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Research Article

Effect of Urea, NPK and Compost on Growth and Yield of Soybean (*Glycine max L.*), in Semi-Arid Region of Sudan

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A field experiment was conducted for two consecutive seasons (2009/2010 and 2010/2011) on the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, to study the effect of some fertilizers on growth and yield of soybean (*Glycine max L. merril*). The experiment was laid out in a randomized complete block design (RCBD) with four replicates. The fertilizers treatments consisted of three types of fertilizers: urea (180 kg/ha), NPK (361 kg/ha), compost (%) and the control. The results showed that fertilizers treatments in first season had significant difference on number of pods/plant, economic yield, harvest index. Mean while, highly significant difference on green, biological and straw yield. In second season fertilizers treatments had significant difference on plant height at 30 days, leaf area at 45 and 60 days, green yield, biological yield and straw yield.

1. Introduction

Soybean (*Glycine max L.*) is a member of Leguminosae family, rich in nutrients, and it is regarded as a nutrient storage. Soybean is not only seen as an oil plant but also used for various purposes [1]. Among grain legumes, soybean is an economically important crop that is grown in diverse environments throughout the world. Its adaptation to tropical and subtropical regions is still involving extensive breeding work [2]. To use land continuously for crop cultivation, incorporating organic and inorganic fertilizers to soil would provide multiple benefits for improving the chemical and physical status of the soil which results in improved crop yield [3]. Organic fertilizers include compost, farm yard manure (FYM), slurry, worm castings, urine, peat, green manure, dried blood, bone meal, fish meal, and feather meal [4]. Inorganic fertilizers include sodium nitrate, rock phosphate, limestone, ammonium nitrate, potassium nitrate, NPK fertilizers, muriate of potash (MOP), and supper phosphates [5]. Both organic and inorganic fertilizers are sources of mineral elements, which plants require for effective growth and development. Essential mineral elements are required in optimum amounts and are classified into micro and macro. Nitrogen, phosphorus, and potassium have great effects in plant growth and development. Their deficiencies or excesses result in marked effects on the growth and yield of crops. Nitrogen is a chlorophyll component, and it promotes vegetative growth and green colouration of foliage [6]. Phosphorus plays a major role in photosynthesis, respiration, energy storage, cell division, and maturation. Potassium is important in plant metabolism, protein synthesis, and chlorophyll development [7]. The most important crop nutrients in agricultural systems are nitrogen (N), phosphorus (P), and potassium (K) [8]. Most compound fertilizers will contain three elements essential for plant growth: NPK which stands for nitrogen (promotes leaf growth), phosphorus (root, flower, and fruit), and potassium (stem and root growth and protein analysis). Soybean nitrogen (N) requirements are met in

Table 1: Full approximate analysis of soil in depth of 30 cm after sowing, season 2010/2011.

Treatments	PH	Ece	Na meq/L	Ca+mg meq/L	K meq/L	CO_2 meq/L	HCO_3 meq/L	Cl meq/L	P ppm	$CaCO_3$	N %	Sand %	Clay %	Silt %
Urea	7.66	2.07	15.50	8.93	0.01	0.30	3.97	15.35	6.00	2.09	0.06	18	60.33	21.67
Compost	7.74	1.94	14.20	8.30	0.03	0.30	4.83	14.23	5.05	2.09	0.07	18	61.50	20.50
NPK	7.79	1.68	11.78	7.98	0.02	0.20	3.98	11.90	5.53	2.32	0.06	17	62.00	21.00
Control	7.74	2.05	14.90	9.10	0.02	0.35	5.35	14.78	4.58	2.31	0.06	17	62.25	20.75
LSD	0.26	0.62	7.38	2.52	0.01	0.28	2.41	6.47	1.94	0.98	0.01	1.92	4.09	2.82
CV%	2.10	19.93	32.74	18.34	42.36	60.98	33.19	28.75	22.89	27.91	14.11	6.87	4.15	8.39
SE±	0.16	0.39	4.61	1.57	0	0.17	1.50	4.04	1.21	0.61	0	1.20	2.55	1.76
Mean before sowing	7.91	1.29	10.88	4.62	0.01	0.02	0.8	10.61	2.4	1.64	0.05	18.3	61.8	19.9

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, and SE± = standard error.

a complex manner, as this crop is capable of utilizing both soil N (mostly in the form of nitrate) and atmospheric N (through symbiotic nitrogen fixation) [9]. The use of fertilizer is considered to be one of the most important factors to increase crop yield. Phosphorous has been shown to be an essential element, and its application has been shown to be important for growth, development, and yield of soybean [10]. Phosphorus deficiency is probably one of the greatest constraints for agriculture. Potassium often limits production and needs to be included in a soil fertility program; potassium should be included as corrective nutrient. Increases in soybean yield were obtained in response to K fertilization. The authors in [11] reported that potassium showed significant effect on yield and yield attributes of soybean in application of 40 kg ha. The increased growth of soybean may be due to optimum nutrient supply and better soil condition for growth of root and shoot of soybean crop [12]. Soybean was tried in several parts of Sudan since 1920s. It could be grown as a summer crop under irrigation in central and northern parts of the country or under rain-fed condition in the southern states [13]. Recently, the interest in soybean has been increased, and research work on soybean has been reactivated, this was due to increasing demand for soybean as an industrial crop in Sudan. The objective of this study was to investigate the effectiveness of urea, NPK, and compost on growth and yield of soybean under a semiarid region of Sudan conditions.

2. Materials and Methods

Afield experiment was conducted for two consecutive seasons (2009/2010 and 2010/2011) in the Demonstrated Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Sudan, latitude 15°40′′N, longitude 32°32′′E, and altitude 386 m above sea level. The soil was montmorillonitic clay soil with a pH in the range of 7.8–8.5 (Table 1) [14].

Climate of the locality has been described by [15] as semidesert and tropical with low relative humidity. The mean annual rainfall is about 160 mm, and the mean maximum temperature is more than 40°C in summer and around 20°C in cool season. Solar radiation is about 400–500 cal cm^{-2} day^{-1}. The land was prepared by disc plough, disc harrowed, and leveled ridging up from north to south, and the spacing between ridges was 70 cm and between holes was 25 cm. The size of the plot was $3 \times 3.5\,m^2$ consisting of four ridges of 2.5 length. Sowing was done manually on the shoulder of the ridges, in the first season on the 16th of July 2009 and in the second season on the 8th of July 2010. Seeds were sown at a rate of 2-3 seeds per hole, and the fertilizers treatments were put immediately after sowing and then immediately irrigated. In both seasons, one genotype (1905 E) of Soybean was used. The treatments consist of three types of fertilizers urea: 46% N (180 kg/ha), NPK 23-23-0 (361 kg/ha), and compost and then control. The treatments were arranged in a randomized complete block design (RCBD) with four replications for two seasons.

Five plants were randomly selected and tagged in each plot and each treatment. Plants samples were taken at 30, 45, 60, and 75 days after sowing. Plant height (cm) was measured from the base of the main stem to the tip of the youngest leaf using measuring tape. The number of leaves/plant was taken by counting all leaves in the tagged plants, and the average number of leaves per plant was determined. Three leaves were randomly selected from tagged plants, and leaf area per plant was counted by using puncher. Days from sowing until first plant in each plot flowered, and days from sowing until 50% and 100% of plants in each plot flowered. The same tagged plants in each plot were harvested separated and immediately weighed, and the average weight of green plant was determined. Pods were separated from the plants, and dried normally by the sun. All pods in the tagged plants were counted and the average number of pods per plant was determined. Plants were dried in oven at 100°C for 24 hours and after that taken and immediately weighed, and the average weight of dry plant was determined. All these pods were threshed, and the seeds were taken and cleaned and then weighed in sensitive balance to determine seed yield per plant. All seeds were counted, and the average number of seeds per plant was determined. The number of seeds per pod was counted by using the following formula: number of seeds/pod = number of seeds/plant ÷ number of pods/plant. 100 seeds, were taken randomly from the tagged plants of

Table 2: Plant height of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

DAP	2009/2010				2010/2011		
treatments	30 days	45 days	60 days	75 days	30 days	45 days	60 days
Urea	17.53	24.20	27.80	32.65	15.35	20.88	26.38
Compost	17.80	23.40	27.40	32.00	18.23	23.85	29.43
NPK	16.25	18.80	29.15	30.40	15.83	23.05	30.20
Control	17.35	22.75	27.90	31.70	16.45	23.85	31.38
LSD	3.33 ns	7.81 ns	3.89 ns	8.42 ns	2.00*	3.53 ns	6.08 ns
CV%	12.07	21.91	8.68	16.60	7.58	9.62	12.94
SE±	2.08	4.88	2.43	5.26	1.25	2.20	3.80

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error, and DAP = days after planting.

Table 3: Number of leaves/plant of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

DAP	2009/2010				2010/2011		
treatments	30 days	45 days	60 days	75 days	30 days	45 days	60 days
Urea	14.10	23.00	38.90	44.45	6.97	21.23	35.43
Compost	13.30	20.90	34.15	52.50	7.62	25.93	44.25
NPK	12.75	18.40	36.45	54.25	7.35	26.05	44.73
Control	12.10	21.90	38.25	54.55	7.30	19.58	31.85
LSD	2.64 ns	7.44 ns	8.20 ns	13.45 ns	0.96 ns	7.23 ns	14.12 ns
CV%	12.64	22.10	13.89	16.35	8.22	19.48	22.59
SE±	1.65	4.65	5.13	8.41	0.60	4.52	8.83

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error, and DAP = days after planting.

each plot then weighed in sensitive balance to determine 100 seeds weight for each treatment. A meter length from the middle ridge of each plot was harvested and immediately weighed to determine green yield and then transferred to kg/ha. The same meter length was dried in oven at 100°C for 24 hours and after that taken and immediately weighed to determine biological yield, then it was transferred to kg/ha. Seeds in the same meter length from each plot were collected and dried naturally by the sun for a week, then cleaned and weighed in sensitive balance to determine seeds yield, and transferred to kg/ha. Straw yield was calculated by the following: straw yield = biological yield − economic yield (kg/ha). Harvest index was calculated by the following: harvest index = biological yield ÷ economic yield ×100. The data of plant parameters were analyzed yearwise on individual basis, and their means were computed. statistical analysis for ANOVA were carried out by using "MSTAT-C," whereas the means were compared through (LSD) tests least significant different [16] at $P = 0.05$ and excel program to illustrate and compare data on figures.

3. Results and Discussion

The effect of fertilizers on plant height of soybean is presented in Table 2. Analysis of variance showed no significant difference between treatments in booth seasons at 30, 45, 60, and 75 days, except in the second season at 30 days. The highest mean plant height in the first season was 32.65 cm given by urea treatment; in the second season was 31.38 cm given by control. A similar result was found by [17, 18]. Meanwhile, [19] indicated that plant height decreased with increased urea. On the other hand, [11] reported that different doses of potassium and sulphur fertilizers had significant effect on the plant height of soybean. Nitrogen fertilization increased the mean plant height [20–23].

The effect of fertilizers on the number of leaves per plant of soybean is presented in Table 3. Analysis of variance showeda no significant difference between treatments in both seasons at 30, 45, 60, and 75 days. Control showed slight increase in the number of leaves in the first season (54.55) and NPK (44.73) in the second season. A similar result was reported by [23, 24]. In on line with [22] that it was showed the difference in nitrogen levels had slight influence on the mean number of leaves per plant.

The effect of fertilizers on leaf area/plant of soybean is presented in Table 4. Analysis of variance showed no significant difference among treatments in first the season at all readings 30, 45, 60, and 75 days and showed significant difference among treatments in the second season at 45 and 60 days. The highest number of leafs per plant was in the first season 85.7 cm^2, in the second season was 135.46 cm^2 which was also given by control. Fertilizers had no effect in leaf area in booth seasons but nitrogen fertilizer increased leaf area in first season at 30 and 45 DAP. The authors in [25] found a different result.

The effect of fertilizers on the number of days to first, 50%, and 100% flowering of soybean is presented in Table 5. Analysis of variance showed no significant difference

Table 4: Leaf area per plant of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

DAP	2009/2010				2010/2011		
treatments	30 days	45 days	60 days	75 days	30 days	45 days	60 days
Urea	40.20	100.30	69.70	82.55	25.43	75.45	125.47
Compost	37.20	93.55	55.00	82.30	28.62	68.47	108.31
NPK	30.80	66.40	52.75	59.05	28.04	64.58	101.12
Control	38.30	112.60	64.80	85.70	30.33	82.89	135.46
LSD	16.22 ns	56.50 ns	16.58 ns	41.68 ns	6.40 ns	11.17*	24.80*
CV%	27.69	37.90	17.12	33.66	14.23	9.59	13.18
SE±	10.14	35.32	10.37	26.06	4.00	6.98	15.50

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error, and DAP = days after planting.

Table 5: Number of days to first, 50%, and 100% flowering of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

Treatments	2010/2011		
	Days to first flowering	Days to 50% flowering	Days to 100% flowering
Urea	48.75	59.00	62.50
Compost	46.75	56.00	62.50
NPK	48.25	56.50	62.75
Control	47.75	57.50	63.00
LSD	2.65 ns	2.59 ns	3.04 ns
CV%	3.46	2.82	3.03
SE±	1.66	1.62	1.62

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error.

Table 6: Number of pods per plant, number of seeds per plant, and number of seeds per pod of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

Treatments	2009/2010			2010/2011		
	No of pods/plant	No of seeds/plant	No of seeds/pod	No of pods/plant	No of seeds/plant	No of seeds/pod
Urea	80.30	139.10	1.71	64.40	114.20	1.75
Compost	95.95	150.75	1.59	75.05	123.70	1.65
NPK	82.55	124.65	1.53	80.20	138.50	1.73
Control	95.55	156.80	1.54	72.15	118.80	1.66
LSD	15.68*	58.36 ns	0.43 ns	21.97 ns	42.24 ns	0.30 ns
CV%	11.07	25.54	16.69	18.83	21.33	11.10
SE±	9.80	36.48	0.27	13.73	26.41	0.19

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error.

between treatments. Days to flowering decreased with the increasing urea fertilization as reported by [21]. In addition, [22] observed that nitrogen fertilization can promote vegetative growth of soybean, and plants can be flowered around 33 days after sowing. Generally, high nitrogen levels of 60 and 120 kg/ha delayed flowering, whereas lower nitrogen levels had no influence on flowering.

The effect of fertilizers on the number of pods per plant, number of seeds per plant, and the number of seeds per pod of soybean is presented in Table 6. Analysis of variance showed no significant difference between treatments in both seasons except in number of pods per plant in the first season. The highest mean number of pods per plant in the first season was 95.95 given by compost treatment, and in the second season was 80.2 given by NPK treatment. The highest mean number of seeds per plant in the first season was 156.8 given by control, and in the second season it was 138.5 given by NPK treatment. Fertilizers increased the number of pods per plant. Similar results were reported by [22, 23, 26, 27]. In contrast, [19, 21] observed that increasing the levels of nitrogen fertilization had no effect on the mean number of pods per plant. The number of seeds per pod was slightly affected by nitrogen fertilization as noticed by [22, 23, 27]. The effect of fertilizers on the weight of seeds per plant and 100 seeds weight of soybean is presented in Table 7. Analysis of variance showed no significant difference among treatments in both seasons. The highest mean weight of seeds per plant in the first season was 12.72 (g) given

Table 7: Weight of seeds per plant and 100 seeds weight (g) of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

Treatments	2009/2010		2010/2011	
	Weight of seeds/plant (g)	100 seeds weight (g)	Weight of seeds/plant (g)	100 seeds weight (g)
Urea	10.81	9.45	6.82	6.04
Compost	11.42	9.78	7.46	5.73
NPK	9.68	9.40	8.34	6.47
Control	12.72	9.83	6.90	6.04
LSD	5.45 ns	0.86 ns	2.94 ns	0.87 ns
CV%	30.52	5.56	24.93	8.97
SE±	3.41	0.54	1.84	0.54

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error.

Table 8: Green yield and biological yield of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

Treatments	2009/2010		2010/2011	
	Green yield	Biological yield	Green yield	Biological yield
Urea	13285.98	7810.87	12928.83	6321.56
Compost	13954.60	8239.45	10714.50	5357.25
NPK	9953.77	6046.55	13964.57	6464.42
Control	15618.17	8953.75	10321.64	5107.25
LSD	2255.89**	1313.84**	3472.11*	1233.10*
CV%	10.68	10.58	18.12	13.26
SE±	1410.29	821.36	2170.63	770.89

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error.

Table 9: Economic yield, straw yield, and harvest index of soybean genotype as affected by urea, NPK, and compost during 2009/10 and 2010/11 seasons.

Treatments	2009/2010			2010/2011		
	Economic yield (g)	Straw yield (g)	Harvest index %	Economic yield (g)	Straw yield (g)	Harvest index %
Urea	1929.33	5881.55	24.77	1193.63	5127.93	18.87
Compost	2118.61	6120.84	25.70	1049.13	4308.12	19.86
NPK	1227.17	4819.38	19.85	1153.74	5310.68	17.57
Control	2150.40	6803.35	23.29	819.80	4287.44	15.49
LSD	563.50*	830.28**	3.66*	418.80 ns	923.21 *	5.30 ns
CV%	18.98	8.79	9.78	24.84	12.13	18.44
SE±	352.28	519.06	2.9	261.82	577.16	3.31

* = significant, ** = highly significant, ns = nonsignificant, LSD = least significant difference, CV% = coefficient of variation, SE± = standard error.

by control, and in the second season it was 8.34 (g) given by NPK, and the highest mean of 100 seeds weight in the first season was 9.83 (g) given by control; in the second season was 6.47 (g) given by NPK treatment. Seeds weight is negatively correlated with the number of seeds per pod in many crops. In soybean, seed weight increased under nitrogen fertilization as indicated by [22, 23].

The effect of fertilizers on mean green and biological yield of soybean is presented in Table 8. Analysis of variance showed highly significant difference among treatments in the first season and significant difference, and in the second season. The highest mean green yield in the first season it was 15618.17 (kg/ha) given by control, and in the second season it was 13964.57 (kg/ha) given by NPK and the highest mean biological yield in first season was 8953.75 (kg/ha) given by control, in second season was 6464.42 (kg/ha) given by NPK treatment. The authors in [28] found similar result.

The effect of fertilizers on mean economic yield, straw yield, and harvest index of soybean is presented in Table 9. In the first season, analysis of variance showed highly significant difference between treatments in straw yield, and significant difference in economic yield and harvest index. The highest mean straw yield was 6803.35 (kg/ha) given by control, economic yield was 2150.40 (kg/ha) given by control, and harvest index was 25.7% given by compost. In the second season, analysis of variance showed significant difference between treatments in straw yield and no significant difference in economic yield and harvest index although they were increased by fertilizers. The highest mean straw yield was 5310.68 (kg/ha) given by NPK, economic yield was

1193.63 (kg/ha) given by nitrogen, and harvest index was 19.86% given by compost treatment. These findings are in accordance with the results obtained by [11, 22, 26, 29–31]. The authors in [30] observed that the soybean grain yield increased with the application of 50 kg K_2O/ha. In contrast, [17, 19] indicated that high levels of nitrogen fertilization had no effect on seed yield of soybean.

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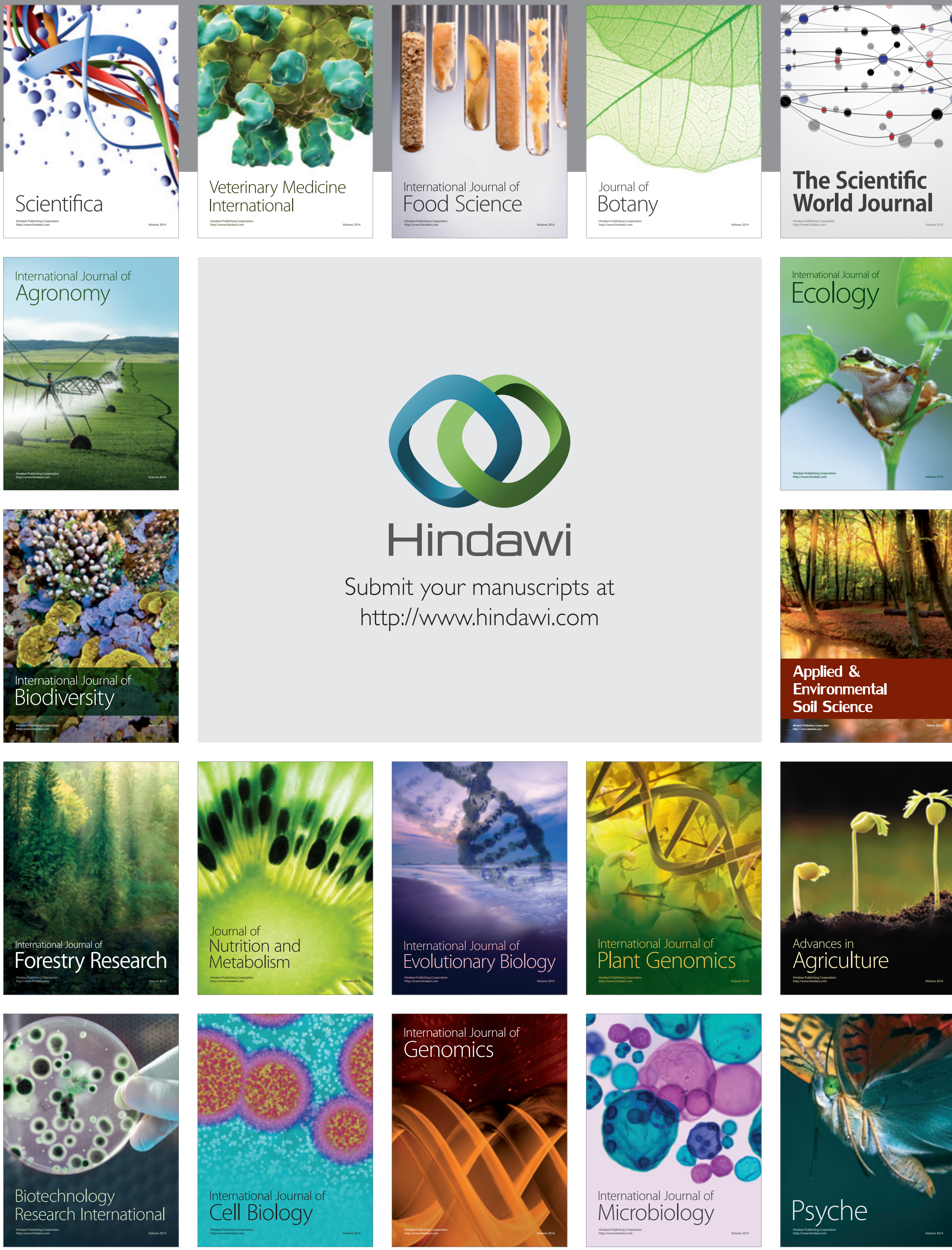

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