施肥レベルと万田31号の併用がウコン (Curcuma spp.) の生育,収量に及ぼす影響

Efficacy of Manda 31 with fertilizer rates on growth and yield of Turmeric (*Curcuma* spp.)

Ichiro NAKAMURA*, Singoro MATSUURA**, Md. Amzad HOSSAIN*, Mitsuhiro DOI** and Yukio ISHIMINE*

Key Words : Chemical fertilizer (N:P:K=9:9:18) rates, Manda 31 (fermented natural plant concentrate), rhizome, turmeric (*Curcuma* spp.), yield.

Summary

Manda 31 (fermented natural plant concentrate) derived from 50 plant materials is used for improving yield and quality of crops, vegetables and fruits. The experiment was conducted at the Agricultural Experiment Farm, Faculty of Agriculture, University of the Ryukyus, Japan in 2000-2001 to evaluate efficacy of Manda 31 with different rates of fertilizer (N:P:K = 9:9:18) on growth and yield of turmeric. The treatments of the experiment were (1) F-1-W: water treated control plot with fertilizer at 133 kg/ha, (2) F-1-M: Manda 31 treated plot with fertilizer at 133 kg/ha, (3) F-2-W: water treated control plot with fertilizer at 200 kg/ha, (4) F-2-M: Manda 31 treated plot with fertilizer at 200 kg/ha, (5) F-3-W: water treated control plot with fertilizer at 266 kg/ha and (6) F-3-M: Manda 31 treated plot with fertilizer at 266 kg/ha. The fertilizer at the recommended rates was applied three times to soil at 60 day intervals starting 60-75 day after planting (DAP) and Manda 31 (0.01 ppm) or water was applied five times to leaves at 30 day intervals starting 60-75 DAP. In both the glasshouse and field experiments, shoot and yield of turmeric were significantly increased by the application of Manda 31 as compared to control plant with the same fertilizer rate. In glasshouse experiment, Manda 31 treated plot with fertilizer at 133 kg/ha obtained higher shoot and yield than control plot with the fertilizer at 200 kg/ha. Shoot and yield in the Manda 31 treated plot with fertilizer at 133 or 200 kg/ha were similar to that in the control plot with the fertilizer at 266 kg/ha. In field experiment, significantly increased shoot and yield were obtained by the application of Manda 31 in the plot with fertilizer at 133 or 200 kg/ha as compared to that in the control plot with fertilizer at 200 or 266 kg/ha, respectively. Similar shoot biomass and yield were recorded in the Manda 31 treated plots with fertilizer at 200 and 266 kg/ha. Field experiment indicated that Manda 31 was more effective with the fertilizer at 200 kg/ha in increasing turmeric yield. Manda 31 may enhanced the plant to use fertilizer properly for higher yield. Over all results of this study indicated that Manda 31 may reduce the amount of chemical fertilizer application in agriculture.

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* Faculty of Agriculture, University of the Ryukyus, Okinawa 901-0213, Japan
** Manda Hakko Kabusiki Kaisha, Hiroshima 722-2192, Japan
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Introduction

Nations, both advanced and developing, have enacted very important policies to regulate human activities so as to save our environment. The need and effort to address environmental problems at national and international levels by developed and developing nations have been discussed in different papers (Erisman et al. 2001; Neera et al. 1999; Sharifuddin and Zaharah 1991). Human existence depends on safety food and healthy environment. Population is increasing with time. Various chemicals have been using in agriculture to meet up additional food for the increasing population. As a result, synthetic chemicals cause 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). Therefore, it is a great concern to reduce or cancel chemical application in agriculture (Erisman et al. 2001). On the other hand, it was encouraged to use natural resources in agriculture for more yield with better quality. Manda 31(fermented natural plant concentrate) derived from natural resources 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 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 desired 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 (K2). Glycine, alanine, serine, proline, valine, threonine, isoleucine, lysine, leucine, glutamine, methionine, histidine, phenylalanine, arginine, tryptophane, asparagine, cystine and tyrosine are the amino acids present in Manda 31 promote growth and quality of plants.

Turmeric (*Curcuma* spp.) is used for imparting color and flavor to food. In old Hindu texts it is ascribed for its aromatic, stimulant and carminative properties (Hermann and Martin 1991). Currently traditional Indian medicine claims the use of turmeric against biliary disorders, coryza, caugh, diabetic, wounds, hepatic disorders, rheumatism and sinusitis. Volatile oil of turmeric inhibits trypsin and hyaluronidase. Curcumin and volatile oil appear to be responsible for the well-documented anti-inflammatory action in the acute and subchronic models. Curcumin inhibits intestinal gas formation, lipid peroxide formation in liver and tumor formation. It also reduce cholesterol levels. Turmeric prevents cancer diseases and the production of tissue-damaging free radicals (Majeed et al. 1995). Scientists are expecting AIDS preventive properties in turmeric. It is now widely used as spices, cosmetic and medicine in the world. As a medicinal plant, turmeric requires to cultivate with reduced chemical fertilizer.

Mazid (1993) reported that efficacy of nitrogen (N) fertilizer on dry matter accumulation of plant was changed with the rates of sulfur fertilizer. Huang et al. (1981) reported that inorganic N fertilizer promoted mineralization of organic N from green manure and the amount of immobilized N was considerably increased by the existence of organic N. As a result, the availability of organic N was increased, more of the inorganic N applied was immobilized and kept in soil used by the crop. Therefore, it was thinking that efficacy of Manda 31 may be influenced by fertilizer rates. Previous study reported that Manda 31 applied to leaf, soil or both leaf and soil increased 15-19% of turmeric yield. Manda 31 applied to leaf may enhanced photosynthetic activities, and applied to soil may influenced on soil microbial activities that supported plant to grow well for higher yield with better quality (Esau et al. 1998; Hossain et al. 2000; Ishimine et al. 1999). Present study was conducted to evaluate efficacy of Manda 31 with fertilizer (N:P:K = 9:9:18) rates on growth and yield of turmeric.

Materials and Methods

Glasshouse experiment:

Glasshouse experiment was conducted from April 1, 2000 to February 20, 2001 at the Agricultural Experiment Farm, Faculty of Agriculture, University of the Ryukyus, Okinawa, Japan. Soil type was dark red (Shimajiri Maji) with pH range of 5.8 to 6.4. Chemical fertilizer (N: P: K = 9:9:18) and Manda 31 (0.01 ppm) were used in this experiment.

The treatments of the experiment were (1) F-1-W: water treated control plot with fertilizer at 133 kg/ha, (2) F-1-M: Manda 31 treated plot with fertilizer at 133 kg/ha, (3) F-2-W: water treated control plot with fertilizer at 200 kg/ha, (4) F-2-M: Manda 31 treated plot with fertilizer at 200 kg/ha, (5) F-3-W: water treated control plot with fertilizer at 266 kg/ha, (6) F-3-M: Manda 31 treated plot with fertilizer at 266 kg/ha. Each treatment consisted of 6 replications. Each wagner pot (size 0.05 m^2, 30 cm depth) contained 12.5 kg soil and 0.5 kg cow-manure. Before planting of turmeric, soil and cow-manure were mixed properly. One turmeric rhizome (cv. *C. longa*, Aki Ukon, 25 g) was planted to 5 cm depth in each pot. Manda 31 solution (0.01 ppm) or water was applied to plants until the solution or water begins to drip 75, 105, 135, 165 and 195 days after planting (DAP). The above fertilizer at the recommended rates was applied 75, 135 and 195 DAP. Water (irrigation) was applied once a day to maintain adequate soil moisture. Average air temperature in the glasshouse ranged from 20 to 31 C.

Field experiment:

Field experiment was conducted from May 4, 2000 to February 23, 2001 at the Agricultural Experiment Farm of the University of the Ryukyus. The soil type, planting material of turmeric rhizome, chemical fertilizer and Manda 31 used in this experiment were similar to that used in glasshouse experiment.

The experiment was laid out in randomized complete block design with three replications. The treatments conducted in this experiment were similar to that in glasshouse experiment. The field was plowed properly for turmeric cultivation and ridges were prepared mechanically maintaining 150 cm apart. Each ridge was 4 m long. Turmeric rhizome (25-30 g) was planted to 8 cm depth in two rows in each ridge maintaining 30 cm distance. Overhead irrigation was done immediately after plantation. The above fertilizer at the recommended rates was applied 60, 120 and 180 DAP. Overhead irrigation was done immediately after fertilizer application. Manda 31 solution (0.01 ppm) or water was applied to plants until the solution or water begins to drip 61, 91, 121, 151 and 181 DAP. Hand hoeing was operated four times for weed management.

Procedures of data collection and analysis:

Plant length, and number of tillers and leaves were recorded at 214 DAP in glasshouse study. In field study, 4 plants were harvested from each replication at 130 DAP. Data on plant length, number of tillers and leaves, shoot biomass (shoot dry weight) and yield (rhizome dry weight) were recorded. Shoot biomass and yield were recorded at harvest time for the glasshouse experiment.

The field experiment was damaged by typhoon occurred in September. Therefore, data was not recorded at harvest time in field experiment. Plant samples were dried at 85 C for 48 hours using an electric oven. Data on all parameters of turmeric m^{-2} were calculated for the field experiment. Data were subjected to analysis of variance (ANOVA) and means were separated using Fisher's Protected LSD test at the 5% level of significance.

Results and Discussion

Glasshouse experiment:

Manda 31 treated plot with the fertilizer (N:P:K =9:9:18) at 133, 200 or 266 kg/ha obtained slightly higher number of shoots and leaves, and shoot length of turmeric than control plot with the same fertilizer rate (data not presented). Significantly increased shoot biomass was recorded at harvest time by the application of Manda 31 as compared to control plant with the respective fertilizer ráte (Fig. 1). Manda 31 treated plot with fertilizer at 133 kg/ha obtained significantly higher shoot biomass than control plot with the fertilizer at 200 kg/ha. Shoot biomass in the Manda 31 treated plot with fertilizer at 133 or 200 kg/ha was similar to that in the control plot with the fertilizer at 266 kg/ha. These data indicated that Manda 31 may promoted the plant to use fertilizer properly in photosynthesis activities, which resulted higher shoot biomass of turmeric. Proline presents in Manda 31 that may enhanced photosynthesis activities (Esau et al. 1998). Yield of turmeric may be increased with the increased shoot biomass influenced by Manda 31 (Hossain 1999; Ishimine et al. 1999; Uddin 1996).

Yield was significantly higher in the Manda 31 treated plot than in the control plot for each fertilizer rate (Fig. 2). Significantly higher yield was obtained from the Manda 31 treated plot with fertilizer at 133 kg/ha than that from the control plot with the fertilizer at 200 kg/ha. Yield was not different between the Manda 31 treated plot with fertilizer at 133 or 200 kg/ha and the control plot with the

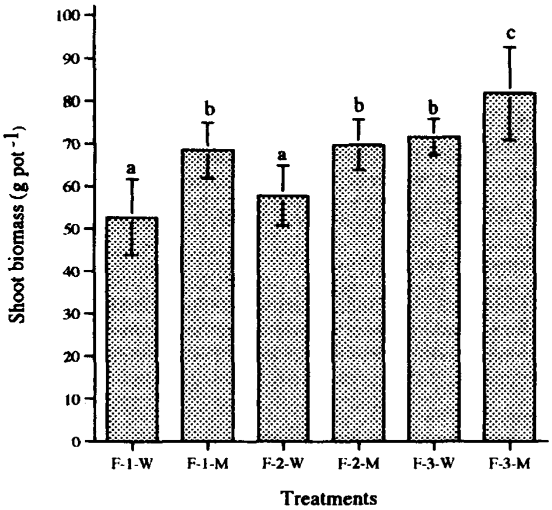

Fig. 1. Efficacy of Manda 31 with fertilizer (N:P:K=9:9:18) rates on turmeric shoot biomass in glasshouse experiment. F-1-W, F-2-W and F-3-W indicate water treated control plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. F-1-M, F-2-M and F-3-M indicate Manda 31 treated plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. Fertilizer was applied to soil 75, 135 and 195 DAP. Manda 31 (0.01 ppm) or water was applied to leaves 75, 105, 135, 165 and 195 DAP. Data are means of 6 replicates ± SD. Bars with the same letter are not different at 5% level of significance, as determined by LSD test.

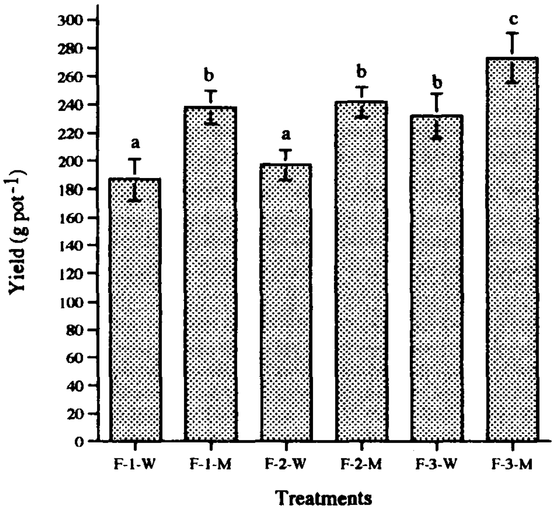

Fig. 2. Efficacy of Manda 31 with fertilizer (N:P:K=9:9:18) rates on turmeric yield in glasshouse experiment. F-1-W, F-2-W and F-3-W indicate water treated control plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. F-1-M, F-2-M and F-3-M indicate Manda 31 treated plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. Fertilizer was applied to soil 75, 135 and 195 DAP. Manda 31 (0.01 ppm) or water was applied to leaves 75, 105, 135, 165 and 195 DAP. Data are means of 6 replicates ± SD. Bars with the same letter are not different at 5% level of significance, as determined by LSD test.

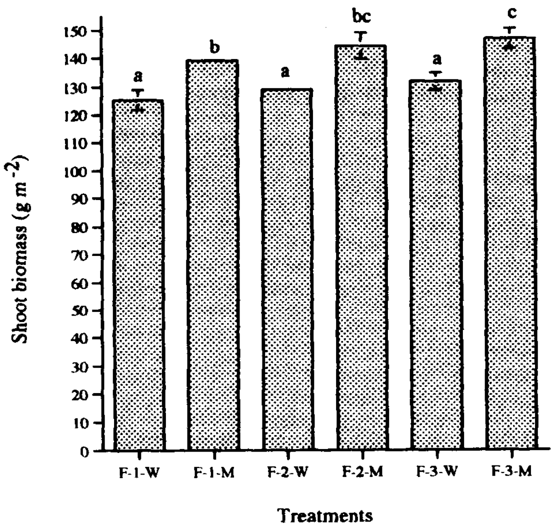

Fig. 3. Efficacy of Manda 31 with fertilizer (N:P:K=9:9:18) rates on turmeric shoot biomass in field experiment. F-1-W, F-2-W and F-3-W indicate water treated control plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. F-1-M, F-2-M and F-3-M indicate Manda 31 treated plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. Fertilizer was applied to soil 60, 120 and 180 DAP. Manda 31 (0.01 ppm) or water was applied to leaves 61, 91, 121, 151 and 181 DAP. Data are means of 3 replicates ± SD. Bars with the same letter are not different at 5% level of significance, as determined by LSD test.

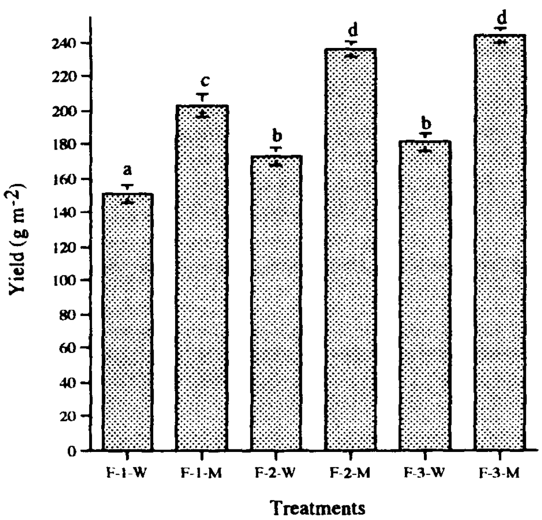

Fig. 4. Efficacy of Manda 31 with fertilizer (N:P:K=9:9:18) rates on turmeric yield in field experiment. F-1-W, F-2-W and F-3-W indicate water treated control plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. F-1-M, F-2-M and F-3-M indicate Manda 31 treated plots with the fertilizer rates of 133, 200 and 266 kg/ha, respectively. Fertilizer was applied to soil 60, 120 and 180 DAP. Manda 31 (0.01 ppm) or water was applied to leaves 61, 91, 121, 151 and 181 DAP. Data are means of 3 replicates ± SD. Bars with the same letter are not different at 5% level of significance, as determined by LSD test.

fertilizer at 266 kg/ha. These results indicated that Manda 31 could increase turmeric yield with even the lower rate of fertilizer (133 kg/ha). Probably, Manda 31 enhanced turmeric in dry matter accumulation.

Field experiment:

Number of shoots and leaves, and shoot length of turmeric were slightly higher in the Manda 31 treated plot than in the control plot with the same fertilizer rate (data not shown). Shoot biomass was significantly increased by the application of Manda 31 as compared to control plant with the respective fertilizer rate (Fig. 3). Manda 31 treated plot with fertilizer at 133 or 200 kg/ha obtained significantly higher shoot biomass than control plot with the fertilizer at 266 kg/ha. Significantly higher yield was recorded by the application of Manda 31 as compared to control plant with the respective fertilizer rate (Fig. 4). Significantly higher yield was obtained from the Manda 31 treated plot with fertilizer at 200 kg/ha than from the control plot with the fertilizer at 266 kg/ha. Similar shoot biomass and yield were recorded in the plots with fertilizer at 200 and 266 kg/ha treated by Manda 31. This result suggested that Manda 31 might effectively increase turmeric yield with the fertilizer at 200 kg/ha.

Previous study reported that Manda 31 increased 24-34% of shoot dry weight and 15-19% of yield of turmeric (Hossain et al. 2000). Another study reported that Manda 31 applied to leaf may enhanced photosynthetic activities, and applied to soil may influenced on soil microbial activities, which resulted increased yield (Esau et al. 1998; Ishimine et al. 1999).

Results of the glasshouse experiment indicated that Manda 31 treated plot with fertilizer at 133 kg/ha achieved higher shoot and yield than control plot with the fertilizer at 200 kg/ha. Shoot and yield in the Manda 31 treated plot with fertilizer at 133 or 200 kg/ha were similar to that in the control plot with the fertilizer at 266 kg/ha. In field experiment, shoot and yield were significantly increased by the application of Manda 31 as compared to control plant with the respective fertilizer rate. Shoot and yield were significantly higher with the supply of Manda 31 in the plot with fertilizer at 133 or 200 kg/ha than in the control plot with the fertilizer at 200 or 266 kg/ha, respectively. Shoot biomass and yield were similar in the plots with fertilizer at 200 and 266 kg/ha treated by Manda 31. Field experiment indicated that Manda 31 with fertilizer (N:P:K = 9:9:18) at 200 kg/ha might effectively increase turmeric yield. Manda 31 may enhanced the plant to use fertilizer properly for higher yield. Over all results of this study indicated that Manda 31 may reduce the amount of chemical fertilizer application in agriculture.

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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施肥レベルと万田31号の併用がウコン（*Curcuma* spp.）の生育、収量に及ぼす影響

仲村一郎*、松浦新吾郎**、Md. アムザド ホサイン*、土井光弘**、石嶺行男*

キーワード：化成肥料（N：P：K＝9：9：18）、万田31号（万田発酵自然植物凝縮物）、根茎、ウコン（*Curcuma* spp.）、収量

万田31号は、50種類の植物素材を組み合わせ発酵させて作られたもので、作物、野菜、果物の収量と品質を高めることがすでに報告されている。

ここでは、施肥量の違いによる万田31号の使用がウコン（*Curcuma* spp.）の生育、収量に及ぼす効果を知るために2000年4月から2001年2月にかけて、琉球大学農学部附属農場において実験を行った。

処理区は(1) 1 ha当り施肥量(化成肥料 N:P:K=9:9:18)133kgに水を散布した対照区（F-1-W）、(2)施肥量133kgに万田31号を散布した処理区（F-1-M）、(3) 1 ha当り施肥量200kgに水を散布した対照区（F-2-W）、(4)施肥量200kgに万田31号を散布した処理区（F-2-M）、(5) 1 ha当り施肥量266kgに水を散布した対照区（F-3-W）、(6)施肥量266kgに万田31号を散布した処理区（F-3-M）、を設け葉面散布を行った。

肥料は、ウコンの植付け後60～75日目から60日間隔で3回施肥し、万田31号（0.01ppm）は植付後60～75日目から30日間隔で5回施用した。

ガラス室での実験では、それぞれの施肥レベルで対照区に比較して万田31号の施用により、ウコンの地上部乾物重と収量は増加した（図1、2）。F-1-M区は、F-2-W区に比べ地上部乾物重と収量が増加した（図1、2）。また、F-1-M区とF-2-M区の地上部乾物重と収量は、F-3-W区と同程度だった（図1、2）。

圃場実験では、各々の対照区より万田31号を施用した区で有意に地上部乾物重が増加した（図3、4）。また、F-1-M区とF-2-W区およびF-2-M区とF-3-W区を比較すると、F-1-M区、F-2-M区で各々地上部乾物重及び収量が増加し、有意差が認められた。また、F-2-M区とF-3-M区を比較すると地上部乾物重および収量に差が認められなかった。このことから圃場実験では、肥料を200kg/haと万田31号（F-2-M区）の組合せがウコンの生育および収量の増加に大きな効果を示した。

以上の実験結果から、万田31号の施用は肥料の利用効率を高めたことが考えられ、万田31号を施用することにより、化成肥料の施肥量を軽減し、環境調和型農業に寄与し得ると考えられる。

* 琉球大学農学部
** 万田酵素株式会社