ウコン (Curcuma spp.) 栽培における万田 31 号(自然発酵植物凝縮物)の施用法に関する研究

Studies on application methods of Manda 31 for Turmeric (*Curcuma* spp.) cultivation

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Key Words : Application interval, fermented natural plant concentrate (Manda 31), turmeric (*curcuma* spp.), yield.

Summary

Activity of a plant growth regulator depends on its application timing, application site (leaf, flower, soil, etc.), number of applications and application interval. Manda 31 is a fermented natural plant concentrate, which improves turmeric yield. The experiments were conducted at the Agricultural Experiment Farm, Faculty of Agriculture, University of the Ryukyus, Japan in 1999-2000. Experiment I was conducted to determine proper application interval of Manda 31 for better economic benefit in turmeric. In the experiment II, Manda 31 was applied to leaf, soil or both leaf and soil to evaluate growth and yield of turmeric. Growth parameters, shoot biomass and yield (rhizome dry weight) of turmeric were significantly increased with Manda 31 applied at 7, 10, 15, 20 or 30 day intervals as compared to control in both glasshouse and field experiments. Yield was not significantly different among the Manda 31 application intervals, which suggested that Manda 31 should be applied at 30 day intervals for better benefit in turmeric cultivation. Manda 31 applied to leaf, soil or both leaf and soil increased turmeric yield by 15, 15 or 19%. Leaf and soil application of Manda 31 resulted in the highest yield, which indicated that Manda 31 is absorbed by plants through leaves and roots. This result suggested that Manda 31 can be applied to both leaf and soil for better yield of turmeric.

Introduction

Human existence depends on safety food and healthy environment. It was suggested to reduce or cancel chemical application in agriculture. Because, synthetic chemical application in

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agriculture causes water contamination, air pollution, degradation of soil fertility, soil microorganism hazards, health hazards and food risk (Li et al. 1999; Neera et al. 1999; Swanton and Weise 1991; Worsham et al. 1995). Manda 31 (fermented natural plant concentrate) improves yield and quality of crops, vegetables and fruits without any hazards of environmental factors and human health (Ishimine et al. 1999, Tsurumaki 1991). Manda 31 is a highly concentrate fermented product from 50 natural plant materials such as soybean, walnut, sesame, brown rice, glutinous rice, wheat, barley, millet, marine algae, banana, apricot, orange, pineapple, apple, lotus root, sugar, honey, and others. Some high technologies are applied for more than three years in fermentation procedures to achieve its consume products. It contains 0.015% ammoniacal nitrogen, 0.004% nitrate nitrogen, 0.280% water soluble organic nitrogen, 0.001% water insoluble organic nitrogen and 0.75% soluble potash (K_2).

Turmeric (*Curcuma* spp.) is one of the most important medicinal plants in the world, which has antioxidant properties and protective powers. Turmeric prevents cancer diseases and the production of tissue-damaging free radicals (Majeed et al 1995). Scientists are looking for AIDS preventive properties in turmeric. It is widely used in Bangladesh, India, Pakistan, Sri Lanka and Burma as spices, cosmetic and medicine.

Studies on application technologies of plant growth regulators, inhibitors, fertilizers or irrigation is important to gain most economic benefit (Hossain 1999). Plant growth requirements differ from species to species because of their different life span. Turmeric requires around one year from planting to harvest. Ishimine et al. (1999) reported that Manda 31 increased turmeric yield by 20% when applied every week at 0.0001 concentration (water : Manda = 10000 : 1). Every week application of Manda 31 is not profitable for turmeric. It was also reported that Manda 31 applied to leaf or soil increased turmeric yield (Ishimine et al. 1999). Application of Manda 31 to both leaf and soil may result in better turmeric yield than that apply to only leaf or soil. Therefore, experiment I was conducted to determine proper application interval of Manda 31 for better economic benefit. In the experiment II, Manda 31 was applied to leaf, soil or both leaf and soil to evaluate growth and yield of turmeric.

Materials and Methods

I. Studies on application intervals of Manda 31

a. Glasshouse experiment

Glasshouse experiment was conducted from April 9, 1999 to February 15, 2000 at the Agricultural Experiment Farm of the University of the Ryukyus, Okinawa, Japan. Soil type was reddish in color (Shimajiri Maji) with an organic matter content of 0.8%. Percent clay, silt and sand were 66.3, 29.3 and 4.4, respectively. Soil pH and bulk density (g cm^{-3}) were 6.08 and 0.85, respectively.

The experiment consisted of 6 treatments with 10 replications, namely T1: Manda 31 applied at 7 day intervals (DI); T_2: Manda 31 applied at 10 DI; T_3: Manda 31 applied at 15 DI; T_4: Manda 31 applied at 20 DI; T_5: Manda 31 applied at 30 DI; T_6: water applied at 15 DI (control). One turmeric rhizome (cv. *C. longa*, Aki Ukon, 25 g) was planted to 5 cm depth in

each pot (size 0.05 m^2, 30 cm depth) contained 14 kg soil. Manda 31 solution (water : Manda = 10000: 1) or water was applied to plants until the solution or water begins to drip. The solution or water was applied to plants until November starting 70 days after planting (DAP). Three top dressing of compound fertilizer N: P: K = 18: 9: 9 at 370 kg ha^{-1} was applied at 60 DI starting 50 DAP. Water (irrigation) was applied once a day to maintain adequate soil moisture. Average air temperature in the glasshouse ranged from 18 to 32 C.

b. Field experiment

Field experiment was conducted from May 2, 1999 to March 1, 2000 at the Agricultural Experiment Farm of the University of the Ryukyus. The field was uncultivated in previous year. The soil type and planting material of turmeric rhizome used in this experiment were similar to that used in glasshouse experiment.

The experiment consisted of 6 treatments (described in glasshouse experiment) with 4 replications. The field was plowed properly for turmeric cultivation and ridges were prepared mechanically maintaining 150 cm apart. Each ridge was 8 m long. Turmeric rhizome was planted to 5 cm depth in two rows in each ridge maintaining 30 cm distance. Overhead irrigation was done immediately after plantation. Manda 31 solution (water : Manda = 10000 : 1) or water was applied to plants until the solution or water begins to drip. Manda 31 or water was applied to plants at different intervals until December starting 70 DAP. Three top dressing of above fertilizer at 370 kg ha^{-1} was applied at 60 DI starting 70 DAP. Overhead irrigation was done immediately after fertilizer application. Hand hoeing was operated three times for weed management.

II. Studies on Manda 31 applied to leaf, soil or both leaf and soil

a. Glasshouse experiment

Glasshouse experiment was conducted from April 9, 1999 to January 25, 2000 at the Agricultural Experiment Farm of the University of the Ryukyus. Soil type, pot size, turmeric-rhizome, plantation procedures, irrigations, fertilizer management and Manda 31 solution used in this experiment were similar to that provided in previous glasshouse experiment. The experiment consisted of 4 treatments with 5 replications, namely T1: Manda 31 applied to leaf; T_2: Manda 31 applied to soil; T_3: Manda 31 applied to both leaf and soil; T_4: water applied to both leaf and soil (control). Manda 31 or water was applied to plants until the solution or water begins to drip. Manda 31 or water was applied to plants at 15 day intervals until November starting 70 DAP. The solution or water was applied to soil at 1000 L ha^{-1}.

b. Field experiment

Field experiment was conducted from May 2, 1999 to February 26, 2000 at the Agricultural Experiment Farm of the University of the Ryukyus. Soil type, field preparation practices, plantation procedures, irrigations, fertilizer management and weed management practices used in this experiment were similar to that provided in previous field experiment. The experiment consisted of 4 treatments with 4 replications. The treatments of this experiment were similar to that of previous glasshouse experiment. Manda 31 or water was applied to plants at 15 day intervals until December starting 70 DAP. The solution or water was applied to soil at 1000

L ha^{-1}. Manda 31 solution used in this experiment was similar to that provided in previous field experiment.

Procedures of data collection and analysis

Plant length, and number of tillers and leaves were recorded 5 times at 30 day intervals starting 75 DAP in glasshouse study. Turmeric was harvested only once in February 2000 for glasshouse study. In field study, 4 and 30 plants were harvested from each replication at 105 and 285 DAP, respectively. Data on plant length, number of tillers and leaves, leaf area, and dry weight of shoots and rhizomes were monitored. Data on all parameters of turmeric for field experiment was calculated m^{-2}. Means were determined on all properties of turmeric data using analysis of variance (ANOVA). Fisher's Protected LSD test at the 5% level of significance was used to compare treatment means.

Results and Discussion

Shoot dry weight was increased by 26, 34, 23, 20 and 34% with the Manda 31 applied at 7, 10, 15, 20 and 30 day intervals, respectively, as compared to control in glasshouse experiment. Whereas in field experiment, shoot dry weight was increased by 14, 11, 13 and 14% with Manda 31 applied at 7, 10, 15, 20 and 30 day intervals, respectively (Table 1). Higher shoot dry weight may resulted in higher turmeric yield (Hossain 1999; Ishimine et al. 1999; Uddin 1996). Manda 31 applied at different intervals did not show significant difference in shoot dry weight in both glasshouse and field experiments. Because, number of shoots and leaves, and shoot length of turmeric were similar in all the Manda 31 applied treatments (data not

Table 1. Shoot and yield of turmeric as influenced by Manda 31 applied at different intervals, in 1999-2000 glasshouse and field experiments.

Treatment (application intervals)	Shoot dry weight		Yield(rhizome dry weight)	
	glasshouse	field	glasshouse	field
	g pot^{-1}	g m^{-2}	g pot^{-1}	g m^{-2}
T1 : Manda 31 (7 days interval)	39.9 a (126)	317 a (114)	35.8 a (116)	581 ab (110)
T2 : Manda 31 (10 days interval)	41.2 a (134)	308 ab (111)	35.9 a (116)	601 ab (114)
T3 : Manda 31 (15 days interval)	39.1 ab (123)	314 a (113)	36.6 a (118)	633 a (120)
T4 : Manda 31 (20 days interval)	38.1 ab (120)	312 a (113)	36.0 a (117)	616 a (116)
T5 : Manda 31 (30 days interval)	41.2 a (134)	317 a (114)	35.6 a (115)	622 a (118)
T6 : Water (15 days interval, control)	31.7 b (100)	277 b (100)	30.9 b (100)	529 b (100)
LSD (0.05)	7.5	33	4.6	88

Note: Data are means of 10 and 4 replicates for glasshouse and field experiment, respectively. Thirty plants were harvested in each replication of field experiment. Data in the parentheses indicate percentage of the control plant. Value of control plant considered 100%. Means within a column followed by the same letter do not differ at the 5% level of significance according to LSD test.

presented). Yield of turmeric was increased by 16, 16, 18, 17 and 15% with the Manda 31 applied at 7, 10, 15, 20 and 30 day intervals, respectively in glasshouse experiment (Table 1). On the other hand, turmeric yield was increased by 10, 14, 20, 16 and 18% with the Manda 31 applied at 7, 10, 15, 20 and 30 day intervals, respectively (Table 1). Manda 31 applied at 7 day intervals resulted in the lowest yield in field experiment. However, yield was statistically similar in all the Manda 31 applied treatments. Ishimine et al. (1999) reported similar results in turmeric with the Manda 31 applied every week at 0.0001 concentration (water : Manda = 10000 :1).

It was reported that short duration vegetables increased their yield with every week application of Manda 31 (personal communication). Shorter interval of Manda 31 application did not show any positive effect on growth parameters of turmeric as compared to that of longer intervals. Turmeric is a long duration crop, which may requires longer interval of Manda 31 application. Similarly, sugarcane is a long duration (12-18 months) crop, which requires three times application of fertilizer in a season (Hossain 1999). On the other hand, rice is a short duration (3-4 months) crop, which also requires three times application of fertilizer in a season. It can be concluded that interval width of Manda 31 application depends on plant life span.

Table 2. Shoot and yield of turmeric as influenced by Manda 31 applied to leaf, soil or both leaf and soil at 15 day intervals, in 1999-2000 glasshouse and field experiments.

Treatment	Shoot dry weight		Yield(rhizome dry weight)	
	glasshouse	field	glasshouse	field
	g pot ^{1}	g m ^{2}	g pot ^{1}	g m ^{2}
T1 : Manda 31 applied to leaf	32 ab (114)	314 ab (124)	34 a (126)	374 a (115)
T2 : Manda 31 applied to soil	32 ab (114)	313 ab (124)	33 a (122)	373 a (115)
T3 : Manda 31 applied to leaf and soil	35 a (125)	339 a (134)	36 a (133)	385 a (119)
T4 : Water applied to leaf and soil (control)	28 b (100)	253 b (100)	27 b (100)	324 b (100)
LSD (0.05)	5	62	4	49

Note: Data are means of 5 and 4 replicates for glasshouse and field experiment, respectively. Thirty plants were harvested in each replication of field experiment. Data in the parentheses indicate percentage of the control plant. Value of control plant considered 100%. Means in each column not followed by the same letter are different at 5% level of significance, as determined by LSD test.

Manda 31 applied to leaf, soil or both leaf and soil increased 24, 24 or 34% of shoot dry weight as compared to that of control (Table 2). Yield was increased by 15, 15 or 19% with the application of Manda 31 to leaf, soil or both leaf and soil. Similar trend was observed in glasshouse experiment (Table 2). Manda 31 applied to leaf may enhanced photosynthetic activities, which resulted in increased yield (Esau et al. 1998; Ishimine et al. 1999). Soil application of Manda 31 may influenced on soil microbial activities that ultimately supported plant to grow well (Uddin 1996). Manda 31 may involved in metabolic function of plant nutrients. Manda 31 enhanced root growth of turmeric, which may help the plants to uptake nutrients properly (data not presented). Similarly, germination test of turmeric showed higher

root growth with Manda 31 application (data not published). Manda 31 may involve in decomposition activities of soil organic matters and compost fertilizers. All the turmerics treated with Manda 31 resulted in statistically similar yield. However, Manda 31 applied to both leaf and soil resulted in the highest yield, which indicated that Manda 31 is absorbed by plants through leaves and roots. This result suggested that Manda 31 can be applied to both leaf and soil for better yield of turmeric.

Results of glasshouse and field experiments indicated that growth parameters, shoot biomass and yield of turmeric were significantly increased with the Manda 31 applied at 7, 10, 15, 20 or 30 day intervals. Yield was not significantly different among application intervals of the Manda 31, which suggested that Manda 31 should be applied at 30 day intervals for better benefit in turmeric cultivation. Manda 31 applied to leaf, soil or both leaf and soil increased turmeric yield by 15, 15 or 19%. Manda 31 applied to both leaf and soil resulted in the highest yield, which indicated that Manda 31 is absorbed by plants through leaves and roots. It was assumed that Manda 31 involved in decomposition activities of soil organic matters and compost fertilizers. Manda 31 enhanced root growth of turmeric. This result suggested that manda 31 can be applied to both leaf and soil in turmeric field for better yield. However, we need further study on Manda 31 regarding decomposition activities on organic matters and compost fertilizers.

Source of Materials

Manda 31, a fermented natural plant concentrate was provided by Manda Hakko Kabusiki Kaisha, Innoshima, Hiroshima 722-2192, Japan.

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ウコン（*Curcuma* spp.）栽培における万田31号（自然発酵植物凝縮物）の施用法に関する研究

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キーワード：施用間隔、自然発酵植物凝縮物（万田31号）、
ウコン（*Curcuma* spp.）、収量

植物生長調節剤の活性は、処理時期、処理部位、処理回数、および処理間隔などで、植物体の生長を大きく左右する。万田31号は天然発酵植物凝縮物で，ウコン（*Curcuma* spp.）の収量を増加させることを既に報告した。

そこで、今回は1999年から翌年の2年間に亘り、琉球大学農学部附属農場のガラス室と圃場において、万田31号の最適な処理間隔の把握（試験１）と処理部位（茎葉処理、土壌処理および茎葉兼土壌処理の３条件）別のウコンの生長と収量に及ぼす影響（試験２）について検討した。

まず試験１の結果より、万田31号の効果は７日～30日の処理間隔に左右されず、ウコン茎葉部の生長促進と収量増をもたらすことが判明し（Table 1.）、経済的な観点から30日間隔での処理が有効であることが示された。

次に試験２の結果より、ウコン茎葉部の生長促進と収量増には茎葉兼土壌処理が最も有効で（Table 2.）、万田31号の植物に対する吸収部位は茎葉および根であることが判明した。

以上の結果より、万田31号の最適な処理間隔と処理方法が明らかとなり、今後継続して詳細な試験を行う予定である。

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