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Varietal Specificities in Yield and Nitrate Content in Cauliflower

R. Pavlovic, Ljiljana Boskovic-Rakocevic
Faculty of Agronomy, Cacak, Serbia

Abstract: Apart from being important factors in producing high yields, nitrogenous fertilisers can act as sources of intensive soil pollution, with increased amounts of nitrogen, particularly of its nitrate form, being uptaken by the plant. To examine the effect of nitrogen fertilisation on cauliflower yield and nitrate accumulation in the cauliflower curd, the trials were set up involving two cauliflower genotypes (variety Snowball and Nautilus F_1 hybrid), applying increasing nitrogen rates - 80,120 and 160kgN/ha broadcast as CAN (calcium ammonium nitrate). The results obtained showed that there was a rising tendency in all the parameters examined (curd weight, curd diameter and total curd yield), concurrent with nitrogen rate increases, the average nitrate content in the cauliflower curd being 1124 mg/kg in the variety and 733 mg/kg in the hybrid.

Key words: cauliflower, variety, hybrid, yield, nitrates.

Introduction

The cauliflower belongs to the group of cruciferous vegetables, but is different from other species of the family in a number of morphological, physiological and biochemical traits. It is particulalry specific in structure, pattern of formation and chemical composition of the productive part, the curd. An important characteristic of this vegetable species is its specific mineral nutrition.

Nutrients are unevenly uptaken by the cauliflower during the growing season, depending on the growth and development phenostage. Nitrogen uptake is most intensive during the peak leafing period, accounting for about 80 % of the total nitrogen amount (Bobosevska, 1970).

Furthermore, excessive nitrogen rates cause injurious effects being reflected in intense increase in crop vigour, deterioration in the curd yield and green mass ratio, curd yield decrease and quality degradation. This can induce

accumulation of harmful nitrates, as the cauliflower belongs to the group of moderately nitrofile vegetables as regards nitrate accumulation (Lazic Branka et al., 1994). The nitrate form of nitrogen derived from food intaken is easily transformed in the human body into a nitrite form, higher amounts thereof being a most likely cause of carcinogenic diseases.

This fact requires more thorough control of nitrate contents in edible parts of vegetables. The objective of this paper was hence focused on examining the effect of nitrogen fertilisation on cauliflower yield and nitrate accumulation in the productive part, the curd.

Furthermore, the research was aimed at identifying nitrogen rates applied by top dressing which produced increasingly higher yields in two cauliflower genotypes, without inducing excessive accumulation of nitrates in the plant.

Material and Methods

Vegetation trials were conducted during 2005 and 2006 to determine the effect of increasing nitrogen rates on the yield and nitrate content in cauliflower. The trials were set up on open field in the doublecropping system at Trbusani near the town of Cacak.

The soil used in the research is smonitza (vertisol) type, with mildly acid reaction and a good supply of humus, total nitrogen, available phosphorus and available potassium (tab. 1).

Tab. 1. Basic agrochemical soil properties

Depth	Humus	pH		Total N	P_2O_5	K_2O
	(%)	H_2O	KCl	(%)	(mg/100g soil)	
0-30 cm	5.11	6.50	5.86	0.256	13.2	19.0

The climatic characteristics of the area for the research period are presented in tab. 2.

Mean monthly air temperatures during 2005 and 2006 slightly exceeded the long-term average. The comparison between precipitations over the research years suggested that considerably lower precipitations (65.5 mm) were recorded in the August of 2005 than in the said period of the following year (190 mm).

Two cauliflower genotypes: the Snowball variety and Nautilus F_1 hybrid were involved in the research.

The Snowball variety is a domesticated variety belonging to the medium-late maturity group, with the growing season lasting from 100 to 120 days. It is a high-vigour plant with big round snow-white curds of 1-2 kg. It is suitable for autumn production.

Nautilus F_1 is a hybrid developed by the French Seed Company *Clause* for summer-autumn production, its growing season lasting for 70-75 days. It has a good tolerance to high temperatures and is adaptable to different growing conditions. It has a good curd self-coverage. The curds are pure white, hard and

compact, their average weight being 1-1.5 kg. It is one of the most widely distributed cauliflower cultivated hybrids in Europe.

Transplanting of cauliflower plants produced in cool beds in a standard manner was carried out at a 70 x 50 cm spacing at the beginning of July.

Tab. 2. – An overview of temperatures and precipitations for the 2005 and 2006 period

Months	Mean monthly air temperatures (°C)		Long-term average	Precipitations (mm)		Long-term average
	2005	2006		2005	2006	
January	1.4	- 4.3	-0.3	33.5	32.0	43.3
February	- 0.8	1.2	2.4	70.0	40.0	41.6
March	5.7	6.0	6.7	43.0	116.0	46.4
April	12.0	14.0	11.3	80.5	61.0	56.2
May	17.2	18.2	16.8	72.5	30.0	73.7
June	21.0	21.7	20.3	83.5	88.3	87.4
July	23.7	24.7	21.7	100.0	44.6	79.2
August	20.3	21.3	21.6	65.5	190.0	53.5
September	18.2	18.9	16.6	91.2	43.0	61.0
October	11.8	14.4	11.7	23.5	28.5	58.6
November	5.2	7.7	5.8	82.5	17.3	48.9
December	2.9	3.2	0.8	41.0	66.0	55.0
Average/sum I - XII	11.6	12.3	11.3	787.0	757.0	704.8

The experiment was laid out as a randomised block design, the elementary plot dimensions being 23 x 6 m. The following treatments were employed:

I treatment – control

II treatment – 80 kg/ha of nitrogen

III treatment – 120 kg/ha of nitrogen

IV treatment – 160 kg/ha of nitrogen

Different nitogen amounts were applied by top dressing with CAN.

During the cauliflower growing season, the usual care and protection measures were applied to the cauliflower crop.

Upon top dressing, to prevent curd discolouration, the technological process of shading was used in the variety by breaking over two or three curd wrapping leaves. The hybrid did not require shading, as the genetic form and position of the leaves provided a good curd self-coverage.

The harvest of cauliflower curds was conducted at the beginning of October in both research years, when yield and yield components (curd weight and curd diameter) were determined. Cauliflower curd samples were then collected for nitrate content measurement.

Laboratory investigations included:

1. Chemical soil analyses prior to trial
2. Chemical analyses of nitrate content in the cauliflower curd.

A two-factor analysis of variance was used in the statistical processing of the results obtained. The F-test and LSD test were performed to evaluate the significance of differences, the threshold values being 5% and 1%, respectively.

Results and Discussion

The individual curd weight i.e. the metamorphosed inflorescence weight is an important complex trait directly affecting cauliflower yield and being variable due to the effect of mineral nutrition, vegetation cover and other factors (Bjelic, 1993). In this respect, Markovic and Djurovka (1990) report that the key factor in curd initiation is a sufficient supply of nutrients, particularly of nitrogen and moisture in the soil, with only vigorous plants being able to yield large quality curds, as determined by soil chemical analyses on the location studied (tab. 1).

The results presented in tab. 3 may suggest that different nitrogen application rates induced differences between both trial treatments and different genotypes. The average curd weight in the variety was 1.38 kg, ranging from 1.0 kg (control) to 1.7 kg (at 160 kgN/ha). As for the hybrid, the weight varied from 1.3 kg (control) to 2.1 kg (with the highest nitrogen rate applied), the average being 1.72 kg. In all nitrogen application treatments, concurrent with the increase in rate of nitrogen, the trait showed a rising tendency, higher values being determined in the hybrid (a 25-70% increase) than in the variety (a 27-61 % increase), consistent with the previous results obtained by Batal et al. (1997).

Tab. 3. The effect of different nitrogen fertiliser rates on curd weight (kg)

Treatments	Genotype				Average		Index	
	Snowball		Nautilus F_1					
	2005	2006	2005	2006	Snowball	Nautilus F_1	Snowball	Nautilus F_1
1	0.9	1.1	1.2	1.4	1.00	1.30	100	100
2	1.2	1.3	1.6	1.7	1.25	1.65	125	127
3	1.4	1.7	1.7	2.0	1.55	1.85	155	142
4	1.5	1.9	1.9	2.3	1.70	2.10	170	161
Average	1.3	1.5	1.6	1.9	1.38	1.72		

LSD 0.05 1.45
0.01 1.99

The cauliflower curd diameter was measured at the widest cross sectional dimension upon removal of the wrapping leaves. This yield component parameter is directly associated with individual curd weight and genetic traits of compactness in the curd. The analysis of the results on the average curd diameter presented in tab. 4 suggests that increasing nitrogen fertiliser rates bring about increases in curd diameter in both genotypes examined. The average curd diameter increases in the variety ranged from 15.2 to 17.8 cm i. e. 21-41 %. The increase in the hybrid varied from 18.4-21.6 cm i.e. 16-36 %. The average curd diameter was 15.4 cm in the variety and 18.8 cm in the hybrid, being within the values reported by Mangal et al. (1982), Booij (1989) and Bjelic (1996), who underlined that the curd diameter increased with the nitrogen rate increase.

Tab. 4. The effect of different nitrogen fertiliser rates on the curd diameter (cm)

Treatments	Genotype				Average		Index	
	Snowball		Nautilus F_1					
	2005	2006	2005	2006	Snowball	Nautilus F_1	Snowball	Nautilus F_1
1	11.9	13.3	14.1	17.8	12.6	15.9	100	100
2	14.1	16.2	17.2	19.6	15.2	18.4	121	116
3	15.3	17.0	17.8	21.0	16.2	19.4	129	122
4	16.3	19.4	19.4	23.8	17.8	21.6	141	136
Average	14.4	16.5	17.1	20.6	15.4	18.8		
LSD	0.05		0.96					
	0.01		1.32					

The application of increasing nitrogen fertiliser rates induced increases in cauliflower yields in both genotypes examined (tab. 5). The highest nitrogen application rate resulted in the statistically highest yield increase (33.5 t/ha – Snowball and 43.6 t/ha-Nautilus F_1), economically justifying the high nitrogen rate used. Lower nitrogen rates also gave rise to an increase in cauliflower yield, ranging from 22.8-27.0 t/ha in the variety, but without producing any statistical significance, and from 29.8-37.6 t/ha in the hybrid. This suggested an increasing tendency of the yield, in both the variety and the hybrid, being induced by rising nitrogen rates, as previously determined by Batal et al. (1997), Rather et al. (1999) and Rogolini et al. (2006).

Tab. 5. The effect of different nitrogen fertiliser rates on the total yield (t/ha)

Treatments	Genotype				Average		Index	
	Snowball		Nautilus F_1					
	2005	2006	2005	2006	Snowball	Nautilus F_1	Snowball	Nautilus F_1
1	19.5	21.3	26.5	27.2	19.9	26.8	100	100
2	22.0	23.7	30.1	29.5	22.8	29.8	115	111
3	25.9	28.1	36.8	38.4	27.0	37.6	136	140
4	32.3	34.7	41.0	46.1	33.5	43.6	168	163
Average	24.9	26.9	33.6	35.3	25.8	34.4		
LSD	0.05		7.83					
	0.01		10.79					

The comparison between the variety and the hybrid suggested that the average yield was higher in the hybrid (34.4 t/ha) than in the variety (25.8 t/ha), resulting from the improvements in the genetic predisposition of hybrids for higher yield.

The cauliflower genotypes studied were determined to have a high nitrate content in the curd on average (1124 mg/kg-Snowball and 733 mg/kg-Nautilus F_1), with the hybrid showing higher tolerance to nitrate uptake and accumulation, being in accordance with the results by Lazic Branka et al. (1994). An increase in the nitrate content in the cv. Snowball was recorded even at the lowest nitrogen rate applied, being statistically very significant as compared to the control (by 308 mg/kg), whereas a slight increase was recorded in the hybrid (by 58 mg/kg). The analysis of the average nitrate content using all nitrogen rates (1264 mg/kg-Snowball and 779 mg/kg-Nautilus F_1) as compared to the nitrate content in the control treatment suggested that the increase was 560 mg/kg (statistically highly significant) in the variety and 184 mg/kg (without statistical significance) in the hybrid. Similar results were obtained by Pimpini et al. (1973) and Rogolini et al. (2006) in their studies on the effect of increasing nitrogen rates on nitrate content changes in cauliflower, as well as by Vagen et al. (2007) who examined the effect of nitrogen application on the uptake in broccoli.

While comparing nitrate contents determined in both research years it was observed that in August 2005 when top dressing was performed and when nitrogen uptake from the soil was most intensive, there were considerably lower precipitations (65.5 mm) as compared to the stated period of the following year (190 mm), giving rise to higher nitrate uptake by the plant in this growing season, the dependence being formerly determined by Lazic Branka et al. (1994), too.

Tab. 6. The effect of different nitrogen fertiliser rates on the nitrate content in cauliflower curd (mg/kg of dry matter)

Treatments	Genotype				Average		Index	
	Snowball		Nautilus F_1					
	2005	2006	2005	2006	Snowball	Nautilus F_1	Snowball	Nautilus F_1
1	728	680	700	490	704	595	100	100
2	1204	820	756	550	1012	653	144	110
3	1596	1114	644	652	1355	648	192	109
4	1596	1256	1260	814	1426	1037	202	174
Average	1281	968	840	626	1124	733		
LSD	0.05			196.50				
	0.01			270.75				

Conclusion

The study results on the effect of increasing nitrogen rates in two different cauliflower genotypes may suggest the following:

The average cauliflower curd weight and diameter increased concurrently with the increasing nitrogen application rates, the highest values being determined at a rate of 160 kgN/ha in both genotypes examined. Higher values for both parameters analysed were recorded in the hybrid than in the variety.

The average cauliflower yield attained was determined to be higher in the hybrid (34.4 t/ha) than in the variety (25.8 t/ha) and showed an increasing tendency with nitrogen rate increases.

Increasing nitrogen rates induced increases in nitrate contents in cauliflower curd in both genotypes examined, with a lower average content being determined in the hybrid (733 mg/kg) as compared to the variety (1124 mg/kg), being their varietal specificity and genetic trait.

The cultivation and a wider distribution of cauliflower hybrids as compared to that of cultivars are highly important and practicable, as they produce higher yields with lower nitrate accumulation in the cauliflower curd as an edible part, which is essential for safe vegetable production.

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SORTNE SPECIFIČNOSTI KARFIOLA NA PRINOS I SADRŽAJ NITRATA

- originalni naučni rad -

R. Pavlović, Ljiljana Bošković-Rakočević
Agronomski fakultet, Čačak

Rezime

Azotna đubriva, pored toga što su značajni činioci u ostvarivanju visokih prinosa, mogu predstavljati izvor intenzivnog zagađenja zemljišta, pri čemu se povećane količine azota, posebno nitratnog oblika, usvajaju od strane biljaka. U cilju ispitivanja uticaja đubrenja azotom na prinos karfiola i akumulaciju nitrata u ruži karfiola, postavljeni su ogledi sa dva genotipa karfiola (sorta Snežna grudva i hibrid Nautilus F_1), primenom rastućih doza azota- 80,120 i 160kgN/ha, u vidu prihranjivanja sa KAN-om. Dobijeni rezultati pokazali su tendenciju porasta svih ispitivanih parametara (masa ruže, prečnik ruže i ukupan prinos) sa povećanjem doze azota, sa prosečnim sadržajem nitrata u ruži karfiola kod sorte 1124 mg/kg i 733 mg/kg kod hibrida.