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Full Length Research Paper

Effects of planting dates and compost on mucilage variations in borage (*Borago officinalis* L.) under different chemical fertilization systems

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The experimental design was a split factorial on the basis of completely randomized block design with three replications at the experimintal field of the Islamic Azad University, Shahr-e-Qods Branch, Iran in 2009. The planting dates (1 March, 15 March and 1 April) were assigned to the main plots and the combination of compost including 5, 10, 15 and 20 ton ha^{-1} and the chemical fertilization systems (N1P1K1 = 160, 128, 160; N2P2K2 = 120, 96, 120; N3P3K3 = 80, 64, 80; N4P4K4 = 40, 32, 40 respectively) were factorially assigned to the subplots. The chemical fertilization systems and compost significantly increased the mucilage percentage, flower yield, grain yield, root dry weight, plant height, flower number per plant and thousand seed weight in borage. Although, the planting date treatment significantly increased the plant features and the highest mucilage percentage (9.4%) was achieved under the treatments of 1 March and N1P1K1. It can be stated that compost is able to enhance the growth of borage under chemical fertilization systems enhancing NPK uptake.

Key words: Planting date, chemical fertilization system, compost, mucilage, borage.

INTRODUCTION

Composts are products containing living cells of different types of microorganisms (Vessey, 2003; Chen, 2006) that have an ability to convert nutritionally important elements from unavailable to available form through biological processes (Vessey, 2003) and are known to help with expansion of the root system and better seed germination. Composts differ from chemical and organic fertilizers in that they do not directly supply any nutrients to crops and are cultures of special bacteria and fungi. They also increase germination and vigor in young plants, leading to improved crop stands (Chen, 2006). Chemical fertilizers are the major nutrient that influences plants yield and protein concentration. When the amount of available soil NPK limits yield potential, additions of NPK fertilizers can substantially increase plants yield. However, plants protein concentration can decrease if the amount of added NPK is not adequate for potential yield (Olson et al., 1976; Grant et al., 1985). Many researchers have found that late-season top-dress NPK additions as dry fertilizer materials were the most effective in attaining higher plants protein concentration (Fowler and Brydon, 1989; Vaughan et al., 1990; Stark and Tindall, 1992; Wuest and Cassman, 1992; Knowles et al., 1994). Good soil fertility management ensures adequate nutrient availability to plants and increases yields. High above-ground biomass yield is obviously accompanied by an active root system, which releases an array of organic compounds into the rhizosphere (Mandal et al., 2007). It is well known that a considerable number of bacterial and fungal species possess a functional relationship and constitute a holistic system with plants. They are able to exert beneficial effects on plant growth (Vessey, 2003) and also enhance plant resistance to adverse environmental stresses, such as water and nutrient deficiency and heavy metal contamination (Wu et al., 2005). The relationship between essential oil content and planting date has not been established. It has been hypothesized that cultivating medicinal plants for essential oil content could

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Table 1. Analysis of variance.

Mean squares							df	Value sources
Plant height	Thousand seed weight	Flower number per plant	Grain yield	Root dry weight	Flower yield	Mucilage percentage		
346.65	4.347	162755.694	4.802	0.036	107.81	107.81	2	Replication
209.167	0.047	360317.291*	136.603**	0.001**	0.001*	31.04	2	PD
37.723	2.701	17703.73	3.792	0.004	0.0001	93.09	4	Error a
31.72	1.97	291690.374**	36.91**	0.003**	0.001**	18921.41**	3	Compost
17.671	2.183	102190.046	8.964	0.003	0.0001	18.93	6	PD × Compost
7874.563**	92.13**	14969087.337**	42.779*	0.694**	0.035**	11.14	3	CFS
5.88	3.05	1736.263	17.977	0.0001	0.0001	5.7	6	PD × CFS
16.459	1.258	142939.147*	2.247	0.002	0.0001	68.11	9	Compost × CFS
4.107	4.421	3072.814	4.204	0.0001	0.0001	1.14	18	PD × Compost × CFS
33.233	2.73	39184.251	6.745	0.009	0.0001	85.17	3	Error bc

CFS = Chemical fertilization systems, PD = Planting date,* and ** : Significant at 5% and 1% levels, respectively.

theoretically be later than medicinal plants for canopy because plants do not have to be harvested at maturity (Zehtab-Salmasi et al., 2001). Early planting increases the total length of time that the plant is in the field and exposed to the environment and also it is associated with increased incidences of several diseases (Bowden, 1997). Thus, early planting increases the probability of adverse consequences relative to essential oil content and planting date may also influence the quality of the essential oil. Several studies have been conducted on the effect of planting date on the essential oil content of cumin (Zehtab-salmasi et al., 2001) and coriander (Carrubba et al., 2002). The objectives of this study were to describe the relationships between planting date and compost on plant features and determine the optimum chemical fertilization systems for the borage mucilage percentage in Iran.

MATERIALS AND METHODS

The experimental design was a split factorial on the basis of completely randomized block design with three replications at the experimintal field of Islamic Azad University, Shahr-e-Qods Branch, Iran in 2009. The planting dates (1 March, 15 March and 1 April) were assigned to the main plots and the combination of compost including 5, 10, 15 and 20 ton ha^{-1} and the chemical fertilization systems (N1P1K1 = 160, 128, 160; N2P2K2 = 120, 96, 120; N3P3K3 = 80, 64, 80; N4P4K4 = 40, 32, 40 respectively) were factorially assigned to the subplots. A total number of 144 plots, each measuring 15 m^2 area (5 × 3 m) and the seedlings were thinned to achieve 40 cm spacing within rows after which the plants were at the 4 leaves stage and also, chemical fertilizers and compost were added in planting time. At the end of flowering stage, we selected 100 g dry matter of flowering shoot from each plot to determine of the mucilage percentage. To determine the flower yield, grain yield, root dry weight, plant height, flower number per plant and thousand seed weight, 10 plants were selected randomly from each plot at maturity. The data were subjected to analysis of variance (ANOVA) using statistical analysis system (SAS Institute, 1988) computer software at P < 0.05.

RESULTS

The final results of plants characters showed that compost significantly increased the mucilage percentage, flower yield, grain yield, root dry weight and flowers number per plant (P ≤ 0.01, Table 1). Also, chemical fertilization systems significantly affected flower yield, root dry weight, plant height, thousand seed weight and flowers number per plant (P ≤ 0.01) and grain yield (P < 0.05, Table 1). Highest thousand seed weight (1.9 g) and plant height (34.2 cm) were achieved by application of 20 ton/ha compost and N2P2K2 and highest root dry weight (0.14 kg/m2) and grain weight (506.8 kg/ha) were performed by N4P4K4 and 5 ton/ha and N2P2K2 and 10 ton/ha respectively, (Table 3). Those findings are in agreement with the observations of Hadj Seyed Hadi et al. (2004) and Hashemi et al. (2008). In addition, planting date had significant effect on grain yield and root dry weight (P ≤ 0.01) and flower yield and flowers number per plant (P < 0.05, Table 1). However, we noted the highest mucilage percentage (9.4%), flower yield (280.91 kg/ha) and flowers number per plant (28.2 flower/plant) were obtained under N1P1K1 and 1 March PD, while other plant characteristics were reduced under this condition (Table 2). Those results were similar with the findings of Hadj Seyed Hadi et al. (2004) and Zehtab-salmasi et al. (2001).

DISCUSSION

The results showed that late-planting decreased quantity and quality features of borage. Selection of borage planting date is one of the most important management decisions to produce mucilage. Planting date affects leaf-spot by avoiding unfavorable weather conditions for disease development. Late planting date was positively associated with more necrosis because of favorable

Table 2. Mean comparison between planting date and chemical fertilization systems.

Plant height (cm)	Thousand seed weight (g)	Flower number per plant (flower/plant)	Grain yield (kg/ha)	Root dry weight (kg/m^2)	Flower yield (kg/ha)	Mucilage percentage (%)	Treatments	
28.4 a	1.9 a	28.2 a	500.12 a	0.13 a	280.91 a	9.4 a	N1P1K1	1 March
27.1 a	0.9 c	28.1 a	491.1 ab	0.12 a	270.1 a	9.3 a	N2P2K2	
20.2 b	0.88 c	27 a	400.1 bc	0.14 a	240.11 b	9 a	N3P3K3	
20.1 b	0.87 c	25.1 a	430.2 b	0.13 a	198.2 c	9.2 a	N4P4K4	
23.2 b	1.57 b	23.1 b	505.2 a	0.11 a	260.45 ab	8.2 ab	N1P1K1	15 March
24.1 b	0.9 c	20.4 b	500.3 a	0.10 a	250.1 ab	8.8 a	N2P2K2	
22.2 b	0.9 c	22.1 b	461.2 b	0.12 a	241.11 b	7.8 ab	N3P3K3	
20.4 bc	0.88 c	19.8 b	400.3 bc	0.10 a	200.3 c	7 b	N4P4K4	
20.1 c	1.84 ab	18.4 c	490.1 ab	0.10 a	190.11 c	7.4 b	N1P1K1	1 April
18.1 cd	0.7 c	18.8 c	470.6 ab	0.11 a	170.2 c	7.1 b	N2P2K2	
18 cd	0.82 c	17.9 c	474.2 ab	0.12 a	177.4 c	7.2 b	N3P3K3	
16.1 d	0.82 c	16.8 c	430.8 b	0.13 a	130.13 d	7 b	N4P4K4	

Table 3. Means comparison between chemical fertilization systems and compost.

Plant height (cm)	Thousand seed weight (g)	Flower number per plant (flower/plant)	Grain yield (kg/ha)	Root dry weight (kg/m^2)	Flower yield (kg/ha)	Mucilage percentage (%)	Treatments (ton/ha)	
25.4 b	1.88 a	11.4 c	495.2 b	0.11 c	140.11 c	4.4 b	5	N1P1K1
27.3 b	1.9 a	14.3 b	497.2 b	0.10 d	145.14 bc	4.7 b	10	
30.2 a	2 a	15.7 b	501.3 a	0.13 b	160.71 b	4.8 b	15	
33.1 a	1.9 a	17.8 a	412.8 bc	0.14 a	210.12 a	8.6 a	20	
20.41 bc	1 ab	12.3 c	491.1 b	0.11 c	134.2 c	4.9 b	5	N2P2K2
27.2 b	1.1 ab	13.8 c	490.6 b	0.10 d	140.1 bc	5.1 b	10	
30.1 a	1.2 ab	16.9 ab	506.8 a	0.13 b	175.1 b	4.7 b	15	
34.2 a	1.9 a	16.8 a	458.1 b	0.14 a	200.3 a	8.3 a	20	
19.8 c	1.1 ab	13.4 c	399.1 c	0.13 b	120.1 c	4.7 b	5	N3P3K3
24.3 bc	1.8 a	13.9 c	380.8 c	0.14 a	118 c	5 b	10	
30.3 a	1.6 ab	15.1 b	390.2 c	0.14 a	168.2 b	3.8 c	15	
30.1 b	1.5 ab	17.4 a	400.1 b	0.13 b	198.4 ab	8.3 a	20	
19.1 c	1 ab	15.1 b	300.41 c	0.14 a	118.1 c	4.6 b	5	N4P4K4
24 bc	1.1 ab	12.1 c	315.1 c	0.13 b	114 c	6.2 ab	10	
29.4 b	1 ab	15 b	301.12 c	0.10 d	160.4 b	4.1 b	15	
26.4 c	1.8 ab	17 a	390.6 bc	0.11 c	180.6 ab	8 a	20	

Means within the same column and factors, followed by the same letter are not significantly difference ($P < 0.05$).

weather conditions. Early planting increased the forage production potential by extending the vegetative growth period and increased the total length of time that the borage was in the field and exposed to the environment. In areas with limited soil moisture, planting too early can cause excessive fall growth these results in depletion of soil moisture for early spring growth. Early planting of borage also breaks winter dormancy earlier in the spring as temperature increases and, thus, has a greater potential for late spring freeze injury. Borage planted at an intermediate date has mucilage content potential than late-planted borage because of increased lateral stems, leafs and flowering stem. Late-planted borage also develops under different temperature and day-length, has a shortened vegetative growth period and requires greater mucilage rate to compensate partially for reduced flowering stem development. In this study, increases in agronomic criteria were observed following inoculation with compost. This may be due to better utilization of nutrients in the soil through inoculation of efficient microorganisms. A positive effect of compost on yield and yield components has been reported in the literature. In addition, higher dry matter production by the inoculated plant might be because of the augmented uptake of N, P and K which in turn was a consequence of the root proliferation. Also, the increased growth parameters in hyssop might be due to the production of growth hormones by the bacteria. Nitrogen of chemical fertilizer, which is a primary constituent of proteins, is extremely susceptible to loss when considering that average recovery rates fall in the range of 20 to 50% for dry matter production systems in plants. Nitrogenous fertilizers generally cause deficiency of potassium, increased carbohydrate storage and reduced proteins, alteration in amino acid balance and consequently change in the quality of proteins and are a main element in chlorophyll production. Toxic concentrations of nitrogen fertilizers cause characteristic symptoms of nitrite or nitrate toxicity in plants, especially in the leaves. Although, pre plant fertilizer applications decrease the potential for nutrient deficiencies in early stages of growth, presence of residual soil NO_3 - N (plant-available mineral N from the previous season) may pose a risk to the environment. The water of soil be salt by inordinate N application and increase its potential. Finally, the plant use high energy for absorb of salt water that be causes dry matter reduces in this condition. Therefore, dry matter reduced under application of high levels of chemical fertilizer application due to injured roots and reduced the absorption.

Conclusion

In general it appears that, as expected, application of compost improved yield and other plant criteria. Therefore, it appears that application of this compost can be promising in production of borage by reduction of chemical fertilizer application. Our finding may give applicable advice to farmers for management and concern on fertilizer strategy and carefully estimate chemical fertilizer supply by compost application.

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