Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2019, Vol. 3 (4), 591-600
https://doi.org/10.29329/ijiaar.2019.217.5

Original article

After-effect of Some Herbicides and Their Mixtures with Growth Regulator and Foliar Fertilizer on the Primary Germ Weight of Cotton Seeds (*Gossypium Hirsutum* L.)

Teodora Barakova [a, *], Grozi Delchev [b] & Stoyan Georgiev [a]

[a] Field Crops Institute, 6200, Chirpan, Bulgaria
[b] Department of Plant Production, Faculty of Agriculture, Trakia University, 6000, Stara Zagora, Bulgaria

Abstract

The trial was carried out during 2013-2015, with two cotton cultivars – Helius and Darmi (*Gossypium hirsutum* L.). Herbicides Goal 2 E (oxifluorfen), Linuron45 SC (linuron), Wing P (pendimethalin + dimethenamid), Merlin 750 WG (izoxaflutole), Bazagran 480 SL (bentazone) were studied. These herbicides were used alone or in combinations with the growth regulator Amalgerol premium or with the foliar fertilizer Lactofol O during the budding stage of cotton. From the viewpoint of cotton growing technology, technologically the most valuable are combinations of all herbicides with Lactofol O, which are followed by Wing-P + Amalgerol, Bazagran 480 SL + Amalgerol and sole use of herbicide Wing-P on cultivar Helius. Technologically the most valuable are herbicides Goal 2 E and Wing-P and tank mixtures Goal 2 E + Amalgerol, Wing-P + Amalgerol, Merlin 750 WG + Amalgerol, Bazagran 480 SL + Amalgerol, Wing-P + Lactofol O, Merlin 750 WG + Lactofol O and Bazagran 480 SL + Lactofol O on cultivar Darmi. These variants combine biggest primary germ weight and high stability of this index during the different years. The alone use of the herbicides Linuron 45 SC and Merlin 750 WG has low assessment and should be avoided.

Keywords: Cotton, Herbicides, Foliar fertilizer, Growth regulator, Primary germ weight.

Received: 31 August 2018 * **Accepted:** 18 September 2019 * **DOI:** https://doi.org/10.29329/ijiaar.2019.217.5

* **Corresponding author:**

Teodora Barakova, Field Crops Institute, 6200, Chirpan, Bulgaria.
Email: tedi_mendeva@abv.bg

INTRODUCTION

Cotton is a crop that is characterized by long growing season and weak competitive capacity to weeds. Therefore, it is highly sensitive to weeding still in the earliest stages of its development (Cardoso, 2011).

Problem in contemporary farming is secondary weed infestation of crop (Boz, 2000; Bukun, 2004). The competition of weeds leads to a decrease in the cotton plants height, the number and length of the fruit twigs, the number of boxes per plant as well as the yield (Byrd and Coble, 1991; Salimi et al., 2006). In the application of the herbicide during the growing season of the cotton often a manifestation of phytotoxicity, this affects the growth and development, yield, quality of the fiber and the crop properties of the seed of crop (Vargas and Wright, 1994; Gao, 2005; Ashok, 2006). The fight against secondary weed infestation is extremely difficult and must look for new approaches and herbicides technology for growing cotton, which are efficacy and selective to crop (Jiang, 2012).

The aim of this research is to investigate the after-effect of some herbicides and their mixtures with growth regulator and foliar fertilizer on the primary germ weight of the seeds on two cotton cultivars - Helius and Darmi (*Gossypium hirsutum* L.).

Material and Methods

The trial was carried out during 2013-2015, on leached vertisol soil type, with two cotton cultivars – Helius and Darmi (*Gossypium hirsutum* L.). The experiment was conducted under the block method, in 4 repetitions; the size of the crop plot was 20 m^2.

Herbicides Goal 2 E (oxifluorfen) - 800 ml/ha, Linuron45 SC (linuron) - 2 l/ha, Wing P (pendimethalin + dimethenamid) - 4 l/ha, Merlin 750 WG (izoxaflutole) - 50 g/ha, Bazagran 480 SL (bentazone) - 1.5 l/ha were studied. These herbicides were used alone or in combinations with the growth regulator Amalgerol premium - 8 l/ha or the foliar fertilizer Lactofol O - 5 l/ha during the budding stage of cotton. The foliar herbicides were treated after the herbicidal combination Dual gold 960 EC (S-metholahlor) – 1.2 l/ha + Goal 2 E (oxifluorfen) – 1.2 l/ha, which is applied after sowing before emergence for controlling of primary weed infestation in cotton. Spraying is done with a knapsack sprayer with a working solution 300 l/ha. Weeds in the economic control are removed by hoeing - 3 times during cotton vegetation.

In laboratory conditions it was investigated the primary germ weight of cotton seeds. The index is reported in grams (g). The primary germ weight was reported for 100 seeds per each variant (25 seeds per 1 replication) of two cultivars of cotton. The seeds are taken from cotton plants treated during the vegetation with the respective herbicides and tank mixtures. It was accounted is the primary germ weight on 7^{th} day.

The math processing of the data was done according to the method of analysis of variance (Shanin 1977; Barov, 1982; Lidanski 1988). The stability of herbicides and cultivars for the primary germ weight with relation to years was estimated using the stability variances σ_i^2 and S_i^2 of Shukla (1972), the ecovalence W_i of Wricke (1962) and the stability criterion YS_i of Kang (1993).

Results and Discussion

We have carried out a significant number of studies to establish antibroadleaf herbicides that can be used during cotton growing. They produce high and stable yields of raw cotton, cotton fiber and cotton seeds over the years (Barakova & Delchev, 2016; Barakova, 2017). The use of the herbicides Goal 2 E (Oxifluorfen), Linuron 45 SC (Linuron), Wing-P (Pendimethalin + Dimethenamid), Merlin 750 WG (Izoxaflutole) and Basagran 480 SL (Bentazone) in cotton provides complete control of late spring annual broadleaf weeds *Xanthium strumarium* L., *Amaranthus retroflexus* L., *Amaranthus albus* L., *Amaranthus blifoides* W., *Chenopodium album* L., *Solanum nigrum* L., *Datura stramonium* L., *Polygonum aviculare* L., *Abutilon teophrasti* Medic., *Portulaca oleracea* L., *Hibiscum trionum* L., *Tribulus terrestris* L. Vegetative treatment with herbicides Goal 2 E (Oxifluorfen), Linuron 45 SC (Linuron) and Merlin 750 WG (Izoxaflutole) provides partial control of perennial broadleaf weeds Cirsium arvense Scop. and Convolvulus arvensis L. (Barakova, 2017). Herbicides Wing-P (Pendimethalin + Dimethenamid), Merlin 750 WG (Izoxaflutole) and Basagran 480 SL (Bentazone) are inefficacy against these weeds.

The obtained results are of great importance not only for Bulgaria but also for the other countries producing cotton in the European Union - Greece, Italy, Spain and Portugal, who cannot use genetically modified cotton cultivars. This requires doing a study of the changes of quality indicators of the fiber and seeds of these cultivars, obtained under the influence of vegetation treatment with antibroadleaf herbicides.

All herbicides reduced on the primary germ weight cultivar Helius (Table 1). This is due to their phytotoxic action these herbicides have on cotton plants. The highest phytotoxic effect on the primary germ weight have herbicides Linuron 45 SC – 4.4 g, Goal 2 E – 4.7 g and Merlin 750 WG – 4.8 g, than that of the economic control – 7.3 g. The biggest primary germ weight is obtained by use of Wing-P + Amalgerol – 7.4 g, Linuron 45 SC + Amalgerol – 7.3 g and Wing-P + Lactofol O – 7.2 g. The reason for this is that the growth regulator Amalgerol and foliar fertilizer Lactofol O reduce phytotoxic effects of all herbicides.

In the cultivar Darmi the highest phytotoxic effect on the primary germ weight has herbicide Merlin 750 WG – 5.1 g and herbicidal mixture Linuron 45 SC + Amalgerol – 5.2 g, than that of the economic control – 7.0 g. The biggest primary germ weight is obtained by use of Wing-P – 7.0 g and herbicidal mixtures Wing-P + Amalgerol – 7.3 g, Merlin 750 WG + Amalgerol – 7.3 g and Bazagran

480 SL + Lactofol O – 7.2 g. The reason for this is that the growth regulator Amalgerol and foliar fertilizer Lactofol O reduce phytotoxic effects of the herbicide Merlin 750 WG.

All herbicides applied alone have a phytotoxic effect on the primary germ weight of the two cotton cultivars, with the exception of the herbicide Wing-P of the cultivar Darmi.

The reason for this is that the growth regulator Amalgerol and foliar fertilizer Lactofol O reduce phytotoxic effects of all herbicides of the cultivar Helius.

Analysis of variance for the primary germ weight of cotton seeds (Table 2) shows that the strength of influence of years is biggest on the primary germ weight – 35.3 % on the variants. The reason for this is the different meteorological conditions during the years. The strength of influence of herbicides is 30.5 % and the strength of influence cultivars is 0.4 %. The influence of years and of herbicides is very well proven at $p \leq 0.1$. The influence of cultivars is proven $p \leq 1$. There is an interaction between cultivars and meteorological conditions of years (AxB) – 0.6 %. It is proven at $p \leq 1$. There is an interaction between years and herbicide (AxC) - 9.4 % and between cultivars and herbicides (BxC) – 11.9 %. They are very well proven at $p \leq 0.1$. There is interaction between three experiment factors (AxBxC) – 6.6 %. It also is very well proven at $p \leq 0.1$.

Table 1. After-effect of some herbicides and their tank mixtures with growth regulator and foliar fertilizer on the primary germ weight of cotton seeds, g (2013-2015)

Cultivars	Variants	2013	2014	2015	Mean
Helius	no treated control	6.3	7.3	5.3	6.3
	economic control	8.0	8.0	6.0	7.3
	Goal 2 E	5.1	5.2	3.9	4.7
	Linuron 45 SC	4.4	4.4	4.3	4.4
	Wing-P	8.0	7.6	4.7	6.8
	Merlin 750 WG	5.0	5.0	4.5	4.8
	Bazagran 480 SL	6.2	6.4	3.8	5.5
	Amalgerol	4.6	6.1	4.6	5.1
	Goal 2 E + Amalgerol	5.8	4.9	4.6	5.1
	Linuron 45 SC + Amalgerol	7.0	7.3	4.1	6.1
	Wing-P + Amalgerol	8.0	8.1	6.0	7.4
	Merlin 750 WG + Amalgerol	6.2	6.4	5.7	6.1
	Bazagran 480 SL + Amalgerol	7.0	7.1	5.1	6.4
	Lactofol O	7.6	7.7	6.4	7.2
	Goal 2 E + Lactofol O	6.6	6.6	5.5	6.2
	Linuron 45 SC + Lactofol O	8.0	8.0	6.0	7.3
	Wing-P + Lactofol O	7.4	7.5	6.7	7.2
	Merlin 750 WG + Lactofol O	6.5	6.6	5.3	6.1
	Bazagran 480 SL + Lactofol O	7.2	7.3	6.1	6.9
Darmi	no treated control	5.7	7.0	5.7	6.1
	economic control	7.8	7.8	5.4	7.0
	Goal 2 E	7.4	7.5	5.9	6.9
	Linuron 45 SC	6.5	6.6	3.6	5.6
	Wing-P	8.0	8.0	5.1	7.0
	Merlin 750 WG	6.0	6.0	3.3	5.1
	Bazagran 480 SL	5.8	6.8	4.3	5.6
	Amalgerol	6.0	6.5	3.3	5.3
	Goal 2 E + Amalgerol	8.0	8.1	4.3	6.8
	Linuron 45 SC + Amalgerol	6.3	6.4	3.0	5.2
	Wing-P + Amalgerol	7.7	7.8	6.5	7.3
	Merlin 750 WG + Amalgerol	7.8	7.9	6.3	7.3
	Bazagran 480 SL + Amalgerol	6.7	6.8	5.1	6.2
	Lactofol O	6.0	8.0	6.2	6.7
	Goal 2 E + Lactofol O	5.0	4.9	6.2	5.4
	Linuron 45 SC + Lactofol O	6.8	6.9	4.0	5.9
	Wing-P + Lactofol O	6.7	6.7	5.9	6.4
	Merlin 750 WG + Lactofol O	7.0	7.0	6.6	6.9
	Bazagran 480 SL + Lactofol O	7.7	7.8	6.0	7.2

LSD, g:

F.A p≤5%=0.1 p≤1%=0.2 p≤0.1%=0.3

F.B	p≤5%=0.11	p≤1%=0.13	p≤0.1%=0.17
F.C	p≤5%=0.3	p≤1%=0.4	p≤0.1%=0.5
AxB	p≤5%=0.1	p≤1%=0.2	p≤0.1%=0.3
AxC	p≤5%=0.5	p≤1%=0.7	p≤0.1%=0.9
BxC	p≤5%=0.4	p≤1%=0.6	p≤0.1%=0.8
AxBxC	p≤5%=0.8	p≤1%=1.0	p≤0.1%=1.3

Table 2. Analyses of variance for after-effect of some herbicides and their tank mixtures with growth regulator and foliar fertilizer on the primary germ weight of cotton seeds

Source of variation	Degrees of freedom	Sum of squares	Influence of factor, %	Mean square
Total	455	394.6	100	-
Tract of land	3	4.0	1.0	4.0***
Variants	113	373.5	94.7	3.3***
Factor A - Years	2	139.3	35.3	69.6***
Factor B - Cultivars	1	1.5	0.4	1.5**
Factor C - Herbicides	18	120.5	30.5	6.7***
AxB	2	2.2	0.6	1.1**
AxC	36	37.1	9.4	1.0***
BxC	18	47.0	11.9	2.6***
AxBxC	36	26.0	6.6	0.7***
Pooled error	339	17.1	4.3	0.2

*p≤5% **p≤1% ***p≤0.1%

Based on proven herbicide x year interaction and cultivar x year interaction, it was evaluated stability parameters for each variant for the primary germ weight of cotton seeds with relation to years (Table 3). It was calculated the stability variances σ_i^2 and S_i^2 of Shukla, the ecovalence W_i of Wricke and the stability criterion YS_i of Kang.

Stability variances (σ_i^2 and S_i^2) of Shukla, which recorded respectively linear and nonlinear interactions, unidirectional evaluate the stability of the variants. These variants which showed lower values are considered to be more stable because they interact less with the environmental conditions. Negative values of the indicators σ_i^2 and S_i^2 are considered 0. At high values of either of the two parameters - σ_i^2 and S_i^2, the variant are regarded as unstable. At the ecovalence W_i of Wricke, the higher are the values of the index, the more unstable is the variant.

On this basis, using the first three parameters of stability, it is found that at cultivar Helius stable are the herbicides Goal 2 E and Bazagran 480 SL, herbicide combinations Wing P + Amalgerol, Wing P + Lactofol O, Goal + Lactofol O, Bazagran 480 SL + Amalgerol, Bazagran 480 SL + Lactofol O, Linuron 45 SC + Lactofol O, Merlin 750 WG + Lactofol O and foliar fertilizer Laktofol O. At cultivar Darmi stable are the herbicides Goal 2 E and Bazagran 480 SL and herbicidal mixtures Wing P + Amalgerol, Wing P + Lactofol O, Merlin 750 WG + Amalgerol, Bazagran 480 SL + Lactofol O.

Other variants have high instability - values of stability variance σ_i^2 and S_i^2 of Shukla and ecovalence W_i of Wricke are the highest and mathematically proven. The reason for this high instability is greater variation in the primary germ weight during years of experience as weather conditions affect those most. At part of them there is instability from linear and nonlinear type - proven values σ_i^2 and S_i^2. At another part of them, instability is a linear type - proven values σ_i^2, the values of S_i^2 are not proven.

To evaluate the complete efficacy of each herbicide should be considered as its effect on the primary germ weight of cotton seeds and its stability - the reaction of cotton to this variant during the years.

Table 3. Stability parameters for the variants for after-effect of some herbicides and their tank mixtures with growth regulator and foliar fertilizer on the primary germ weight of cotton seeds with relation to years

Cultivars	Variants	$\bar{x}$	σ_i^2	S_i^2	W_i	YS_i
Helius	no treated control	6.3	0.3	0.7	0.6	21+
	economic control	7.3	0.08	0.06	0.2	37+
	Goal 2 E	4.7	0.09	-0.03	0.2	-1
	Linuron 45 SC	4.4	1.7**	-0.07	3.2	-10
	Wing-P	6.8	1.7**	0.7	3.2	18+
	Merlin 750 WG	4.8	0.9*	-0.04	1.8	-4
	Bazagran 480 SL	5.5	0.5	0.08	1.0	8
	Amalgerol	5.1	1.4**	2.0**	2.7	-7
	Goal 2 E + Amalgerol	5.1	1.2**	1.0*	2.3	-5
	Linuron 45 SC + Amalgerol	6.1	1.4**	0.02	2.6	6
	Wing-P + Amalgerol	7.4	0.09	0.02	0.2	41+
	Merlin 750 WG + Amalgerol	6.1	0.7*	0.07	1.4	9
	Bazagran 480 SL + Amalgerol	6.4	0.04	0.01	0.1	22+
	Lactofol O	7.2	0.09	-0.03	0.2	36+
	Goal 2 E + Lactofol O	6.2	0.2	0.01	0.4	18+
	Linuron 45 SC + Lactofol O	7.3	0.08	0.06	0.2	37+
	Wing-P + Lactofol O	7.2	0.5	-0.08	1.1	35+
	Merlin 750 WG + Lactofol O	6.1	0.09	-0.03	0.2	16+
	Bazagran 480 SL + Lactofol O	6.9	0.2	-0.05	0.3	28+
Darmi	no treated control	6.1	1.3**	1.5**	2.5	6
	economic control	7.0	0.4	0.09	0.8	31+
	Goal 2 E	6.9	-0.01	0.02	0.02	30+
	Linuron 45 SC	5.6	1.2**	0.1	2.3	1
	Wing-P	7.0	1.1**	0.1	2.1	24+
	Merlin 750 WG	5.1	0.8*	0.1	1.5	-3
	Bazagran 480 SL	5.6	0.4	0.6	0.8	10
	Amalgerol	5.3	1.2**	0.05	2.3	-3
	Goal 2 E + Amalgerol	6.8	3.1**	0.1	5.9	19+
	Linuron 45 SC + Amalgerol	5.2	2.0**	0.1	3.9	-4
	Wing-P + Amalgerol	7.3	0.09	-0.3	0.2	37+
	Merlin 750 WG + Amalgerol	7.3	-0.01	0.02	0.02	37+
	Bazagran 480 SL + Amalgerol	6.2	-0.01	0.05	0.01	17+
	Lactofol O	6.7	2.2**	3.7**	4.1	17+
	Goal 2 E + Lactofol O	5.4	5.9**	0.0	11.3	-2
	Linuron 45 SC + Lactofol O	5.9	1.0**	0.06	1.9	4
	Wing-P + Lactofol O	6.4	0.5	0.03	1.0	23+
	Merlin 750 WG + Lactofol O	6.9	1.1**	-0.05	2.1	20+
	Bazagran 480 SL + Lactofol O	7.2	-0.01	0.09	0.02	34+

Valuable information about the value of technologic value of the variant give the stability criterion YS_i of Kang for simultaneous assessment of the primary germ weight and stability, based on the reliability of the differences in yield and variance of interaction with the environment. The value of this criterion is experienced that using nonparametric methods and warranted statistical differences we get a summary assessment aligning variants in descending order according to their economic value.

Generalized stability criterion YS_i of Kang, taking into accounts the stability and value of the primary germ weight gives negative assessments of herbicides Goal 2 E, Linuron 45 SC, Merlin 750 WG, of growth regulator Amalgerol and herbicide combination Goal 2 E + Amalgerol on cultivar Helius. Negative assessment on cultivar Darmi has herbicide Merlin 750 WG, growth regulator Amalgerol and herbicide combinations Linuron 45 SC + Amalgerol, Goal 2 E + Lactofol O. They are characterized as the most unstable and with low values. According to this criterion, technologically the most valuable are herbicide combinations Wing-P + Amalgerol and Bazagran 480 SL + Amalgerol, all herbicide combinations with foliar fertilizer Lactofol O, also alone use of herbicide Wing-P on cultivar Helius. Technologically the most valuable are herbicides Goal 2 E and Wing-P, herbicide combinations Goal 2 E + Amalgerol, Wing-P + Amalgerol, Merlin 750 WG + Amalgerol, Bazgran 480 SL + Amalgerol, Wing-P + Lactofol O, Merlin 750 WG + Lactofol O and Bazgran 480 SL + Lactofol O and foliar fertilizer Laktofol O on cultivar Darmi. They combine relatively high values of the primary germ weight of cotton seeds and high stability during the years of the investigation. The alone use of the herbicides Linuron 45 SC and Merlin 750 WG receives low assessment and should be avoided. This is due to the high phytotoxicity of these two herbicides.

Conclusions

The foliar treatment with the herbicide Wing-P and tank mixtures Wing-P + Amalgerol, Wing-P + Lactofol O and Linuron 45 SC + Lactofol O lead to the biggest primary germ weight of cultivar Helius. The foliar treatment with the herbicide Wing-P and the tank mixture Wing-P + Amalgerol, Merlin 750 WG + Amalgerol and Bazagran+ Lactofol O leads to the biggest primary germ weight of cultivar Darmi.

The highest phytotoxicity on the primary germ weight of cultivar Helius was obtained after using the herbicides Goal 2 E, Linuron 45 SC and Merlin 750 WG. The highest phytotoxicity on the primary germ weight of cultivar Darmi was obtained after using the herbicide Merlin 750 WG and tank mixture Linuron 45 SC + Amalgerol.

From the viewpoint of cotton growing technology, technologically the most valuable are combinations of all herbicides with Lactofol O, which are followed by Wing-P + Amalgerol, Bazagran 480 SL + Amalgerol and sole use of herbicide Wing-P on cultivar Helius.

Technologically the most valuable are herbicides Goal and Wing-P and tank mixtures Goal 2 E + Amalgerol, Wing-P + Amalgerol, Merlin 750 WG + Amalgerol, Bazagran 480 SL + Amalgerol, Wing

+ Lactofol O, Merlin 750 WG + Lactofol O and Bazagran + Lactofol O on cultivar Darmi. These variants combine biggest primary germ weight and high stability of this index during the different years.

The alone use of the herbicides Linuron 450 SC and Merlin 750 WG has low assessment and should be avoided.

REFERENCES

Ashok, Y. (2006). Integrated control of weeds in cotton. Environ. Ecol., 24S (Special 3A), 883-885.

Barakova, T. (2017). Development of elements of integrated weed control in cotton vegetation and testing of cotton genotypes (Gossypium hirsutum L.) for resistance to herbicides. Chirpan, Bulgaria, Doctoral dissertation, 164 pp.

Barakova, T. and Gr. Delchev (2016). Selectivity and stability of vegetation-applied herbicides at cotton (Gossypium hirsutum L.). Agric. Sci. Technol., 8 (2), 121-126.

Barov, V. (1982) Analysis and schemes of the field experience. Sofia, Bulgaria, NAPO, 668.

Boz, O. (2000) Determination of weed flora, distribution and density of weed species occurring in cotton growing in Aydin. Turkey Herbology Dergisi, 3, 10-16.

Bukun, B. (2004) Critical periods or weed control in cotton in Turkey. Weed Res., 44, 404-412.

Byrd, J. and H. Coble (1991) Interference of selected weeds in cotton (*Gossypium hirsutum*). Weed Technol, 5, 263-269.

Cardoso, G. D. (2011) Critical periods of weed control in naturally green coloured cotton BRS Verde. Ind. Crop. Prod., 34, 1198-1202.

Gao, X. H. (2005). The effect of different mixed herbicides in controlling weeds. China Cotton, 32, 19-23.

Jiang, K. L., (2012). A study of eight foliar herbicides to control *Solanum nigrum* L. in cotton field. Xinjiang Agric. Sci., 49 (3), 477-481.

Kang, M. (1993) Simultaneous selection for yield and stability: Consequences for growers. Agronomy J., 85, 754-757.

Lidanski, T. (1988). Statistical methods in biology and agriculture, Sofia, Bulgaria,376.

Salimi, H. (2006). Determination of the critical period of weed control in cotton fields (*Gossypium hirsutum* L.). Appl. Entomol. Phytopath., 74 (1), 35-37.

Shanin, Yo. (1977). Methodology of the field experience, BAS, 384.

Shukla, G. (1972). Some statistical aspects of partitioning genotype - environmental components of variability. Heredity, 29, 237-245.

Vargas, R. and S. Wright (1994). Nightshade control with phrithiobace (Staple) in California. Proc. Beltwide Cotton Conferences, 1689-1691. San Diego, California, USA.

Wricke, G. (1962). Über eine Methode zur Erfassung des ökologischen Straks breiten Feldersuchen. Berlin, Germany Pflanzenzurecht, 47, 92-96.