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Research Article

Evaluation of Animal Dungs and Organomineral Fertilizer for the Control of *Meloidogyne incognita* on Sweet Potato

Oluremi Solomon Osunlola[1] and Bamidele Fawole[2]

[1]*Department of Crop Production, Kwara State University, Malete, PMB 1530, Ilorin, Nigeria*
[2]*Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria*

Correspondence should be addressed to Oluremi Solomon Osunlola; remiosunlola@gmail.com

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Root-knot nematode, *Meloidogyne incognita*, is an important animate pathogen causing major damage and severe reductions in the growth, yield, and quality of sweet potato. Nematicides are expensive and their application also causes environmental pollution. A field experiment was therefore conducted to evaluate the effectiveness of poultry dung (10 or 20 t/ha), cow dung (10 or 20 t/ha), horse dung (10 or 20 t/ha), goat dung (10 or 20 t/ha), organomineral fertilizer (2 or 4 t/ha), and carbofuran (3 kg a.i/ha) in the management of *M. incognita* on sweet potato using a randomized complete block design. The unamended plots served as control. Data were analysed using ANOVA ($p \leq 0.05$). All organic materials and carbofuran significantly ($p \leq 0.05$) reduced nematode reproduction and root damage compared with control. Poultry dung (10 and 20 t/ha) and carbofuran were, however, more efficient in nematode control than other organic materials. Sweet potato plants that were grown on soil treated with organomineral fertilizer had the highest mean number of vines and fresh shoot weight, while poultry dung improved sweet potato quality and yield. It is therefore recommended that the use of poultry dung be employed in combination with other nematode control strategies to achieve sustainable, economic, and environment-friendly nematode management.

1. Introduction

Sweet potato (*Ipomoea batatas* L. Lam) is a dicotyledonous crop that belongs to the family Convolvulaceae. It is the world's second most important root and tuber crop after potato [1]. Sweet potato is normally cultivated for its large, starchy, sweet-tasting tuber which is primarily used as food stuff and is often boiled, fried, roasted, baked, canned, or fermented for human consumption [2, 3]. It is also used to produce flour for bread and pastry making [4]. Different kinds of products such as edible and fermentable syrups, industrial alcohol, dye, acetone, lactic acid, vinegar, yeast, pie fillings, purees, candied pieces, soufflés, and baby foods are made from sweet potato [5]. Sweet potato has also been used as a laxative and antidiabetic and in the treatment of low fever and skin diseases [5]. Root-knot disease caused by root-knot nematodes, *Meloidogyne* spp., is a well known disease of many tropical and subtropical crops. *Meloidogyne incognita* is the most important nematode pest of sweet potato which occurs in most sweet potato growing regions where it causes severe damage [6, 7]. Symptoms of *M. incognita* infection include patchiness in field, stunting, wilting, chlorosis, and galling of the root system. Galls are, however, not usually well-developed on tubers, but the obvious symptoms on tubers are longitudinal cracks and blister-like bumps [8]. *M. incognita* has been implicated in yield reduction of sweet potato by earlier workers. Losses between 20 and 83.2% have been reported by earlier workers [9–12]. Although the use of nematicides has been found to be effective for nematode control, due to high toxic residual effect of chemicals on environment, particularly on nontarget organisms [13], there is a need to develop alternative nematode control measures. Earlier workers have reported the effectiveness of different materials like plant manures, plant extracts, and animal manures in nematode management and consequent improved crop growth and yield [14–16].

The objective of this study was to evaluate poultry, cow, goat, and horse dungs and organomineral fertilizer in the management of *M. incognita* and assess their effects on the growth, yield, and quality of sweet potato in the field.

2. Materials and Methods

The experiment was carried out in 2009 and 2010 cropping seasons on a piece of land that was naturally infested by *Meloidogyne incognita* in the Crop Garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan. Three months before the commencement of the experiment, the nematode was multiplied under *Celosia argentea* to augment the field population. The piece of land was divided into seven equal blocks and each block was further divided into twelve equal plots measuring 2.5 × 2.5 m each. There was a spacing of 1 m between the blocks and 0.5 m between plots. Soil samples were collected in a zigzag manner from each plot four days before planting. Nematodes were extracted from the soil samples using the method of Whitehead and Hemming [17]. The root-knot nematode juveniles (J_2) extracted were counted under a stereoscope after 48 hours in a counting dish. The animal dungs used in the study were collected from the Teaching and Research Farm of the University and were air dried for three weeks before use. Organomineral fertilizer was obtained from the Department of Agronomy, University of Ibadan, while carbofuran was purchased from an agrochemical shop in Ibadan. The plots were thereafter treated with air-dried poultry manure, goat manure, cow manure, and horse manure each at two rates: 10 t/ha and 20 t/ha; organomineral fertilizer at two rates: 2 t and 4 t/ha; carbofuran at 3 kg a.i/ha, and untreated plots served as control. Three weeks after the application of the organic materials and chemical, vine cuttings of *M. incognita* susceptible sweet potato cultivar (CV TIS 4400-2) [18] were planted to each plot. The experiment was laid out in a randomized complete block design with twelve treatments in seven replicates.

The plants were rain fed as the experiment was carried out during the raining seasons. The experimental plot was kept weed-free by regular hoeing. The plants were harvested five months after planting and the root systems were rated for root damage (gall index) on a scale of 0–5 where 0 equals no gall; 1 equals 1–20% of the root system galled; 2 equals 21–40% of the root system galled; 3 equals 41–60% of the root system galled; 4 equals 61–80% of the root system galled; and 5 equals 81–100% of the root system galled [19]. Similarly, data were taken on number of vines per plant, fresh shoot weights (g), fresh root weights (g), number of tubers, and tuber weight (g). The dry shoot and root weights (g) were also taken and this was accomplished by transferring them in well labeled envelopes into the oven that was set at 80°C for three days. Swollen root quality which was rated on a scale of 0–5 where 0 equals completely smooth tubers/no cracks; 1 equals 1–20% of the tubers skin rough/cracked; 2 equals 21–40% of the tubers skin rough/cracked; 3 equals 41–60% of the tuber skin rough/cracked; 4 equals 61–80% of the tuber skin rough/cracked; and 5 equals 81–100% of the tuber skin rough/cracked was also taken. The root and soil nematode populations were also determined with the methods of Hussey and Barker [20] and Whitehead and Hemming [17], respectively. All data were processed with Analysis of Variance (ANOVA) using Statistics Analysis Software (SAS) [21] and the means were separated using Duncan's Multiple Range Test at a probability level of 5%. The second trial was carried out in the adjacent piece of land in the crop garden during the 2010 cropping season as described for the first trial above.

3. Result

The least mean gall index (root damage) came from the carbofuran-treated soil and was followed by the values from poultry manure (20 and 10 t/ha) amended soil in both trials (Table 1). The highest significant mean gall index was obtained from the plants grown on unamended soil (Table 1). Carbofuran-treated soil had the least significant mean soil nematode population (J_2) which was not significantly lower than the values obtained from plants treated with poultry manure (10 and 20 t/ha) (Table 1). The highest significant mean number of second stage (J_2) number was obtained from unamended soil. The least mean nematode egg population was recorded from plants raised in carbofuran-treated soil and this did not differ significantly from the values obtained from the plants treated with both levels of poultry manure (Table 1). The plants from unamended soil produced the highest significant mean nematode egg population (Table 1).

The plants grown on organomineral fertilizer (4 t/ha) produced the highest mean number of vines which did not differ significantly from the values obtained from other organic materials. The least significant value came from the unamended soil (Table 2). The highest mean fresh and dry shoot weights were recorded from the plants grown on organomineral fertilizer (4 t/ha) treated soil. They were, however, not significantly higher than the values obtained from other treatments except those from amended soil which produced the lowest values (Table 2). The highest mean fresh and dry root weights came from sweet potato plants grown on poultry manure (20 t/ha) treated soil followed by values from those plants grown on organomineral fertilizer (4 t/ha). The unamended soil produced the plants with the least mean fresh and dry root weights (Table 2). The highest mean number of swollen roots and swollen root weight were produced by the plants from poultry dung (20 t/ha) amended soil. It was not significantly higher than the values from poultry dung treated plants (10 t/ha) and other treatments except the unamended plots which had the least value (Table 3). The lowest mean swollen root damage index came from carbofuran-treated soil which was not significantly lower than the value obtained from poultry manure (10 and 20 t/ha) amended soil (Table 3). The highest significant mean value was recorded from plants grown on unamended soil (Table 3).

4. Discussion

Results from this experiment showed that various animal dungs, organic fertilizer, and carbofuran effectively reduced sweet potato root damage (galls) and nematode reproduction compared with control (unamended soil). Carbofuran and poultry dung were however superior to other treatments. This is consistent with the findings of Babatola, Oduor-Owino, Orisajo et al., Daramola et al., and Shiferaw et al. [14, 15, 22–24] who reported the effectiveness of poultry manure and

Table 1: Comparative effects of different organic materials and carbofuran on the means of gall index and *Meloidogyne incognita* reproduction on sweet potato.

Treatments	*Gall index		J_2 population in 200 mL soil (×500)		Root egg population/100 g root (×1000)	
	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial
Poultry manure 10 t/ha	1.6e**	1.6de	1.9bcd	2.0bc	39.9cde	41.9def
Poultry manure 20 t/ha	1.0f	1.1de	1.6cd	1.7cd	30.9de	30.7ef
Goat manure 10 t/ha	1.9cde	1.9bcd	2.6bc	3.0b	51.7bcd	53.1cd
Goat manure 20 t/ha	1.7de	1.8cd	2.3bcd	2.4bc	41.6cde	49.6de
Cow manure 10 t/ha	2.3bc	2.6bc	3.3b	3.3b	58.0bc	57.3bc
Cow manure 20 t/ha	1.7de	1.7de	3.0bc	3.1b	44.3cd	51.9cd
Horse manure 10 t/ha	2.7b	2.9b	3.4b	3.6b	68.3b	68.9b
Horse manure 20 t/ha	2.0cde	2.1bcd	3.1bc	3.4b	57.1bc	55.4bc
Organomineral fertilizer 2 t/ha	2.3bc	2.5bc	3.4b	3.4b	68.6b	70.0b
Organomineral fertilizer 4 t/ha	2.1cd	2.1bcd	3.0bc	3.1b	57.3bc	56.7bc
Carbofuran 3 kgai/ha	0.4f	0.5e	0.7d	0.8d	20.1e	16.3f
Unamended soil	4.0a	4.0a	13.0a	13.4a	199.9a	207.3a

*0 equals no gall; 1 equals 1–20% of the root system galled; 2 equals 21–40% of the root system galled; 3 equals 41–60% of the root system galled; 4 equals 61–80% of the root system galled; and 5 equals 81–100% of the root system galled. **Means followed by the same letter in the same column are not significantly different according to Duncan's Multiple Range Test ($P < 0.05$). Each value is a mean of seven replicates.

Table 2: Effect of various organic materials and carbofuran on the growth of sweet potato.

Treatments	Number of vines		Fresh shoot weight (g)		Dry shoot weight (g)		Fresh root weight (g)		Dry root weight (g)	
	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial
Poultry manure 10 t/ha	28.4a*	29.0ab	412.2a	413.4abc	115.3ab	117.3abc	110.2ab	104.6abc	11.9bc	13.3c
Poultry manure 20 t/ha	30.1a	30.9ab	439.4a	415.3ab	122.9a	126.0ab	119.8a	111.7a	14.7a	15.1ab
Goat manure 10 t/ha	28.0a	28.4ab	411.6a	398.0bc	113.9ab	112.0bcd	103.1cde	101.4cd	13.4ab	13.6abc
Goat manure 20 t /ha	28.6a	30.0ab	410.6a	386.1bc	115.6ab	120.3ab	118.lab	111.1ab	14.3a	14.4abc
Cow manure 10 t /ha	27.0a	28.3ab	372.9a	370.0bcd	110.4ab	109.9cd	98.0def	96.7de	10.9cd	9.8de
Cow manure 20 t/ha	28.3a	28.6ab	409.9a	385.4bc	114.2ab	115.9bcd	108.7abcd	103.3bcd	11.6bcd	11.4d
Horse manure 10 t/ha	25 6a	24.7abc	380.7a	368.6bcd	102.6ab	105.6cde	96.8ef	95.7de	11.4bcd	11.1d
Horse manure 20 t/ha	27.7a	26.6abc	387.9a	376.0bc	112.9ab	111.0bcd	100.4cde	97.4de	11.1cd	10.3d
Organomineral fertilizer 2 t/ha	26.1a	25.7abc	404.9a	383.3bc	115.6ab	120.7ab	108.5bcd	102.3bcd	11.3bcd	10.9d
Organomineral fertilizer 4 t/ha	30.3a	32.7a	469.6a	422.4a	127.5a	128.6a	110.2abc	104.3abc	14.7a	15.3a
Carbofuran 3 kgai/ha	25.7a	27.0abc	372.9a	369.4bcd	105.6ab	109.3cd	106.3cde	101.7cd	11.1cd	10.4d
Unamended soil	23.1a	18.1c	328.2a	312.7d	90.7b	90.7e	87.1ef	86.9ef	9.5d	8.2e

*Means followed by the same letter in the same column are not significantly different according to Duncan's Multiple Range Test ($P < 0.05$). Each value is a mean of seven replicates.

carbofuran and rapeseed cake in curtailing the menace of plant-parasitic nematodes on tomato, cacao seedlings, and pineapple. Poultry dung extract was found to cause 100% mortality of *Rotylenchulus reniformis* on cowpea compared with other dungs in a laboratory trial [25]. Reduction in root damage and nematode reproduction could be due to a number of factors. For example, poultry manure is reputed to have high nitrogen content [25] and the ammonification of nitrogen compound was reported to be nematicidal [26]. The suppression of nematode population has been attributed to the low C : N ratio of the poultry litter used in their study [14]. It has also been reported that soil amendment with a low C : N ratio (less than 20 : 1) substrate gave rise to abundance of enrichment-opportunistic antagonistic microbes and rapid mineralization of N and absorption by plant roots [27–29]. Three nematophagous fungi species were isolated from poultry, horse, pig, and carabao dungs [25]. Poultry manure treated soil had been earlier reported to contain the highest percentage of nematophagous fungi compared with cow and horse manures [30]. The suppression of nematode population could also be due to changes in soil physical and chemical conditions which may have altered the plant/nematode relationships resulting in the plant being more resistant to the development of nematode within its roots. All organic materials also improved sweet potato growth and yield compared with control. Increase in top weights of sweet potato and cassava grown on nematode-infested soil treated with nematicide and poultry manures was also reported by

Table 3: Effect of various organic materials on tuber yield and quality.

Treatments	Number of swollen roots		Swollen root weight (g)		Swollen root quality**	
	1st trial	2nd trial	1st trial	2nd trial	1st trial	2nd trial
Poultry manure 10 t/ha	3.4ab*	3.7ab	329.5ab	387.7a	1.3cd	1.4de
Poultry manure 20 t/ha	4.0a	4.2a	471.5a	446.1a	0.7de	0.6f
Goat manure 10 t/ha	2.6ab	2.6bc	301.0ab	309.7ab	1.7bc	1.7cde
Goat manure 20 t/ha	3.3ab	3.1ab	439.6a	437.1a	1.3cd	1.4de
Cow manure 10 t/ha	2.7ab	2.9bc	290.8ab	299.9ab	1.9bc	1.9bcd
Cow manure 20 t/ha	2.9ab	2.9bc	328.3ab	371.3a	1.7bc	1.7cde
Horse manure 10 t/ha	2.4ab	2.4bc	260.0ab	289.0ab	2.3ab	2.4b
Horse manure 20 t/ha	2.7ab	2.7bc	312.2ab	339.4ab	2.1ab	2.1bc
Organomineral Fertilizer 2 t/ha	2.5ab	2.4bc	308.0ab	327.0ab	2.1ab	2.1bc
Organomineral fertilizer 4 t/ha	3.4ab	3.4ab	384.1ab	404.9a	2.1ab	2.0bcd
Carbofuran 3 kgai/ha	3.4ab	3.1ab	318.6ab	351.0ab	0.4f	0.4f
Unamended soil	2.0b	1.9c	218.0b	248.7b	3.6a	3.4a

*Means followed by the same letters in the same column are not significantly different according to Duncan's Multiple Range Test ($P < 0.05$). **0 equals completely smooth tubers/no cracks; 1 equlas 1–20% of the tubers skin rough/cracked; 2 equals 21–40% of the tubers skin rough/cracked; 3 equals 41–60% of the tuber skin rough/cracked; 4 equals 61–80% of the tuber skin rough/cracked; and 5 equals 81–100% of the tuber skin rough/cracked. Each value is a mean of seven replicates.

[31]. Poultry manure-treated plants had higher top weight than carbofuran-treated plants. Soil amendment with poultry litter alone or in combination with carbofuran significantly increased the dry shoot weight and stem girth of cacao seedlings compared with control [14]. The improvement in the growth and yield of sweet potato could be due to fertility provided by various organic materials used [14, 22]. Poultry litter has been reported to contain significant quantities of N, P, K, Ca, Mg, and micronutrients and can be used as a substitute for commercial fertilizers [32].

5. Conclusion

The results of this study showed that the application of poultry dung at 10 t/ha compete favourably with carbofuran in terms of nematode population reduction. Aside from this, poultry manure also improved soil fertility, which enhanced the growth and yield of sweet potato better than carbofuran. Furthermore, the use of poultry manure for nematode control will help to a large extent to solve the problem associated with its disposal. Therefore, from economic, health and environmental considerations, the use of poultry dung in the control of root-knot nematode is recommended.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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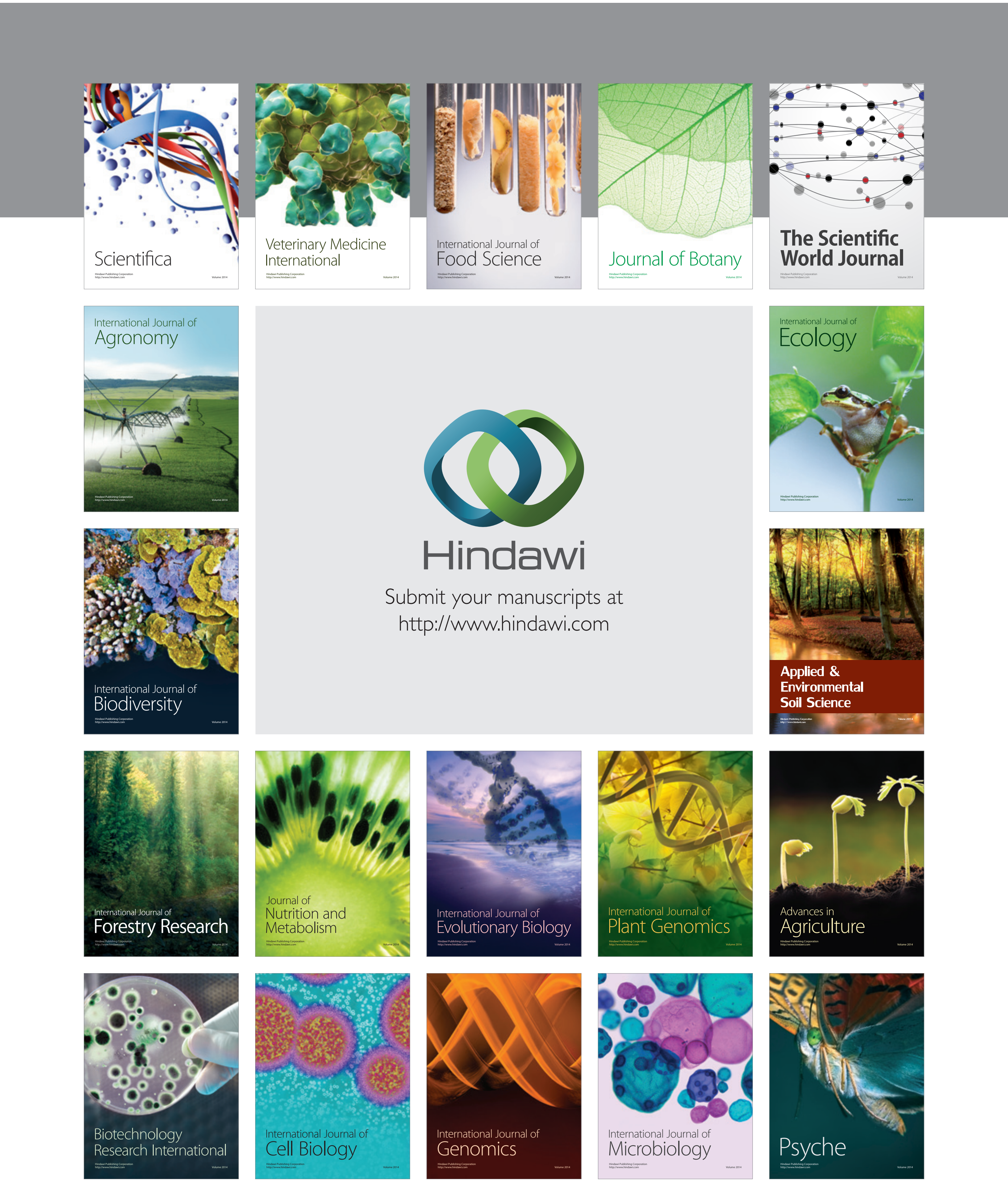
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