INFLUENCE OF CROP ROTATION ON WEED INFESTATION, *FUSARIUM* SPP. ATTACK, YIELD AND QUALITY OF WINTER WHEAT

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ABSTRACT

Crop rotation is one of the main technological steps which contribute to yield increases. The concept of agricultural land management within an intensive system of agriculture was the basis for developing at Fundulea, on a leached chernozem, experiments meant to study the effects of modern crop management, with the aim of maintaining a high yield level. The studies carried out referred to: the relationship between annual rainfalls and yields achieved, infection of wheat grains at harvesting with *Fusarium* spp. and the evolution of floristic composition of weeds in winter wheat in different crop rotations for a period of 25 years. Determinations regarding weed infestation were made in wheat monoculture and rotations of 2 - 3 - 4 years (wheat - maize, wheat - maize- peas respectively wheat - sugar beet – maize - sunflower) at the beginning of April and in July (at harvesting). After 25 years of experiments, weed infestation decreased very much within the rotations studied (monoculture = 100 %; two-years rotation = 36 %; three years rotation = 17 %; four-years rotation = 5 %). Balanced fertilization with chemical fertilizers in wheat in rotations of 3 - 4 years determined a reduction of the infection rate of grains at harvesting. The level of annual rainfalls during the vegetation period of wheat had a determining role in yield formation under non-irrigation conditions. Treatments with different fertilizing elements influenced the level of weed infestation within all crop rotations studied with wheat.

Key words: crop rotation, *Fusarium* spp. infection, *Triticum aestivum*, weed infestation, winter wheat.

INTRODUCTION

Utilization of agrotechnical and chemical measures of weed control leads to maintaining weed-free crops. Wheat cultivation in long-term crop rotation determined different weed infestation degrees depending on the duration of crop rotation, weather conditions and fertilization level.

The results achieved in a stationary system regarding crop rotation effects revealed a whole range of weed infestation in the sense of increasing it in monoculture as compared to crop rotation (Pintilie and Sin, 1974; Sin, 1984; Isaieva, 1989; Ioniță et al., 1994; Kostrzevska and Zawislak, 1994; Mazurek and Grabinski, 1994).

The present paper includes particular aspects less known, regarding important changes in the weed infestation level, attack of *Fusarium* species, relationships between rainfalls and yields achieved in long term experiments in wheat in different crop rotations in the period 1970 - 1994.

MATERIALS AND METHODS

Research was carried out in the Research Institute for Cereals and Industrial Crops, Fundulea, in the period 1970 - 1994 on leached chernozem, well drained, with a content of 33 % clay, 2.8 % humus, 6.7 pH (determined in a water solution 1:2.5) in the arable layer.

Multiannual average temperature was of 10.4°C and annual rainfalls amounted to 565 mm.

Experimental factors were: factor A - crop rotation with four gradations (wheat monoculture; two-years rotation, wheat-maize; three-years rotation, wheat-maize-peas; four-years rotation, wheat – sugar beet – maize – sunflower) and factor B - fertilizers applied in three gradations (non-fertilized; nitrogen 90 kg a.i /ha.+ phosphorus 75 kg a.i P2O5./ha; manure applied annually, 20 t/ha)

During the experimental period, five local wheat varieties were used in cropping: Dacia (1970 - 1974), Iulia (1975 - 1979), Fundulea 29 (1980 - 1985), Fundulea 133 (1986 - 1987), and Flamura (1988 - 1994).

Chemical weed control was ensured by the utilization of selective herbicides for wheat crop (metyl amin salt of 2.4 D acid, 2 l/ha or metyl amin salt 2.4 D acid + dicamba, 1 l/ha). No treatments were applied during vegetation for protection against diseases.

The degree of weed infestation was determined at the beginning of April and in July (during harvesting). The reserve of weed seeds and the infection percentage with Fusarium spp. of wheat grains was determined after wheat harvesting. Yields were calculated and their quality indices were analysed.

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Annual data obtained were processed through the method of variance analysis.

RESULTS AND DISCUSSIONS

Influence of crop rotation and fertilization on weed infestation in wheat. At the beginning of the experimental period, 1974 - 1978, there was a large number of weed species. Gradually, they were reduced by improving crop management in wheat (crop rotation, soil tillage methods and herbicide application). The most important changes in the floristic composition of weeds in wheat crops consisted in reducing the number of species during the experimental period both within crop rotation and the fertilization levels used (Table 1).

Table 1. Influence of crop rotation (A) and fertilizers (B) on weed infestation (no. of species) in winter wheat in early spring time, Fundulea

Crop rotation (A)	Fertilizer (kg/ha) (B)					
	1974-1978			1991-1994		
	N_0P_0	$N_{90}P_{75}$	Manure	N_0P_0	$N_{90}P_{75}$	Manure*
Monoculture	16	12	14	8	8	8
Wheat-maize	10	13	12	5	5	5
Wheat-maize-peas	13	10	11	5	6	5
Wheat-sugar beet-Maize-sunflower	11	9	12	4	4	3
LSD $P \leq 0.05$ A	1.4			0.7		
B	0.8			0.8		
AxB	1.9			1.3		

* - 20 t/ha, every year

The data of the last period of experiments (1991 - 1994) showed a 50 % reduction of the number of weed species in monoculture and 63 - 75 % in four - years crop rotation as compared to the period at the beginning of the experiment (1974 - 1978).

Table 2. Influence of crop rotation (A) and fertilizers application (B) on weed infestation (no. of species) in winter wheat crop at harvesting time (Fundulea, 1991-1994)

Crop rotation (A)	With application of herbicides			Control*
	Fertilizer (kg/ha) (B)			
	N_0P_0	$N_{90}P_{75}$	Manure, 20 t/ha	$N_{90}P_{75}$
Monoculture	7	5	5	4
Wheat-Maize	7	4	7	3
Wheat-Maize-Peas	4	5	7	5
Wheat-Sugar beet-Maize-Sunflower	6	5	5	5
LSD $P \leq 0.05$ A	1.8			
B	1.2			
AxB	2.2			

*) Without herbicides

Although in the case of monoculture the number of weed species was constant, in the last period, irrespective of the fertilizers applied, it has decreased considerably, especially in the four-years rotation. In terms of the aspect of participation in weed infestation, in the moment of harvesting poor differentiation was observed as regards the number of species among the plots on which herbicides were applied and those on which no herbicides were applied (Table 2).

The analysis of the weed seed reserve in the arable layer of 0 - 30 cm revealed an increase of this reserve by 17 % in monoculture and a decrease by 31 % in four-years crop rotation as compared to average data recorded in two and three-years crop rotations (Table 3).

Table 3. Weed seeds reserve during 25 years of experimentation at Fundulea in 0-30 cm soil layer, determinations after winter crop

Crop rotation	Seeds of weed		
	thousands/ha	differences, ±	%
Monoculture	19552	2871	117
Two and three years rotation	16771	-	100
Four years rotation	11511	-5255	69

Reaction to diseases. *Fusarium* infection on stems and ear blight, a disease generated by two fungi (*Gibberella zeae*, Schw., Petch with the conidian form *Fusarium roseum* f. *cerealis* Cke., Snyder et Hansen and *Gibberella avenacea* Cke.) gives rise annually to significant damage in wheat crop, by affecting the yield quantity and quality (Ittu et al., 1979).

The forms of resistance in *Fusarium* species are transmitted from one year to the other by means of infected wheat seeds and the rest of ears and chaff remained on the soil after wheat harvesting (Bobeș, 1983; Toropova and Pavlova, 1995). Although wheat varieties resistant to the attack of *Fusarium* species were cultivated, there was the permanent possibility of the attack of different *Fusarium* forms during the whole vegetation period of wheat.

A great variability of ecological conditions (drought in autumn associated with prolonged period in autumn with positive temperatures higher than 10^0C, excess of soil moisture at tillering, increase of atmosphere humidity over 90 % during ear formation and flowering) promoted the development and dissemination of *Fusarium* species (Bobeș, 1983; Burgess and Swanl 1995). Under these conditions a sufficient high reserve of fungi was maintained which gave rise to *Fusarium* stem infection and ear blight in wheat. Wheat monoculture and wheat-maize crop rotation promoted the intensification of the attack of *Fusarium* species.

By increasing the interval of cereal return on the same land through their cultivation in 3-4 years crop rotation, infection of wheat grains with *Fusarium* species was greatly diminished when nitrogen and phosphorus fertilizers were used in moderate rates (Figure 1).

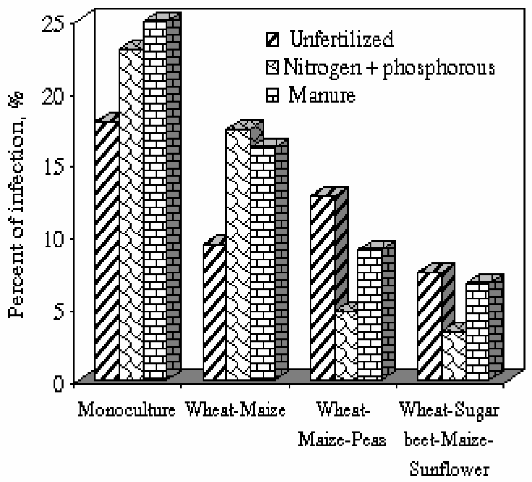

Figure 1. Percent of infection with *Fusarium* sp. on winter wheat kernels in different crop rotations during 25 years of experimentation

Influence of rainfalls on the level and quality of wheat yields. The Research Institute for Cereals and Industrial Crops of Fundulea is located in the zone of Dfax climate type where frequently (75-85 % of the years) rainfalls recorded in March - May are below 200 mm.

A thorough analysis of the rainfall and yield interaction under non-irrigation conditions at Fundulea, both for the whole vegetation period and for certain development stages of wheat, revealed the dependency of yield on rainfall.

Thus for the achievement of maximum yields in rotations of two and three years, it is necessary to have rainfalls of 200 - 250 mm (Figure 2). For the same wheat yields, rainfalls recorded during wheat vegetation period amounted to 350 - 450 mm (Figure 3).

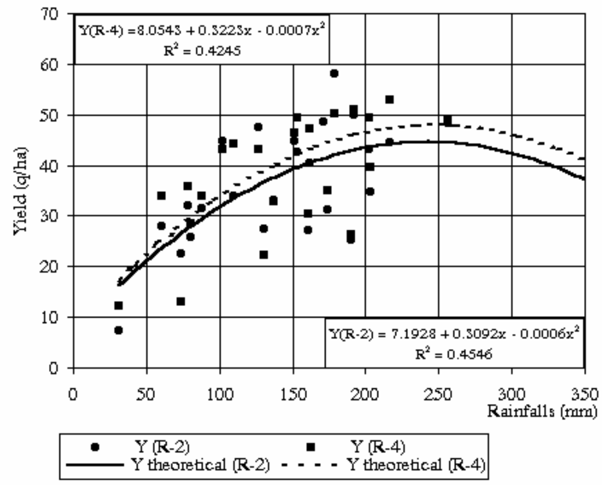

Figure 2. Relationship between rainfall in March - May period and winter wheat yields in crop rotation of R-2 and R-4 years (Fundulea, 1970 - 1994)

During the whole experimental period, the lowest yields were achieved in wheat monoculture while the maximum yields were achieved in three years crop rotation where wheat follows after peas.

In four years crop rotation, the presence of the row-crops which are great consumers of nutritive elements and water (maize, sugar beet, sunflower) determined the obtaining of intermediary wheat yields as compared to monoculture and three years crop rotation (Figure 4).

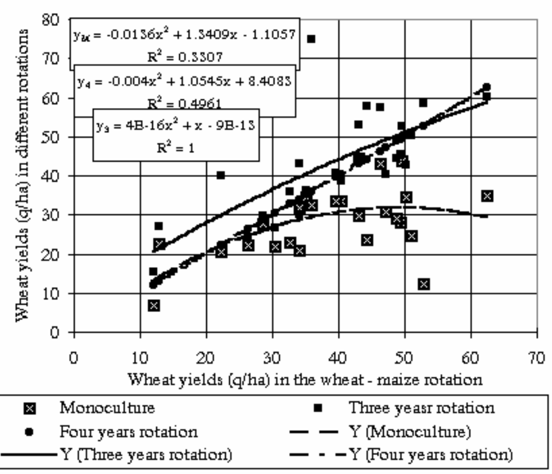

Figure 4. Influence of crop rotation on winter wheat yields (Fundulea, 1970-1994)

Data regarding protein content of wheat grains as well as thousand kernel weight indicated superior values of these qualitative indices for three years crop rotation on all basal dressings studied in comparison to monoculture and two and four years crop rotations (Table 4).

Table 4. The influence of crop rotation and fertilizers on the level and quality of yields in winter wheat crop (Fundulea 1970-1994)

Crop rotation	Fertilizer rates	Yield q/ha	Protein content %	1000 seeds weight g
Monoculture	Unfertilized	21.6	11.6	36.0
	$N_{90}P_{75}$	28.4	14.4	35.5
	Manure 20 t/ha	29.1	13.5	36.9
Wheat-Maize	Unfertilized	19.1	12.5	37.2
	$N_{90}P_{75}$	36.6	14.6	36.2
	Manure 20 t/ha	31.5	12.5	38.7
Wheat-Maize-Peas	Unfertilized	33.9	13.7	38.4
	$N_{90}P_{75}$	42.7	16.2	37.2
	Manure 20 t/ha	41.4	14.9	38.1
Wheat-Sugar beet-Maize-Sunflower	Unfertilized	24.6	12.3	37.8
	$N_{90}P_{75}$	39.1	15.6	36.2
	Manure 20 t/ha	34.7	14.1	38.2

*) LSD ($P \leq 0.05$) between crop rotation = 3.4 qha

Annual determinations regarding floristic composition of weeds in winter wheat in different crop rotations indicated the presence of three gropus of weeds. These are:

a) species of weeds existing at the beginning of the experiment and which disappeared in the meanwhile, such as *Agrostema githago*, *Consolida regalis*, *Viola* sp.;

b) species of weeds which continue to emerge annually with increasingly small frequency: *Vicia* sp., *Sinapis arvense*, *Raphanus raphanistrum*, *Gallium aparine*, *Thlaspi arvense*, *Euphorbia* sp., *Laminum amplexicaule*, *Lithospermum arvense*;

c) weed species with greater frequencies of emergence in wheat at present that compete with wheat plants especially in years with rainy spring seasons. Among these the following are more important: *Cichorium inthybus, Papaver rhoeas, Cirsium arvense, Veronica* sp., *Polygonum convolvulus, Matricaria inodora.*

Fertilizer application in rates of 90 kg a.i. /ha nitrogen + 75 kg a.i /ha P_2O_5 in wheat in three and four-years crop rotation led to fields less affected by the presence of weeds.

By plant cultivation in four years crop rotation, the alternation of different plant species and of plant management and fertilization measures meant to protect the crops, directly contributed to continuously reducing the reserve of weed seeds (Table 3)

The increase of the infection percentage with *Fusarium* spp. on wheat grains in monoculture and in wheat-maize crop rotation may be explained by the possibility of developing the fungus on both crop plants. Winter wheat cultivation in 3-4 years crop rotations as well as the utilization of moderate nitrogen and phosphorus fertilizer rates led to diminishing infections with *Fusarium* species (Figure 1).

For the growth and development of wheat plants, rainfalls in the period March - May are extremely important, when wheat consumes large quantities of water in view of developing the elements of productivity. The analysis of rainfalls recorded in this interval, for the whole experimental period, indicates a frequency of 84 % of the years with rainfalls under 150 mm and 6 % of the years with over 250 mm, the latter being considered years of exception (Figure 2). Rainfalls recorded in the months of May in the years 1971 and 1991, 267 mm respectively 183 mm, did not lead to maximum wheat yields, but on the contrary are situated by 10 % below the average recorded for the whole experimental period, because under conditions of excessive humidity leaf diseases emerged, which diminished the yields.

CONCLUSIONS

Wheat in 3-4 yeras crop rotation permits an efficient weed control and a better protection against the attack of *Fusarium* species, which is an important factor for diminishing yields.

Maintaining under crop management wheat-maize rotation for a long time on the same land leads to a critical weed infestation and to an increased attack of fungi common to the two plants, above normal limits.

The level of weed infestation was significantly modified both within crop rotations and the basal dressing used.

The combination of nitogen 90 kg/ha + phosphorus 75 kg/ha P_2O_5 gave rise to the best wheat yields within all crop rotations.

Under non-irrigation conditions, total rainfalls of 200 - 250 mm for the period March - May corresponding to maximum requirements for water, permit the formation of economical grain yields.

Studies regarding the relationship between rainfalls and wheat crop indicate the need of this crop for additional water by irrigation, in the southern part of the country, to increase the efficiency of cereal crops in terms of yields.

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Crop rotation (A)	FERTILIZER* (B)					
	1974-1978			1991-1994		
	N_OP_O	NP	Manure	N_OP_O	NP	Manure
Monoculture	16	12	14	8	8	8
Wheat-Maize	10	13	12	5	5	5
Wheat-Maize-Peas	13	10	11	5	6	5
Wheat-Sugar beet-Maize-Sunflower	11	9	12	4	4	3
LSD $P \leq 0.05$	(A) 1.4				0.7	
	(B) 0.8				0.8	
	(AxB) 1.9				1.3	

Table 2. Influence of crop rotation (A) and fertilizers application (B) on weed infestation (no. of species) in winter wheat crop at harvesting time, Fundulea 1991-1994

Crop rotation (A)	With application of herbicides			Control**
	Fertilizer* (B)			
	N_OP_O	NP	Manure	NP
Monoculture	7	5	5	4
Wheat-Maize	7	4	7	3
Wheat-Maize-Peas	4	5	7	5
Wheat-Sugar beet-Maize-Sunflower	6	5	5	5
LSD $P \leq 0.05$	(A)	1.8		
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*) N_OP_O = unfertilized; NP = Nitrogen 90 kg/ha + Phosphorous 75 kg/ha; Manure = manure 20 t/ha every year
**) Without herbicides

Table 4. The influence of crop rotation and fertilizers on the level and quality of yields in winter wheat crop, Fundulea 1970-1994.

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Wheat-Maize-Peas	Unfertilized	33.9	13.7	38.4
	N90P75	42.7	16.2	37.2
	Manure 20 t/ha	41.4	14.9	38.1
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	N90P75	39.1	15.6	36.2
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*) LSD ($P \leq 0.05$) between crop rotation = 3.4 dt/ha

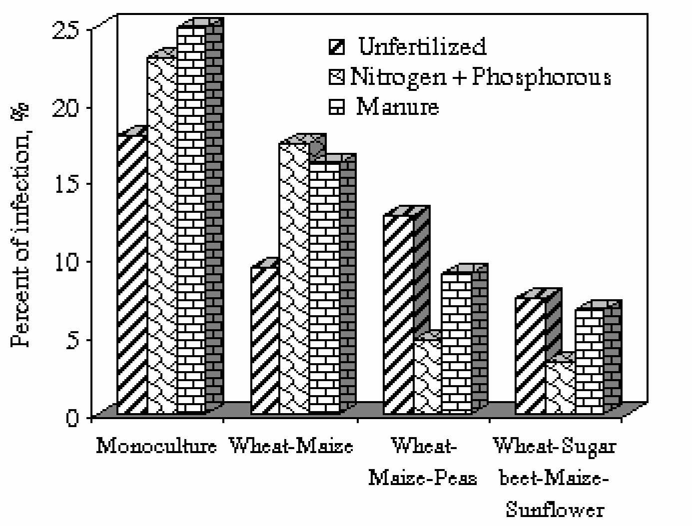


Figure 1. Percent of infection with *Fusarium* sp. on winter wheat kernels in different crop rotation during 25 years of experimentation

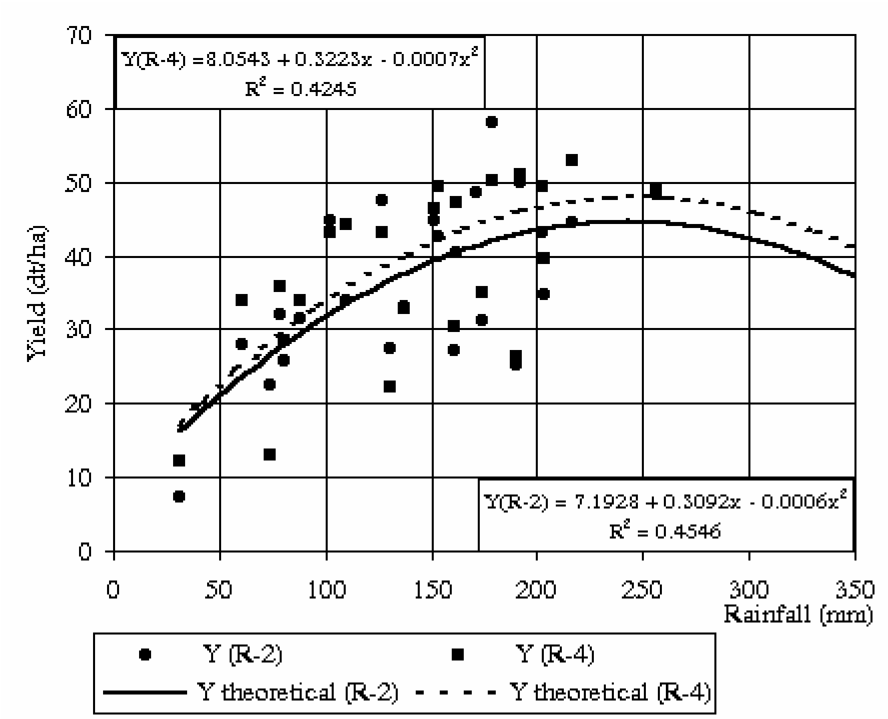


Figure 2. Relationship between rainfall in March - May period and winter wheat yields in crop rotation of R-2 and R-4 years (Fundulea, 1970 - 1994).

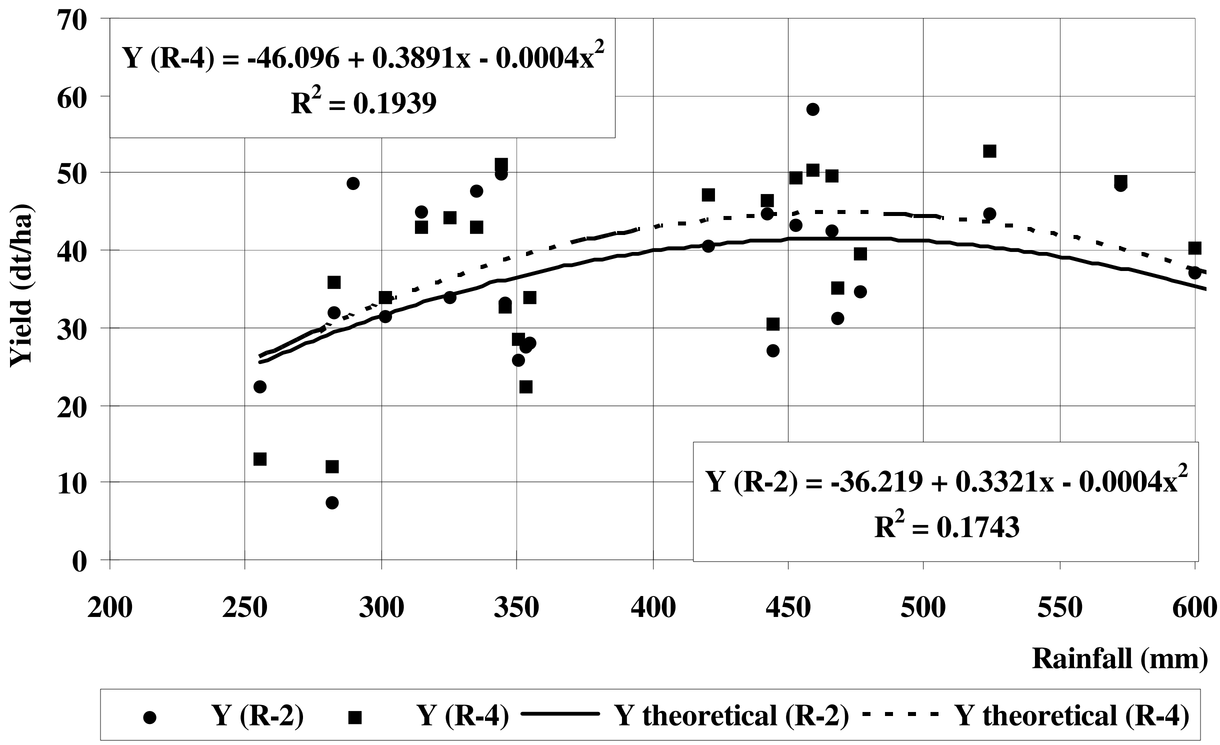
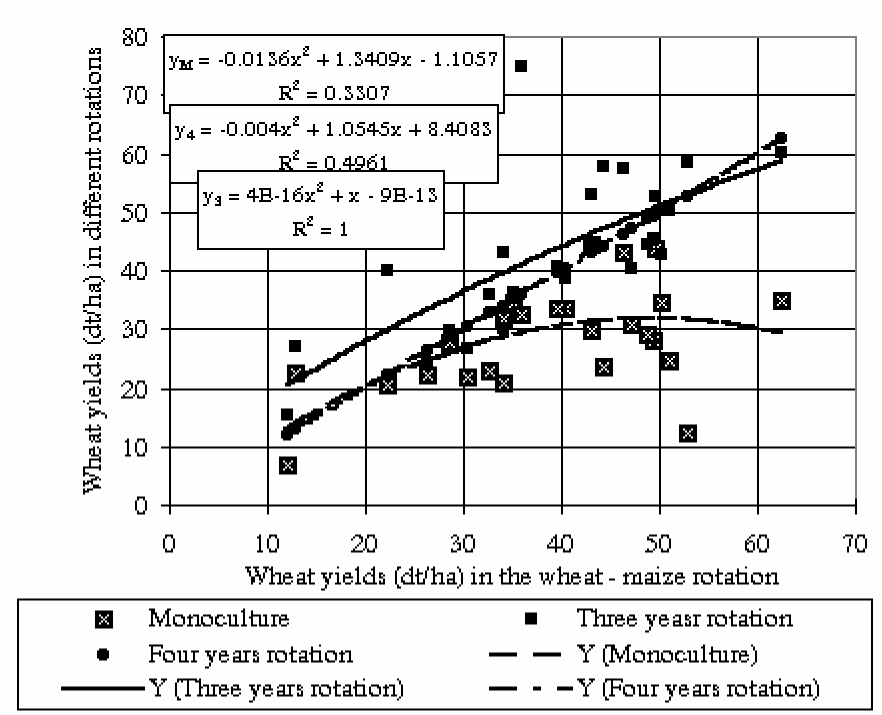


Figure 3. Relationship between rainfall during vegetation period and winter wheat yields in crop rotations of R-2 and R-4 years (Fundulea, 1970-1994).



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