryegrass monoculture, and 100 + 100 mixture of wheat and ryegrass.



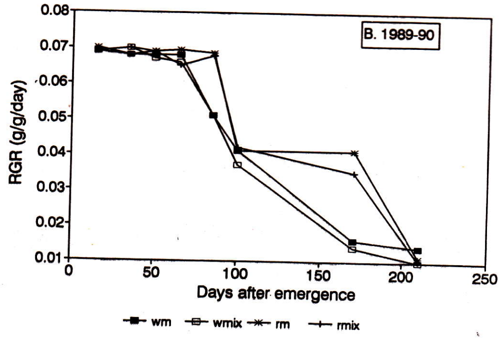


Fig. 7. Dynamics in relative growth rates of wheat and ryegrass in monoculture and mixture in 1988-89 and 1989-90. wm is wheat monoculture, wmix wheat mixture, rm ryegras monoculture, and rmix ryegrass mixture. Results are on the basis of all observations in monocultures and mixtures of each species. Means are comparable within the species only.

i.e., during reproductive stages demonstrate that ryegrass was more aggressive in terms of resource usurp than wheat.

The results on the morphological characters and growth of winter wheat and ryegrass up to their flowering stages demonstrate that ryegrass had less leaves, tillers, and leaf area per plant than wheat during vegetative stages but more leaves, tillers, and leaf area per plant than wheat during the reproductive stages. These indicate that wheat was more competitive than ryegrass during vegetative stages but ryegrass was more competitive during the reproductive stages. The results on the relative growth rates of these species also indicate that competitive behavior of these species shifted after vegetative stages. Concannon (1987) found that wheat was more competitive than ryegrass during the vegetative stages. Based on this observation she predicted that wheat is always more competitive than ryegrass during their life cycle. The results on the growth dynamics of these two experiments indicate that the prediction by Concannon (1987) was unreliable. So, in predicting the relative competitive ability of species, growth dynamics should be taken into consideration.

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