囊叢枝菌根在花卉上之應用

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摘　要

囊叢枝菌根(ＶＡＭ)在花卉上之應用最近才起步，其研究遠比果樹與蔬菜爲少，但其應用則頗具前途。本研究室以百日草、萬壽菊、百合、菊花、組織培養非洲菊及矮牽牛爲材料研究其菌根反應，發覺ＶＡＭ一般可促進作物之營養生長及生殖生長；提早開花自１～４週；增加花數與鮮花重量；延長非洲菊之瓶插壽命；促進花梗維管束組織之發育提高花卉品質；抗水分逆境；增加養分之吸收等功效。

歸納學者所提有關ＶＡＭ促進作物營養生長之原因，主要以它可促進作物更有效利用氮、磷肥與其他微量元素之吸收。而促進生殖生長則可能原因有四，即(１)促進寄主之耐磷肥及其他微量元素的吸收；(２)促進荷爾蒙的平衡及產生；(３)加速作物營養生長，間接提早生殖生長；(4)作物本身的基因表現所致。

日本「出光興產株式會社」近年來致力於研究ＶＡＭ在花卉上之應用，可能是對花卉菌根最有研究之單位，已正式在販售ＶＡＭ菌種中，商品名叫金剛博士(Dr. Kinkon)。

關鍵字：生長反應，開花期，切花，瓶插壽命。

在園藝囊叢枝菌根(Vesicular-arbuscular mycorrhiza；VAM)研究中，花卉之研究遠比果樹及蔬菜爲少，然而外國文獻中仍可見天竺葵、百合、聖誕紅、玫瑰、鬱金香、唐菖蒲、香水草、吊鐘花、除蟲菊、菊花、萬壽菊及組織培養的波士頓腎蕨等皆可形成囊叢枝菌根[1]。菌根之矮牽牛及菊花的花數及乾物重皆比非菌根者增加[11,13]。百合菌根植株組織內所含之N、P、K、Ca、Mg亦較多，且球數增加、體積變大[5]。菌根鬱金香之株高及根部發育皆受促進[10]。聖誕紅接種大孢子屬孢子(*Gigaspora calospora*)後，總鮮重增加25-45%[8]。菌根矮牽牛之花數增多，且含較多的維管束[11]。菌根天竺葵可產生較多花莖且開花整齊[9]。菌根玫瑰之植株乾重、葉面積及根表面積皆顯著增加[13]。除蟲菊屬之菌根植株種苗較高，分枝數、根長皆可增加，並可提早開花7～10天[14]，而香水草屬(*Heliotropium*)及吊鐘花(*Fuchsia*)之菌根植株可提早開花並可增加花數[7]。ＶＡＭ又可促進聖誕紅之扦插發根及根鮮重[8]；組織培養(*Pistacia integerrima*)之幼苗生長[20];增加波士頓腎蕨組培苗葉片長度及匍萄莖數目等[18,19]。菌根萬壽菊可增加花數、枝條及根之鮮重[16]及磷含量[17]，並可增加花鮮重與乾重[2]。菌根玫瑰抗水分逆境之能力增強[12]。

本研究室自1988年起致力於菌根花卉之生理研究，以孔雀草、萬壽菊、百日草、百合、菊花及組織培養之非洲菊、矮牽牛和百合小苗爲材料，期望由其生長與發育之反應評估VAM在花卉應用上之可行性。

綜合中外文獻與本研究室多年之研究成果，歸納出VAM對花卉作物有如下功效：

1. 促進花卉作物之營養與／或生殖生長：例如百日草(表1)、萬壽菊(表2)。
2. 提早開花：少則一週(如孔雀草、萬壽菊、百日草等)，多則11-24天(表3)。
3. 增加花數與鮮花重量：菌根非洲菊(表４)、百合(表５)及矮牽牛(表６)之花數皆可顯著增加。且非洲菊鮮花之乾重亦增加(表７)。
4. 延長鮮花之瓶插壽命：菌根非洲菊鮮花之瓶插壽命在8-HQS溶液中可比非菌根者長約3～5天之多(表８)。
5. 促進維管束組織之發育：如萬壽菊根部維管束組織以菌根者發育爲佳(圖1)。因而較可避免維管束被細菌阻塞而成垂頸現象，故可延長鮮花之瓶插壽命。
6. 改善花卉品質：紫皇百日草之菌根植株其花瓣數顯著增加(表９)。
7. 抗水分逆境：玫瑰及天竺葵皆有此類報導[12,21]，可能原因計有(1)菌絲伸出根外增加吸收面積；(2)增加鉀與氮離子吸收而增加滲透調節[6]；(3)經由荷爾蒙調節作用，改善氣孔開閉作用[3]；(4)增進對氣孔的控制[4]；(5)增加組織內水分運輸能力，因此有較大膨壓而抗旱。
8. 增加養分之吸收：菌根萬壽菊植株體內總含磷量增加，亦可增加氮、鉀、鎂、銅之含量[17]。菌根玫瑰可增加鉀、磷、硫、錳、鋅之吸收[12]。菌根百合對氮、磷、鉀、鈣、鎂之吸收皆有增加[5]。菌根聖誕紅之磷含量增加，但錳含量降低[15]。菌根非洲菊植株內之鉀、磷、鋅、銅含量增加，但錳之含量降低[1]。

至於菌根花卉對土生病害抗性之研究成果甚少，仍有待吾人去深入探討。

歸納學者所提有關VAM促進作物營養生長之原因，主要以它可促進作物更有效利用氮、磷肥與其他微量元素之吸收。而促進生殖生長則原因有四，即(１)促進寄主之耐磷肥及其他微量元素的吸收；(２)促進荷爾蒙的平衡及產生；(３)加速作物營養生長，間接提早生殖生長；(４)作物本身的基因表現所致。

結論與建議

囊叢枝菌根在花卉上之研究雖然起步較晚，但可能是園藝菌根中最具應用潛能之植物種類，值得吾人重視之。建議適用之範圍如下：

1. 穴盤育苗。
2. 組織培養苗之移植接種。
3. 高價花苗之培育。
4. 可減少磷肥之施用量。
5. 產期調節。

對花卉菌根最有研究之單位，已正式在販售VAM菌種中，商品名叫金剛博士(Dr. Kinkon)。

表1．紫皇品種之百日草於25/20℃下接種不同*Glomus* spp.三個月後之生長反應[2]。

處理[x]	株高	地上部鮮重	地上部乾重	地下部鮮重	地下部乾重	花鮮重	花乾重	花瓣數
Ge	63.17	23.45	4.28a	6.86	0.86	9.60b	1.77	132.33b[y]
Gf	56.33	21.03	3.22b	7.29	0.86	8.10c	1.32	123.33b
Gm	59.33	18.19	2.80b	5.94	0.63	12.13a	1.87	231.67a
NM control[z]	54.50	20.42	2.96b	5.62	0.58	4.65d	0.83	37.67b

X. Three samples were tested for each treatment.
Y. Means followed by the different letter in the column are significant (p=0.05) as determined by Duncan's new Multiple Range Test.
Z. NM control = Non-mycorrhizal control.
growth medium：Soil：sand：bark = 2:1:1.

表2．橙扣品種之萬壽菊接種三種*Glomus* spp.四個月後之生長反應[2]

處理[x]	株高	地上部鮮重	地上部乾重	地下部鮮重	地下部乾重	花鮮重	花乾重	根徑	花徑
Ge	87.60	62.07	10.70	15.14	3.04	31.97a	4.55	8.10	10.23a[Y]
Gf	94.20	63.62	11.05	14.81	2.03	23.76ab	3.35ab	8.00	8.90ab
Gm	88.20	63.16	10.70	16.91	3.26	26.11ab	3.56ab	8.60	9.50ab
NM control[Z]	92.20	74.72	11.90	20.34	2.58	18.27b	2.54b	8.50	7.30b

X. Three samples were tested for each treatment.
Y. Means followed by the different letter in the column are significant (p=0.05) as determined by Duncan's new Multiple Range Test.
Z. NM control = Non-mycorrhizal control.
growth medium： Soil：sand：bark = 2:1:1.

表3．繡球屬菌根菌對四種切花作物開花期之影響

Crop	Cultivar	*Glomus* spp.	Days to flowering		
			Non-Mycorrhizal	Mycorrhizal	Extent of early flowering(days)
French Marigold	Bolero	Ge. Gm.	61-65	50	11-15
	Queen Sophia	Ge.Gm.	42	35-36	6-7
	Scarlet Sophia	Ge.Gm.	61-65	50	11-15
	Yellow Boy	Ge.Gm.	78	59-60	18-19
Marigold	Clinton	Ge.	75	63	8
	Sunshine	Ge.	109	88	21
Gerbera	Tennessee	Ge.	128	112	16
	Regina	Gm.	87	78	9
Zinnia	Lilliput Mixed	Ge. Gf. Gm.	50-60	45-52	5-8
	Royal Purple	Ge.Gm.	84	60-64	20-24

Glomus spp :
Ge *Glomus etunicatum* Becker & Gerd.
Gf *Glomus fasciculatum*(Thaxter sensu Gerd.) Gerd. & Trappe
Gm *Glomus mosseae*(Nic. & Gerd.) Gerd. & Trappe

表4．*Glomus* sp.對十五個月大「Regina」品種組織培養非洲菊在25℃下切花產量之影響(1)

處　　理[z]	側枝數目	切花產量(花數/株)
Noninoculated[x]	5.6b[y]	23.0b
Inoculated		
Ge	8.0a	28.3a
Gf	6.0b	25.6b
Gm	8.0a	29.6a

X. Three replications were tested for each treatment.
Y. Least Significant Difference (L.S.D., p=0.05)*Significant, NS Nonsignificant.
Z. Noninoc. Noninoculated
Ge *Glomus etunicatum* Becker & Gerd.
Gf *Glomus fasciculatum* (Thaxter sensu Gerd.) Gerd. & Trappe
Gm *Glomus mosseae* (Nicol. & Gerd.) Gerd. & Trappe

表5．不同菌對亞洲百合 *Grand Paradiso* 生長之影響

菌　種	株　高	花　數	苞　長
CK[x]	64.10b[y]	2.3b	5.2
Glomus mosseae	65.80b	2.3b	5.2
Glomus etunicatum	73.60a	3.0a	6.0

X. Each value is the mean of 30 replicates
Y. Means followed by the different letters are significant (p=0.05) by Duncan's Multiple Range Test.

表6．矮牽牛極白(Ultra whita)品系在根基旺中接種不同種類菌根菌對生長與開花數之影響

菌　種	地上部鮮重	地下部鮮重	地下部根重	開花數
CK	48.02b[x]	3.28a	0.48ab	56.00b
Gig	73.12a	4.96a	0.63a	92.00a
Go	66.76a	4.48a	0.38a	87.60a
Gx	63.32a	4.72a	0.61a	53.40b

Five replications were tested for each treatment.
X:Means followed by the different letter in the column are significant (p=0.05) as determined by Duncan's Multiple Range test.
CK：Non-mycorrhizal
Gig：*Gigaspora* spp.
Go ：*Glomus occultum*
Gx ：*Glomus etunicatum* and *Glomus mosseae*

表7．溫度對菌根與非菌根非洲菊(cv. *Tennensee*)切花鮮重之影響[(1)]

Treatment	Fresh Weight of flower (g)			
	NM[z]	Ge	Gf	Gm
30/25℃	16.08c[y]	19.61c	16.59c	18.20c[x]
25/20℃	27.14b	27.45b	27.31b	26.71b
20/15℃	34.45a	35.96a	33.23a	35.99a

X. Three replications were tested for eacth treatment and 6-12 samples for each replication
Y. Means followed by the different letter in the column are significant (p=0.05) as determined by Duncan's Multiple Range test.
Z. NM Nonmycorrhizal
Ge *Glomus etunicatum* Becker & Gerd.
Gf *Glomus fasciculatum* (Thaxter sensu Gerd.) Gerd.
Gm *Glomus mosseae* (Nicol. & Gerd.) Gerd. & Trappe

表8．在埔里田間生長之「田納西」品系組織培養非洲菊在移植時接種*Glomus* sp.所產切花在二種保鮮液中之瓶插壽命(天數)[1]

菌　　種	保鮮藥劑	
	8-HQS	8-HQS+蔗糖
CK	14.0b[x]	21.4a
Ge	18.0b	22.6a
Gf	17.0b	21.2a
Gm	19.6a	20.4a

X. Means followed by the different letter in the column are significant (p=0.05) as determined by Duncan's Multiple Range test.
CK ：Non-inoculated
Ge ：*Glomus etunicatum* Becker Gerd.
Gf ：*Glomus fasciculatum* (Thaxter sensu Gerd.) Gerd. & Trappe
Gm：*Glomus mosseae* (Nicol. & Gerd.) Gerd. & Trappe

表9．不同品種之百日草於不同溫度下接種*Glomus* spp.後之一朵花之花徑與花瓣數[2]

Treatment[x]	Temperature regime			
	30/25℃		25/20℃	
	Petal number	Flower diameter	Petal number	Flower diameter
	Royal Purple			
G. etunicatum	148.40	7.50	288.33a[y]	9.17
G. fasciculatum	170.80	7.00	310.66a	8.27
G. mosseae	135.80	7.60	342.66a	9.00
NM control[z]	199.80	7.80	88.33b	9.00
	Lilliput Mixed			
G. etunicatum	56.40	3.55	135.00	4.00
G. fasciculatum	73.60	3.50	187.60	3.88
G. mosseae	47.80	2.95	174.00	3.30
NM control	102.20	3.57	107.20	3.30

X. Three samples were tested for each treatment.
Y. Means followed by the different letter in the column are significant(p=0.05) as determined by Duncan's new Multiple Range Test.
Z. NM control = Non-myhcorrhizal control.

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The Use of Vesicular-arbuscular Mycorrhiza on Flower Crops

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Abstract

Researches for the use of vesicular-arbuscular mycorrhiza (VAM) on flower crop were started recently. Thus, its researches are much less than that of fruit and vegetable crops. But it has the greatest potential for practical use. The responses of zinnia, marigold, lily, chrysanthemum, micropropagated gerbera and petunia on the infection of VAM fungi were studied. It was found that VAM showed the following benefits: 1. enhanced vegetative and reproductive growth of crops; 2. earlier flowering for 1-4 weeks; 3. increased flower number and fresh weights; 4. prolonged vaselife for gerbera; 5. enhanced the development of vasicular bundles in flower scapes; 6. higher flower quality; 7. increased water-stress resistance; and 8. stimulated mineral absorption.

Scientists summerized that the cause of increase in mineral absorption by VAM was mainly due to the available use of nitrogen and phosphate fertilizer and increase in the uptake of some microelements by the VAM plants. There were four possible reasons for the VAM to enhance reproductive growth, i.e. 1. increased the tolerance of phosphate by the host plant, and stimulated the absorption of mineral elements; 2. enhanced the equlibrium and production of hormones; 3. stimulated vegetative growth and indirectedly enhanced reproductive growth; 4. the gene expression of the crops.

Idenitsu Kosan Co., Ltd. of Japan recently intensively studied the use of VAM on flower crops, and found promising results. Now they have made VAMF inoculum named 'Dr. Kinkon' as commercial product.

Key words: Growth response, Flowering period, Cut flower, Vase-life