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MIXED CROPPING EFFECTS ON AGRONOMIC PARAMETERS AND MYCORRHIZAL STATUS OF *GLADIOLUS GRANDIFLORUS* HORT. AND *NARCISSUS PAPYRACEUS* KER-GAWL.

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Abstract

Investigation on the effect of mixed cropping of two famous cut-flowers namely, *Gladiolus grandiflorus* Hort. and *Narcissus papyraceus* Ker-Gawl. on various agronomic characters and arbuscular mycorrhizal (AM) colonization was carried out. Five varieties of *Gladiolus viz.* Pricella, Fado, Blues, Victor Brogy and Chinon were sown in 3 × 5 m^2 field plots with inter plant distance of 7 cm. Narcissus bulbs were sown in between the two *Gladiolus* corms. For comparison, bulbs of *Gladiolus* varieties and *N. papyraceus* were also sown in monocultures with inter plant distance of 7 cm. In general, mixed cropping with *Narcissus* increased root length and corm weights in *Gladiolus* varieties while exhibited no pronounced effect on days to sprouting and spike emergence, shoot and spike length, number of flowers and corm size. Except for reduction in root length of *Narcissus* due to mixed cropping with Victor Brogy, the effect of mixed cropping with different varieties of *Gladiolus* had no effect on various vegetative and reproductive growth parameters of *Narcissus.* In general, mycorrhizal colonization was significantly higher in mixed cropped *Gladiolus* as well as *Narcissus* plants than corresponding mono cultivated plants. The effect of mixed cropping on mycorrhizal colonization was more pronounced in *Narcissus* than in *Gladiolus*. The mixed cropping of *Gladiolus* and *Narcissus* increase mycorrhizal colonization in both the cut-flowers.

Introduction

Gladiolus is among the most famous and commonly used cut flowers in home gardening and landscape (Luo *et al.* 2012). *Narcissus papyraceus* or paper white is native to the Mediterranean region. It is a widely grown perennial ornamental bulbous plant (Blanchard 1990). The plant bears white flowers in bunches having strong fragrance.

In warmer climates of the world especially in the tropics, mixed cropping is a widespread and age-old practice. Kurdali (2010) reported that combined dry biomass of shrubby medic (*Medicago arborea* L.) and saltbush (*Atriplex halimus* L.) was considerably higher in mixed sowing than that of solely grown shrubs. Gunes *et al.* (2007) studied the effect of mixed sowing of wheat/chickpea and wheat/lentil on yield and nutrition of the crops and observed improved phosphorus nutrition of wheat by chickpea and lentil, probably due to enhanced leaf acid phosphatase in the mixed cropping system. Similarly, Zuo and Zhang (2008) observed greater iron concentration in peanut shoots grown in mixed cropping systems with oats, barley and wheat as compared to plants in monocropping. Recently, Arneja and Sadana (2012) reported that mixed cropping of berseem (*Trifolium alexandrium* L.) with raya (*Brassica juncea* L.) increased concentration of Mn in the shoot of berseem possibly a result of the ability of raya to mobilizes Mn by acidification of the rhizosphere (Sayyari-Zahan *et al.* 2009).

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Arbuscular mycorrhizal (AM) fungi are ubiquitous in terrestrial ecosystem and are symbiotically associated with most herbaceous plants (Smith and Read 2008). AM fungi play a critical role in the nutrition and growth of plants. In addition, they also give other benefits to plants including increased photosynthesis, nitrogen fixation, drought tolerance, protection against pests, production and vase life of flowers and improvement in soil structure (Javaid 2009). Depending upon the composition of root exudates, mycorrhizal colonization may be affected negatively or positively in mixed cropping (Javaid 2007, 2008). The present study investigated the effect of mixed cultivation of *G. grandiflorus* with *N. papyraceus* on agronomic performance and mycorrhizal colonization of the two cut-flowers.

Materials and Methods

Experiment was conducted under natural environmental conditions in a commercial field in the district Sheikhupura, Pakistan. The study site is situated at 31-71″N and 73-98″E. The soil of the experimental field was sandy loam in texture, 0.89% organic matter, 0.047% N, 6 mg/kg available P and 101 mg/kg exchangeable K. Field experiment was conducted in a completely randomized design with three replications. Each plot was 3 × 5 m^2 with six longitudinal ridges of 18 cm high. Corms of uniform size of five *G. grandiflorus* varieties *viz.* Pricella, Fado, Blues, Victor Brogy and Chinon were planted with inter plant distance of 7 cm. In between the two *G. grandiflorus* plants, one bulb of *N. papyraceus* was planted. For control treatments, bulbs of *G. grandiflorus* varieties and *N. papyraceus* were sown in monocultures with inter plant distance of 7 cm. Days to sprout of bulbs were recorded as soon as green shoot emerged from the soil. Likewise, data regarding shoot length, root length, days to spike emergence, spike length, number of flowers, corm size and weight of corms were recorded. For root length measurement, plants were carefully dug out, removed extra soil, washed under tap water and length of root was measured.

A part of fine roots of *G. grandiflorus* and *N. papyraceus* was cut from the plants of each replicate, rinsed in tap water and cut into 1 cm pieces. These root pieces were cleared and stained for analysis of AM colonization as per procedure described by Phillips and Hayman (1970). The roots were cleared in 10% KOH solution for 30 min in an autoclave, placed for 10 min in 10% HCl to neutralize and then stained with 0.05% glycerol-trypan blue solution. Twenty root pieces of each replicate (1 cm each) were mounted in lactophenol on glass slides and studied under compound microscope (×10). The percentage occurrence of various AM structures *viz.,* mycelium, arbuscules and vesicles was recorded based on their presence and absence. For percentage colonization of these structures, each of the 20 root pieces was observed at 5 points under ×10 power of a compound microscope. For quantification of arbuscular and vesicular colonization, number of these structures per 20 cm of root length was recorded.

All the data were subjected to analysis of variance followed by DMRT to separate the treatment means at 5% level of significance using computer software COSTAT.

Results and Discussion

Shoots of *Gladiolus* plants were above the soil surface 19 - 21 days after planting. Pricella and Blues took more time to sprout than rest of the three varieties. Shoots of Pricella appeared significantly later than shoots in Fado and Victor Brogy. Mixed cropping of *Gadiolus* with *Narcissus* had no influence on sprouting time in all the five varieties of *Gladiolus* (Table 1). Victor Brogy had the longest shoot (88.1 cm) followed by Fado (85.4 cm) and Blues (84.9 cm). Pricilla (73.4 cm) and Chinon (73.3 cm) had the shortest shoots. Mixed cropping with *Narcissus* reduced shoot length in *Gladiolus* Blues and Victor Brogy and had no effect on shoot length in

other varieties (Table 1). Root length in various varieties of *Gladiolus* ranged from 13.1 - 16.7 cm. Mixed cropping with *Narcissus* increased root length in all the varieties of *Gladiolus* except Pricilla (Table 1). Recently, Liab *et al.* (2012) reported enhanced root length in faba bean due to mixed cultivation with maize. Depending on plant species, mixed cropping exhibited variable effects on crop growth ranging from negative to no effects to growth stimulation (Amoah *et al.* 2012).

Spike emergence duration ranged from 71 days in Pricella to 89 days in Blues. Mixed cropping with *Narcissus* delayed spike emergence in Pricella and had no influence on other *Gladiolus* varieties. Spike length ranged from 40.4 cm in Fado to 48.7 cm in Chinon (Table 1). Mixed cropping with *Narcissus* had no effect on spike length in *Gladiolus*. On average, Pricella produced the fewest flowers (9 per plant) and Chinon produced the most (13 per plant). Mixed cropping with *Narcissus* had no influence on the number of flowers and corm size in all the *Gladiolus* varieties. Mixed cropping increased corm weight in Fado and had no effect on corm weight in other *Gladiolus* varieties (Table 1).

Table 1. Effect of mixed cropping with *Narcissus* on vegetative and reproductive growth of different varieties of *Gladiolus.*

Treatments	Days to sprout	Shoot length (cm)	Root length (cm)	Spike emergence (days)	Spike length (cm)	No. of flowers	Corm size (cm)	Weight of corms (g)
Pricilla	20.6 ab	73.4 d	13.1 f	70.6 f	47.0 a-c	9.0 f	15.8 c	32.4 a-c
Pricilla + *Narcissus*	21.3 a	71.7 d	14.7 c-f	72.0 e	45.8 b	9.0 f	15.8 c	34.9 ab
Fado	19.0 c	85.4 b	13.2 f	85.6 c	40.4 d	9.6 ef	17.8 b	29.3 cd
Fado + *Narcissus*	19.3 bc	84.9 b	15.6 b-d	86.0 bc	40.7 cd	9.6 ef	17.8 b	34.9 ab
Blues	20.0 a-c	84.9 b	13.6 f	89.0 a	42.6 c	10.3 c	19.0 ab	36.1 a
Blues + *Narcissus*	20.6 ab	81.6 c	15.2 b-e	89.0 a	41.0 cd	10.0 cd	18.8 ab	37.0 a
Victor Brogy	19.0 c	88.1 a	14.0 d-f	87.3 b	41.2 cd	11.0 b	20.7 a	33.0 a-c
Victor Brogy + *Narcissus*	19.0 c	84.1 b	15.8 bc	87.0 bc	42.0 cd	11.0b	20.7 a	34.7 a-c
Chinon	19.3 bc	73.3 d	16.7 ab	83.6 d	48.7 a	13.0 a	14.5 c	26.3 d
Chinon + *Narcissus*	19.6 bc	73.8 d	18.2 a	83.6 d	47.6 ab	13.0 a	14.5 c	30.0 b-d
LSD ($p \leq 0.05$)	2.4	3.4	1.7	1.4	2.2	0.7	2.0	5.6

Values with different letters in a column show significant difference ($p \leq 0.05$) as determined by DMRT.

In general, vegetative and reproductive growth of *Narcissus* grown in monoculture at 7 cm spacing were similar to growth of *Narcissus* grown at closer spacing in mixed culture between *Gladiolus.* Only spike emergence in *Narcissus* was reduced when grown in mixed copping with Victor Brogy (Table 2).

Mycorrhizal colonization differed among *Gladiolus* varieties. On average, percentage of mycelial colonization in Pricilla, Fado and Chinon was greater than in Blues and Victor Brogy. Similarly, percentage of arbuscular colonization in Pricella and Fado was greater than in other varieties (Table 3). In general, colonization of different mycorrhizal structures in *Gladiolus* varieties was stimulated in mixed cropping with *Narcissus.* Mycorrhizal colonization on Fado roots was found to be the most responsive where percentage of mycelial, arbuscular and vesicular infections were significantly increased due to mixed cropping with *Narcissus.* Similarly, mycorrhizal colonization on Chinon roots was also very responsive where percentage colonization

of different mycorrhizal structures were significantly greater in mixed than in mono cultivated plants. (Table 3).

Table 2. Effect of mixed cropping with different varieties of *Gladiolus* on vegetative and reproductive growth of *Narcissus.*

Treatments	Days to sprout	Shoot length (cm)	Root length (cm)	Spike emer-gence (days)	Spike length (cm)	No. of flowers	Corm Size (cm)	Weight of corms (g)
Narcissus	10.3 a	67.7 ab	15.3 a	67.3 a	13.9 a	7.6 a	15.1 a	29.1 a
Narcissus + Pricella	9.0 a	64.6 b	14.7 a	70.0 a	15.0 a	7.0 a	16.6 a	30.2 a
Narcissus + Fado	9.6 a	70.8 a	16.6 a	69.0 a	14.8 a	7.3 a	15.7 a	33.8 a
Narcissus + Blues	10.0 a	68.2 ab	14.8 a	68.6 a	15.4 a	7.3 a	15.0 a	35.4 a
Narcissus + Victor B.	10.3 a	66.6 ab	14.0 a	64.6 b	14.6 a	7.6 a	15.2 a	33.5 a
Narcissus + Chinon	10.0 a	65.4 ab	17.0 a	68.0 a	14.6 a	7.0 a	15.1 a	33.4 a
LSD ($p \leq 0.05$)	1.5	6.1	3.6	2.6	1.3	0.8	1.8	7.1

Values with different letters in a column show significant difference ($p \leq 0.05$) as determined by DMRT.

Table 3. Effect of mixed cropping with *Narcissus* on vesicular arbuscular mycorrhizal colonization of different varieties of *Gladiolus.*

Treatments	VAM colonization (%)		
	Mycelium	Arbuscules	Vesicles
Pricilla	39.6 b	5.6 c	2.0 f
Pricilla + *Narcissus*	42.6 b	8.6 b	3.6 d-f
Fado	39.3 b	5.0 cd	4.0 c-e
Fado + *Narcissus*	55.6 a	10.6 a	6.0 ab
Blues	15.6 d	3.3 d-f	2.0 f
Blues + *Narcissus*	25.6 c	4.0 c-f	2.6 ef
Victor Brogy	15.3 d	2.6 ef	2.6 ef
Victor Brogy + *Narcissus*	25.6 c	4.6 c-e	5.6 a-c
Chinon	41.6 b	2.0 f	5.3 b-d
Chinon + *Narcissus*	58.5 a	5.0 cd	7.3 a
LSD ($p \leq 0.05$)	9.9	1.9	2

Values with different letters in a column show significant difference ($p \leq 0.05$) as determined by DMRT.

Generally, *Gladiolus* varieties stimulated mycorhizal colonization in *Narcissus.* All the varieties of *Gladiolus* except Pricella significantly enhanced percentage of mycelial colonization

in *Narcissus.* Similar effect of Fado, Blues and Victor Brogy was also recorded on percentage of arbuscular colonization.

Table 4. Effect of mixed cropping with different varieties of *Gladiolus* on vesicular arbuscular mycorrhizal (VAM) colonization of *Narcissus.*

Treatments	VAM colonization (%)		
	Mycelium	Arbuscules	Vesicles
Narcissus	49.3 b	9.6 b	3.3 a
Narcissus + Pricella	54.6 ab	14.0 ab	6.0 a
Narcissus + Fado	59.6 a	17.0 a	5.6 a
Narcissus + Blue	57.3 a	16.6 a	7.0 a
Narcissus +Victor B	58.6 a	16.0 a	6.3 a
Narcissus + Chinon	57.0 a	13.3 ab	7.3 a
LSD (P≤0.05)	7.9	6.2	4.5

Values with different letters in a column show significant difference ($p \leq 0.05$) as determined by DMRT.

In contrast, none of the *Gladiolus* varieties exhibited significant effect on percentage colonization of vesicles in *Narcissus* (Table 4). In the present study, both *Gladiolus* and *Narcissus* exhibited positive effects on mycorrhizal colonization to each other. Earlier, Javaid *et al.* (1995) reported enhanced mycorrhizal colonization in *Trifolium alexandrianum* L. co-cultivated with *Brassica campestris* L. as compared to mono-cultivated crop. However, there are also reports of negative effects of mixed cropping on mycorrhizal colonization of one or both the partners, especially when one of the co-cultivated crops is a non-mycorrhizal one (Bajwa *et al.* 1996, Javaid *et al.* 1996). It seems probable that mycorrhizal response to mixed cropping depends upon the composition of root exudates of the plant species involved.

The mixed cultivation of *Gladiolus* and *Narcissus* does not have any pronounced adverse effect on the growth of *Narcissus.* In general, mixed cropping has little effect on growth of *Gladiolus* that varies with the *Gladiolus* cultivar. While growing in mixed culture with *Narcissus,* only a suitable *Gladiolus* variety should be selected. Especially, Pricella should not be selected for mixed sowing as this practice delayed spike emergence in this variety. Mycorrhizal colonization of both the said cut-flowers enhanced in mixed cropping as compared to monocultures.

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