Systematic incorporation of post-harvest residues – an inexpensive agronomy practice of increasing yield and quality of production

Gencho Milev
Dobroudja Agricultural Institute – General Toshevo 9520, Bulgaria
E-mail: gencho_milev@yahoo.com

Abstract

Data are analyzed from a long-term field trial carried out on the slightly leached chernozem soils of Dobroudja region. The aim was to establish the effect of the systematic incorporation of post-harvest residues from wheat on the yield and technological properties of the grain from bean and sunflower. The data averaged from twelve-year period showed that the yield from the two crops increased with 4 %. The technological properties of grain such as oil content in kernel of sunflower and cooking time, taste, water absorption and percent of seed coat of bean were also improved. The agronomic and economic advantages and shortcomings related to the systematic incorporation of post harvest residues in crop rotation were analyzed. The results showed that if the agronomy practice of post-harvest residue incorporation is strictly observed, the advantages are considerably more than the negative effects.

Key words: Post-harvest residues (PHR), Grain yield, Seed quality

Introduction

Considerable amounts of post-harvest residue (PHR) remain in the field after harvesting of the economically valuable part of the crops. It is a common practice to remove or burn these residues in the field when they are not used as fodder. Thus an important source for enriching soil with fresh organic substance is lost, which would help for the complex improvement of soil properties. From agrotechnical and economic point of view, PHR incorporation is equal in efficiency to manure fertilization or mulching because no expenses are needed for composting and transportation. The results from long-term field experiments have shown that 20-30 % of PHR and 50 % of root residues are incorporated in the organic substance of soil (Buyanovsky et al., 1986; Opoku and Vyn, 1997).

Investigations in Bulgaria focused on the utilization of PHR have been done by a number of authors (Goushevilov, 1998; Donkova, 2005, etc.). Short-term investigations on utilization of PHR from maize followed by wheat have been carried out at Dobroudja Agricultural Institute (DAI), too, at the beginning of the 1970s (Simeonov, 1973). Worldwide, this problem is also the subject of constant investigations and publications (Mihailina, 1983; Hramtsov, 1998; Derbyshire, E., 1985; Shomberg, 1994; Schoenau, 1996; Dormar, 1996).

With a view of considering some agro-technology aspects of this problem, a long term stationary field trial was initiated in the trial field of DAI in 1995. The aim is to investigate the effect of systematic PHR incorporation and mineral fertilization in crop rotation on the productivity of wheat, bean, maize and sunflower. This paper reports the results from the effect of wheat PHR incorporation on the yield and the technological properties of bean and sunflower seeds.

Material and methods

A stationary field trial with bean and sunflower is being carried out in the trial field of DAI on slightly leached chernozem soil. The trial was designed by the split plot method. The variants of the trial were the following: A_0 – growing of the crops without incorporation of previous crop PHR (PHR is packed in bales and removed from the field) and A_1 – growing of the crops with incorporation of previous crop PHR through ploughing into soil. Previous crop of spring crops was wheat. Wheat straw was chopped and evenly spread on the trial area by the straw-cutter of the harvester. Straw was incorporated in soil during the autumn deep ploughing. Against the above two back grounds of PHR treatment, mineral fertilization was applied with the following elements and rates (kg/ha active substance): N_0P_0, $N_{60}P_{120}$, $N_{120}P_{120}$. Medium-early bean varieties and sunflower hybrids were used in the investigation. The mean annually harvested number of plants per ha was 40 000 for sunflower and 300 000 for bean. In order to register the effect of the investigated factors, the following indices were followed: phenological observations, phytosanitary condition of the crop, vegetation rainfalls, productive moisture in the 1m soil layer, amount of incorporated PHR, yield and technological properties of seeds.

The soil in the trial area was slightly leached chernozem with 3.30 % humus content in the ploughing layer (according to Tyurin), pH_{kcl} 5.29, mineral nitrogen 9.3 mg/1000 g (in 1 % K_2SO_4), mobile forms of phosphorus and potassium 4.6 and 23.6 mg/100 g, respectively (according to Ivanov).

ANOVA was applied to find out significant differences between the control variant and the independent effects of the studied factors using the statistical software BIOSTAT© (Penchev et al., 1989-1991, version 1.0).

Results and discussion

The mean annual amount of vegetation rainfalls during the investigated period was 353 mm; it was with about 17 % higher than the mean long-term amount (averaged for 50 years). Precipitation during the autumn-and-winter period was 237 mm; this sum was also higher than the mean long-term amount (with about 6 %). These data lead to the conclusion that the growth and development of sunflower occurred under less favourable conditions in comparison to the mean long-term period.

The mean annual amount of incorporated straw was 5960 kg/ha, regardless of the variant of the trial. Mineral fertilization lead to significant increase of post-harvest biomass: with 1840 kg/ha for fertilization rate $N_{60}P_{120}$ and with 2190 kg/ha for fertilization rate $N_{120}P_{120}$, respectively, according to the check variant without fertilization. This is equal to 40 % and 48 %, respectively. The variation in the soil moisture due to the water-retention capacity of the PHR during July reached 15-20 mm in favour of variant A_1.

The systematic incorporation of PHR has a small but permanent positive effect on seed yield (Table 1). Averaged for 12 years, the increase was 80 kg/ha in bean, and 130 kg/ha in sunflower. The variations were statistically significant. Mineral fertilization had expected higher positive effect in comparison to the effect of PHR incorporation.

Table 1. Effect of PHR treatment and mineral fertilization on grain yield, averaged for 12-year period, kg/ha

Variants (fertilization, PHR)	Bean		Sunflower	
A_0 N_0P_0, check	174	D±	323	D±
$N_{60}P_{120}$	198	+24**	340	$+17^{NS}$
$N_{120}P_{120}$	194	+20**	339	$+16^{NS}$
Average for A_0, check	189	-	334	-
A_1 N_0P_0	181	D±	335	D±
$N_{60}P_{120}$	204	+23**	356	$+21^{NS}$
$N_{120}P_{120}$	204	+23**	350	$+15^{NS}$
Average for A_1	197	-	347	-
D±	+8*	-	+13*	-

A_0 – without PHR incorporation; A_1 – with PHR incorporation

*- significant differences according to the check variant for P levels 5 % and 1%; NS-not significant

All indices characterizing the technological properties of bean changed favorably as a result from PHR incorporation (Table 2). Also positive were the changes in oil content in seed of sunflower. Oil content in the seeds from variant A_1 was higher with 0.8 % than in variant A_0.

Table 2. Technological properties of seeds from a bean variety and a sunflower hybrid, averaged for 12-year period

Variants (fertilization, PHR)	Bean				Sunflower
	Cooking time, min	Protein content %	% of seed coat	taste, mark (2-6)	% of oil in seed
A_0 N_0P_0	129	18.6	8.43	4.00	44.1
$N_{60}P_{120}$	136	21.1	8.29	4.10	44.2
$N_{120}P_{120}$	137	22.9	5.08	4.15	42.2
Average for A_0, check 1	134	20.9	8.27	4.08	43.5
A_1 N_0P_0	125	19.4	8.34	4.25	44.6
$N_{60}P_{120}$	134	21.0	8.16	4.30	44.9
$N_{120}P_{120}$	134	23.7	8.02	4.30	43.5
Average for A_1	131	21.4	8.17	4.28	44.3
D±	-3*	+0.5*	-0.1^{NS}	+20*	+0.8*

A_0 – without PHR incorporation; A_1 – with PHR incorporation
*- significant differences according to the check variant for P levels 5 %; NS-not significant

The comparison of the two variants of PHR treatment is reasonable in purely agronomic perspective. Chopping of PHR leads to increased fuel expenses (with 20-30 %, personal unpublished data). This is, however, balanced by the shorter time, expressed in terms of human and machine exploitation, because one round of the equipment driven by a single operator includes two processes: harvesting and chopping of PHR. In variant A_0 packing in bales and transportation of straw is needed, which implies the involvement of at leas two machines: baler and one or more transporters, and at least two operators. Furthermore, the process goes back in time. The expense of fuel in this variant of PHR utilization is significantly higher, especially if transportation at greater distances in necessary.

The crops are typically more often attacked by pests in the variants with PHR incorporation in comparison to the check variant. Thus, for example, in years, when great amounts of straw are incorporated in soil with ploughing combined with high soil moisture, snap beetle attacks are more frequent at the beginning of sunflower and maize vegetation. The frequency of these attacks was equal to 16 % for the entire 12-year period. In years with significant losses of the economically valuable part of the crop during harvesting, the population of striped field mice increases and damages the next crop in the crop rotation. The frequency of these attacks during the investigated period was 30 %. The outlined negative processes can be controlled easily and with minimal expenses through agro-technical practices (especially by reduction of losses at harvesting) and chemical means (seed and crop treatments).

Conclusions

The results from this investigation can be summarized as follows:

1. The systematic PHR incorporation leads to small but stable increase of yield and improves the technological properties of bean and sunflower seeds.

2. From agronomic and economic point of view the application of the above agronomical

practices has definite advantages to the traditional ones. The negative phytosanitary effects can be easily controlled through agro-technical and chemical means.

References

Buyanovsky, G.A. and G.H. Wagner, 1986. Post-harvest residue input to cropland, Plant and Soil, v. 93, Number 1, pp. 57-65.

Goushevolov, J., 1998. Amount of plant residues from the crops in 4-field crop rotation on carbonate chernozem soil according to the fertilization system, Agricultural science, vol. 5, pp. 15-18.

Derbyshire, E., 1985. Legume seed protein composition and the effects of some environmental factors, Energy nuclei Agr., 7 (1/2): 37-44.

Donkova, D. and T. Tonev, 2005. Post-harvest residues of winter wheat and corn and their incorporation depending on nitrogen fertilization. I. Amount of post-harvest residue. Bulg. J. Agric. Sci., 11: 11-21.

Dormaar J. F., J. M. Carefoot, 1996. Implication of crop residue management and conservation tillage on soil organic matter, Can. Journal Pl. Sc., 76, 4, pp. 627-634

Hramtsov, I. F., E. B. Beznikonniy, 1998. Effect of the mineral fertilization, the straw and the means for plant protection on the fertility of slightly leached chernozem soil and the productivity of the crops in crop rotation, Agrochemistry, vol. 5, pp. 31-37.

Ivanov, P.,1984. A new acetate-lactate method for PK movable forms, Soil Sci. and Agrochemistry, 3: 23-26, (Bg.)

Mihailina V. I., 1983. Effect of organic fertilization on the increase of soil fertility, Moscow, p. 67..

Opoku G., T. J. Vyn, 1997. Wheat residue management options for no-till corn, Can. Journal of Pl. Sc., 77, 2, pp. 207-213

Simeonov, B., 1973. Effect of ploughing of post-harvest residues from maize stalks and straw on wheat yield. In: Problems of wheat breeding and agrotechnics, Sofia, BAS, pp. 385-392.

Schoenau Jeff. J., C. A. Campbell, 1996. Impact of crop residue on nutrient availability in conservation tillage systems, Can. Journal of Pl. Sc., 76, 4, 621-626

Schomberg H. H., J. L.. Steiner, P. W. Unger, 1994. Decomposition and nitrogen dynamics of crop residues: Residue quality and water effects, Soil Sc. Society American Journal, 58, III-IV, pp. 372-381