Bulgarian Journal of Agricultural Science, 16 (No 2) 2010, 196-202
Agricultural Academy

EFFECT OF DIFFERENT TYPES OF MAIN SOIL TILLAGE ON BEAN YIELD UNDER THE CONDITIONS OF DOBRUDZHA REGION

P. YANKOV
Dobrudzha Agricultural Institute, BG-9520 General Toshevo, Bulgaria

Abstract

YANKOV, P., 2010. Effect of different types of main soil tillage on bean yield under the conditions of Dobrudzha region. *Bulg. J. Agric. Sci.,* 16: 196-202

The investigation was carried out during 2003-2006 in the trial field of Dobrudzha Agricultural Institute on slightly leached chernozem soil type. A stationary field trial initiated in 1987 has been investigating 24 soil tillage systems based on different soil tillage tools and operations. The following field crops have been involved in 6-field crop rotation: wheat, grain maize, bean and sunflower. The following variants of main soil tillage were used in this analysis: ploughing at 24-26 cm, disking in autumn and double cultivation in spring (check variant); cutting at 24-26 cm, disking in autumn and double cultivation in spring; double disking at 10-12 cm accompanied by autumn disking and double spring cultivation; direct sowing – pre-sowing treatment of field with total herbicide. With the reduction of the number and depth of the soil tillage operations in bean, the number of pods per plant, number of seeds per pod, 1000 seed weight per plant and 1000 seed weight decreased. Replacing deep ploughing with plowless tillage, with shallow and no tillage lead to a significant decrease of seed yield from bean variety Abritus from 4.3 to 16.5 %.

Key words: bean, main soil tillage, structural elements of yield, yield

Introduction

Bean (*Phaseolus vulgaris* L.) is a main legume crop in Bulgaria. Dry seeds and green pods are food with high biological value and are used for human consummation, while straw has high protein content and is a valuable fodder for animals (Milev, 1995).

Bean productivity is strongly affected by the soil and climatic conditions and the way of cultivation (Stamboliev et al., 1995).

The soil tillage system is a part of the agronomy practice for field bean production. The applied soil tillage has to ensure good thermal regime, good aeration and accumulation of high autumn and winter moisture reserves in soil. It is a prerequisite for development of a powerful root system and higher microbiological activity, especially of the tuber bacteria which form symbiosis with the bean plant.

The official prescriptions for bean growing recommend differentiation of the mail soil tillage depths according to the soil type and the degree of occurrence of weeds, varying from 23-25 cm to 28-30 cm (Klochkov et al., 1988; Georgiev et al., 1998).

Besides ploughing and disking, plowless tillage and direct sowing of field crops have also been used in practice during the last decades. These types of till-

age protect soil from water and wind erosion, preserve the available moisture, reduce the energy and labour expenses, the number and type of machines in the farms, and the number of operations involved in soil tillage, etc.

The various effects of soil tillage leading to improving or deterioration of soil's major characteristics, which are of crucial importance for plant development are best manifested in yield size.

The aim of this investigation was to study the effects of different main soil tillage types on the yield from common bean.

Material and Methods

The investigation was carried out during 2003-2006 in the trial field of Dobrudzha Agricultural Institute on slightly leached chernozem soil (Haplic Chernozems, FAO, 2002). According to Yolevsky et al. (1959), the mechanical composition of the slightly leached chernozem soils ensures favourable water and air regime. By their bulk density, these are soils with friable composition along the entire profile, without any compact horizons. The humus horizon is about 70 cm thick, the mean humus content in the plough layer being 3.7 %. The total nitrogen content characterizes these soils as having medium reserves; with regard to mobile phosphorus and potassium forms, they belong to the soils with good to moderate reserves, respectively. Soil reaction is neutral.

In a stationary trial initiated in 1987, 24 soil tillage systems are being investigated based on different soil tillage tools and operations. The variants are arranged by the non-standard design, in four parallel crop rotations. The size of the trial plots is 72 m^2. The following crops were included in 6-field crop rotation: wheat, grain maize, bean and sunflower. The present analysis involves the following variants for main soil tillage:

- ploughing at 24-26 cm, disking in autumn and double cultivation in spring (check variant);
- cutting at 10-12 cm accompanied with autumn disking and double spring cultivation;
- double disking at 10-12 cm followed by autumn disking and double spring cultivation;
- direct sowing – pre-sowing treatment of the field with total herbicides.

Nitrogen fertilization was done according to the previous crop, namely 40 kg/ha N was applied after previous crop wheat against background of $P_{120}K_{80}$. Phosphorus and potassium were introduced before main soil tillage, and nitrogen – before sowing. Bean was sown with seeders for direct sowing "Bettison

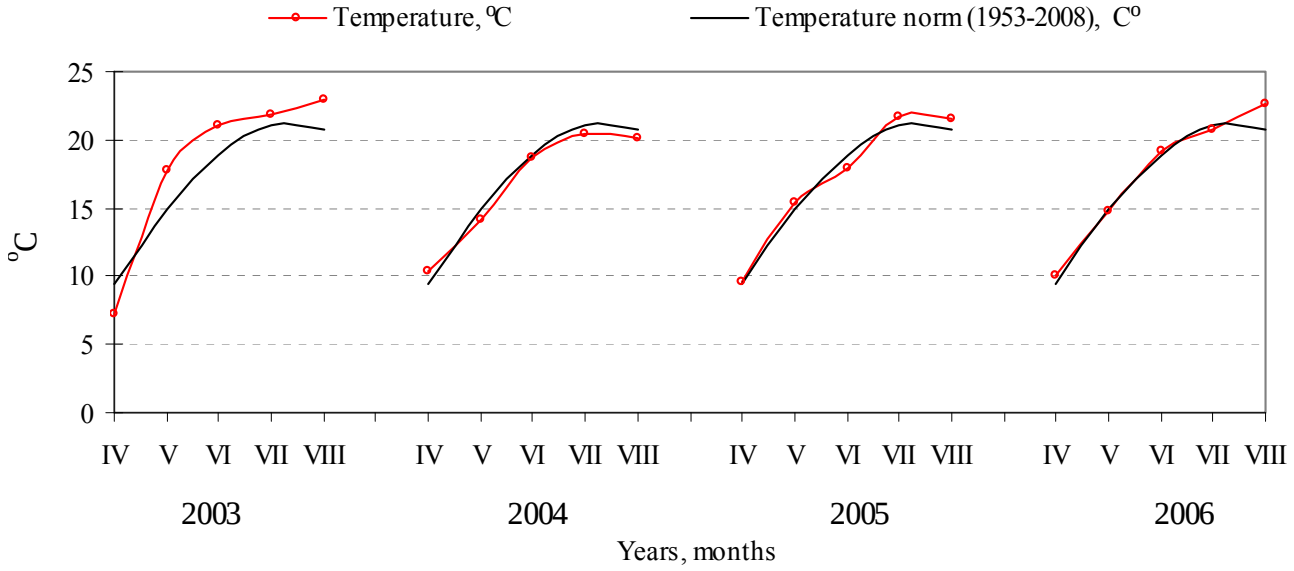

Fig. 1. Air temperatures by months from April to August during 2003-2006

3D". The variety used was Abritus, and the sowing norm was 35 germinating seeds per m^2. This variety has a non-climbing non-lodging habit type suitable for direct harvesting (Genchev, 2007).

Weeds were controlled with soil herbicides according to the following scheme: pre-sowing treatment with incorporation of grass herbicide and treatment after sowing with deciduous herbicide before emergence. In direct sowing a total herbicide was applied – one or twice according to the rate of weed attack.

Sowing is done at the end of April and in 2003 this month was colder than usual (Figure 1). From 2003 to 2006, July and August were warmer than normal, with the exception of 2004. The summer of 2004 was cooler.

During the period of investigation only one of the years was with autumn and winter precipitation sum close to the climatic norm (2005/2006); the rest of the years had precipitation sums higher than the norm (Figure 2). The sum of vegetation rainfalls (April-August) during two of the investigation years was higher than the precipitation norm – from 24.5% (2006) to 43.9% (2004). In one of the years the amount of rainfalls was close to the climatic sum (2005). Typical in this year was the favourable moisture during the month critical for the development of the crop (July). The highest sum of vegetation rainfalls was registered in the summer of 2003 – 150.3 mm, which was 61.0 % of the mean long-term sum.

The analysis of the investigated years according to the index precipitation sum for the entire economic period (October-August) showed that in none of the years the precipitation sum corresponded to the climatic norm for the period 1953-2008 (474.3 mm). The years with precipitation sum higher than the norm prevailed (2004, 2006 and 2006). In 2003 the amount of rainfalls was lower in comparison to the mean long-term value.

The statistical processing of the data was performed with the help of the software SPSS 13.0.

Results and Discussion

The replacement of deep ploughing with plough less tillage and with shallow and no tillage decreased the values of the structural elements of yield (Table 1). In none of the investigated years the variations in the number of pods per plant according to the used type of soil tillage were significant. The same tendency was observed with regard to number of seeds per pod, with the exception of year 2006. The use of

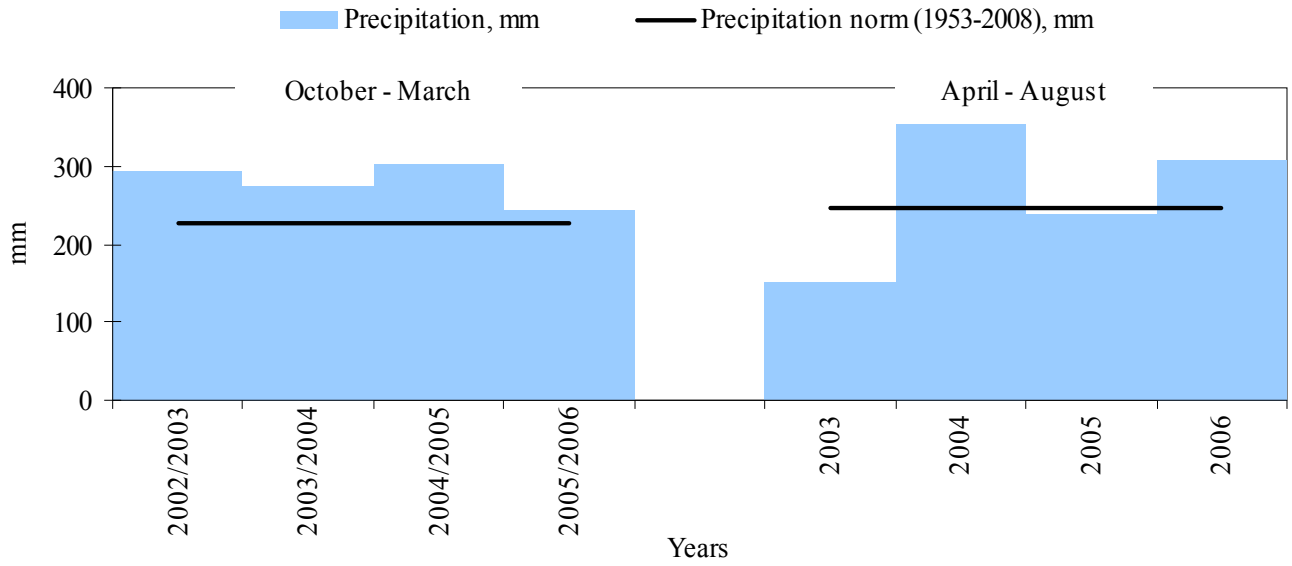

Fig. 2. Amount of autumn-and-winter and vegetation rainfalls during October 2002 - August 2006

disking and direct sowing during this year caused lower values of the above index significant at P=0.05. The different types of main soil tillage had stronger effect on seed weight per plant and 1000 seed weight. During the years the variations in the values of these indices were significant at different P levels. An exception was year 2004 when there was no variation in the seed weight per plant and 1000 seed weight after using cutting without turning of the plough layer and annual ploughing.

The dispersion analysis showed that only the meteorological conditions affected significantly to a maximum degree the indices number of pods per plant and number of seeds per pod (Table 2). The interaction of the meteorological year conditions and the type of main soil tillage was not significant. Separately, these two factors affected significantly to a maximum degree seed weight per plant and 1000 seed weight. Their interaction, however, was significant only with regard to absolute weight.

Based on Duncan's test, similarities were found between years 2005 and 2006 in the number of pods per plant (Table 3). Year 2004 had the most favourable meteorological conditions for the expression of this index. Two groups were formed according to number of pods per plant: the first included the more unfavourable year 2006, and the other – the years with better conditions – 2004 and 2005. Each of the investigated years fell within a separate group with regard to the indices seed weight per plant and 1000

Table 1
Structural elements of yield from bean variety Abritus

Indices	Year	Ploughing	Cutting	Disking	Nil	Gd		
						0.05	0.01	0.001
Number of pods per plant	2003	15.0	14.8NS	14.2NS	14.2NS	2.07	2.91	4.11
	2004	20.0	19.6NS	19.0NS	18.8NS	2.15	2.98	4.23
	2005	18.2	17.8NS	17.6NS	17.2NS	1.68	2.36	3.34
	2006	17.8	17.2NS	17.0NS	16.6NS	2.20	3.08	4.35
	Mean	17.8	17.4NS	17.0NS	16.7NS	1.27	1.78	2.52
Number of seeds per pod	2003	4.3	4.1NS	3.9NS	3.9NS	0.75	1.05	1.48
	2004	5.0	4.9NS	4.9NS	4.7NS	0.79	1.11	1.57
	2005	4.9	4.8NS	4.7NS	4.6NS	0.65	0.92	1.30
	2006	4.6	4.3NS	4.2a	4.1a	0.37	0.51	0.72
	Mean	4.7	4.5NS	4.4NS	4.3NS	0.41	0.57	0.80
Seed weight per plant, g	2003	12.2	11.1a	9.9c	9.7c	0.87	1.22	1.72
	2004	22.8	21.9NS	20.9a	19.5b	1.81	2.53	3.58
	2005	17.7	16.7NS	16.1b	15.4c	1.09	1.53	2.16
	2006	16.2	14.1c	13.4c	12.9c	1.03	1.44	2.04
	Mean	17.2	16.0c	15.1c	14.4c	0.65	0.90	1.28
1000 seed weight, g	2003	190.2	186.5b	182.2c	177.9c	2.23	3.20	4.71
	2004	229.5	226.9NS	224.3b	224.0b	3.53	5.07	7.46
	2005	200.7	196.7a	195.4a	195.3a	3.90	5.60	8.23
	2006	198.5	191.3c	190.7c	187.9c	3.35	4.82	7.09
	Mean	204.7	200.3c	198.2c	196.3c	1.54	2.21	3.25

a, b, c – Significance of effects and variations at P levels 0.05, 0.01 and 0.001, respectively;
NS – Variations and effects not significant

Table 2
Dispersion analysis on the effect of the investigated factors on the structural elements of yield and on yield from bean variety Abritus

Indices	df	Number of pods per plant		Number of seeds per pod		Seed weight per plant, g		1000 seed weight, g		Yield, kg/ha	
		F	Sig.	F	Sig.	F	Sig.	F	Sig.	F	Sig.
Year (**A**)	3	39.410	.000	13.773	.000	441.254	.000	1225.405	.000	433.846	.000
Type of tillage (**B**)	3	2.110	.108	2.082	.111	34.042	.000	48.331	.000	56.208	.000
A_xB	9	0.039	1.000	0.169	.996	0.651	.749	2.697	.013	4.257	.000

seed weight. Most favourable was 2004, followed by 2005 and 2006. Lowest were the values of all structural elements in 2003. This year was characterized by high air temperatures during the entire vegetation period and low amount of rainfalls during July, the month critical for bean development (48.2 mm).

Based on number of pods per plant and number of seeds per pod, the test divided the used types of main soil tillage in two groups. Constant disking and cutting occupied a medium position with regard to these indices. These two types of soil tillage were similar to both direct sowing and ploughing. Based on seed weight per plant and 1000 seed, each of the investigated type of soil tillage fell into separate group. The values of the two indices decreased with the reduction of the number and depth of the soil tillage operations.

During all the years of investigation seed yield after direct sowing and constant disking was lower in comparison to the yield after ploughing (Table 4). The variations were significant at different P levels. Cutting caused yield decrease in comparison to ploughing only in 2004, significant at P=0.05. The lower seed yields in the variants with annual disking and direct sowing can be explained by the deteriorated development of the plants as a result from the greater compactness of the surface soil layer. Probably it caused both weaker development of the roots and suppres-

Table 3
Statistical groups by year of investigation and type of main soil tillage based on yield's structural elements and yield from bean variety Abritus (Duncan)

Indices	Number of pods per plant	Number of seeds per pod	Seed weight per plant, g	1000 seed weight, g	Yield, kg/ha
	Groups (Values)				
Year (N=20)					
· 2003	**a** (14.55)	**a** (4.02)	**a** (10.72)	**a** (184.22)	**a** (1844.4)
· 2004	**c** (19.35)	**b** (4.89)	**d** (21.29)	**d** (226.17)	**d** (2990.6)
· 2005	**b** (17.70)	**b** (4.75)	**c** (16.49)	**c** (197.03)	**c** (2682.5)
· 2006	**b** (17.15)	**a** (4.29)	**b** (14.16)	**b** (192.13)	**b** (2089.4)
Soil tillage (N=20)					
· ploughing	**b** (17.75)	**b** (4.69)	**d** (17.24)	**d** (204.74)	**d** (2606.1)
· cutting	**a,b** (17.35)	**a,b** (4.54)	**c** (15.96)	**c** (200.34)	**c** (2495.0)
· disking	**a,b** (16.95)	**a,b** (4.41)	**b** (15.08)	**b** (198.18)	**b** (2328.8)
· nil	**a** (16.70)	**a** (4.33)	**a** (14.38)	**a** (196.29)	**a** (2176.0)

Table 4

Seed yield from variety Abritus according to main soil tillage, kg/ha

Soil tillage	Yield by years, kg/ha				Mean yield	
	2003	2004	2005	2006	kg/ha	%
Ploughing	2045	3277	2749	2355	2606	100.0
Cutting	1974^{NS}	3032^{a}	2704^{NS}	2272^{NS}	2495^{b}	95.7
Disking	1752^{c}	2975^{a}	2660^{a}	1928^{c}	2329^{c}	89.4
Nil	1604^{c}	2677^{c}	2617^{b}	1803^{c}	2176^{c}	83.5
Gd 0.05	133.2	229.1	75.2	126.3	67.9	
0.01	191.4	329.2	108.1	181.4	97.6	
0.001	281.5	484.2	159.0	266.9	143.5	

a, b, c – Significance of effects and variations at P levels 0.05, 0.01 and 0.001, respectively;
NS – Differences and variations not significant

Table 5

Correlations between seed yield obtained after different types of main soil tillage and structural elements of yield

Indices	Ploughing	Cutting	Disking	Nil
Number of pods per plant	.789**	.815**	.720**	.745**
Number of seeds per pod	.500*	.535*	.620*	.370^{NS}
Seed weight per plant	.943**	.962**	.909**	.874**
1000 seed weight	.902**	.875**	.868**	.809**

*,**,*** – Significant values of **r** at levels 0.05, 0.01 and 0.001;
NS – Value of **r** not significant

sion of the propagation of tuber bacteria, which are aerobic micro organisms. Numerous investigations have shown that in the lack of sufficient oxygen fewer tuber bacteria smaller in size a formed thus decreasing nitrogen fixation. Highest yields were obtained in years with good soil moisture during the vegetation period and favourable conditions for flowering – a stage which is critical for bean in relation to high seed yields (2004 and 2005). In years with lower amounts of autumn-and-winter and vegetation rainfalls and high air temperatures during the entire period of crop development, yields decreased (2003 and 2006).

The investigated types of soil tillage and the meteorological conditions during the period of study were the factors with maximum significant high effect on seed yield from variety Abritus (Table 2). The interaction between these factors also had a maximum degree of significance.

Based on the statistical analysis of the sums of squares, Duncan's test allocated each of the investigated years to a separate group (Table 3). It confirmed the effect of the autumn-and-winter rainfalls, the amount and distribution of vegetation rainfalls, and the air temperatures during vegetation on seed yield. The four types of main soil tillage also fell into different groups. With the reduction of the number and depth of the soil tillage operations, seed yield from variety Abritus significantly decreased.

In order to characterize the effect of the investigated types of main soil tillage, correlation analysis between seed yield and yield's structural elements was done (Table 5). Judging by the value of the correla-

tion coefficients of all soil tillage types, seed weight per plant had higher significance for seed yield. In contrast to the other soil tillage types, in constant direct sowing the correlation coefficient between seed yield and the number of seeds per pod was not statistically significant.

Conclusions

With the reduction of number and depth of the soil tillage operations in bean, the number of pods per plant, number of seeds per pod, seed weight per plant and 1000 seed weight decreased.

The replacement of deep ploughing with shallow and no tillage or plowless tillage significantly decreased seed yield from variety Abritus from 4.3 to 16.5 %.

References

Genchev, D., 2007. Breeding and genetic investigations on dry bean (*Phaseolus vulgaris* L.). D. Sci. Thesis, DAI, (Bg).

Georgiev, D., D. Genchev, G. Sabev, P. Dimitrov, N. Nankov, T. Tonev, G. Milev, I. Kiryakov and P. Yankov, 1998. Bean producing technology. Advances in Common Bean (*Phaseolus vulgaris* L.). Research in Bulgaria: pp. 19-23 (Bg).

FAO, 2002. World reference base for soil resources. Rome, Italy.

Klochkov, B., À. Karaivanov, À. Dimov, B. Simeonov, V. Kovachev, D. Davidov, D. Ivanov, G. Gospodinov, G. Sabev, I. Dimitrov, I. Kabakchiev, I. Kalinov, I. Loukov, G. Moskov, I. Panayotov, L. Shtereva, Ì. Gospodinov, Ì. Krasteva, Ì. Yolevsky, Ì. Petkova, N. Donchev, P. Ivanov, P. Palazov, P. Shterev, Ò. Zahariev, H. Kontev, H. Filipov and Y. Georgieva, 1988. Technologies for Production of Grain Crops. *Zemizdat*, Sofia, 236 pp. (Bg).

Milev, G., 1995. Study on the response íà field bean varieties to inoculation with *Rhizobium leguminosarum* Biovar. *Phaseoli* and mineral fertilization under the conditions of slightly leached chernozem soil. (Ph.D. Thesis), DAI (Bg).

Stamboliev, Ì., D. Georgiev, Ê. Tsvetanova and Ò. Tonev, 1995. Effect of soil moisture reserves on the development and yield of bean grown on carbonate chernozem soil. *Plant Sciences*, **31 (**5): 62-64 (Bg).

Yolevsky, M., K. Macheva and P. Petkov, 1959. The soils in the trial field of Dobrudzha Agricultural Research Institute and in the trial fields of Karvuna, Dobrich district and Suvorovo, Silistra district. *Research Communications of DSNI*, **III** (1, 2): 5-62 (Bg).

Received July, 23, 2009; accepted for printing December, 22, 2009.