Advances in Life Science and Technology
ISSN 2224-7181 (Paper) ISSN 2225-062X (Online)
Vol.33, 2015

Crop Response to Mineral Fertilizer, Vermicompost and Density in Cassava + Groundnut Intercrop

Oroka, Frank Oke
Department of Agronomy, Faculty of Agriculture, Delta State University, Asaba Campus, Nigeria
Email:orkfra@yahoo.com

This research was financed by the International Foundation for Science (IFS), Stockholm, Sweden through a grant to the author

Abstract
In other to observe the effects of *Eichhornia crassipes*/animal manure-based vermicomposts on the growth and yield of groundnut planted sole and intercropped with cassava, a field experiment was conducted in the 2008/2009 cropping seasons in the humid rainforest zone of Southern Nigeria. Treatments consist of four nutrient levels (0 kg; 200 kg NPKMg 12:12:17:2; 40 tons water hyacinth/poultry manure-based vermicompost, VP; 40 tons water hyacinth/ cow dung-based vermicompost, VC), three cropping densities (50,000, 100,000 and 200,000 plants^{-1}) and three cropping patterns (sole groundnut, sole cassava and groundnut/cassava) intercrop, arranged in a 4x3x3 factorial , with a randomized complete block design. Results showed significant increase in plant height, leaf number, , and seed and haulm dry matter yield of groundnut with vermicomposts relative to mineral fertilizer and control. Vegetative and yield attributes of groundnut were depressed by intercropping with cassava at higher densities. *Eichhornia crassipes*/animal manure-based vermicomposts were suggested for adoption as organic manure for improved crop performance.
Keywords: *Eichhornia crassipes*, nodulation, vermicompost, LEC, AHER

INTRODUCTION

Sustainable agriculture in the humid tropics requires frequent additions of nutrients and organic materials and intercropping with legumes for maintaining crop growth and yield. Although inorganic fertilizers may provide these nutrients, timely supply, cost of fertilizers and negative impact of continuous use on soil health may limit their use. The use of nontraditional organic resources such as aquatic weeds like water hyacinth (*Eichhornia crassipes* Mart Solms) has been studied (Chukwuma and Omotayo, 2009; Gashamura, 2009) and these studies have established the high potential of water hyacinth in improving nutrient status and subsequent crop yield in soils amended with these resources. Introduction of earthworms in the composting process, commonly termed vermicompost is fast becoming an increasingly adopted biotechnology for improved crop performance. Significant increase in growth and yield of legumes and other crops has been reported with application of vermicompost (Karmegam and Daniel, 2000; Daniel et al. 2005). The inclusion of legumes in intercropping is aimed at improving soil fertility. However, researches on the impact of such intercropping on the legume crop, especially for an associated upper storey crop such as cassava need further investigation.

Leihner (2002) suggested that maintaining cassava planting density of 10,000 plants ha^{-1} is well suited in the arrangement of the cassava crop without compromising on tuber yield. As noted by Ikeorgu and Odurukwe (1990), the performance of cassava-legume association is largely dependent upon the cropping density of the legume crops. For instance, intercropping cowpea with the population density of 8000 plants ha^{-1} could results in more economic benefits due to higher tuber yield of cassava relative to the pure cowpea or cassava in Nigeria. Intercropping with soybean has been reported to increase the root yield of cassava relative to the pure cassava (Mbah *et al*, 2010; Umeh *et al*. 2012) while cassava root yields were observed to decrease by intercropping with cowpea (Polthanee *et al*., 2001).

The objective of this study is to investigate the overall impact of a mix of *Eichhornia crassipes* and poultry manure or cowdung –based vermicompost in comparison with mineral fertilizer on the growth and yield attributes of groundnut under varying densities and cassava intercropping.

MATERIALS AND METHODS

A field trial was conducted during the 2008/2009 cropping seasons at the Teaching and Research Farm of the Delta State University, Abraka (latitude 5^0 46' and longitude 6^0 5') on a well drained leached tropical soil in the humid rainforest zone of Southern Nigeria.

Four nutrient levels (no mineral fertilizer or vermicompost i.e 0kg, 200kg NPKMg 12:12:17:2, 40 tons of water hyacinth/poultry manure-based vermicompost, VPM { 75% dry water hyacinth + 25% dry poultry manure}, and 40 tons of water hyacinth/cow dung-based vermicompost, VCD { 75% dry water hyacinth + 25% dry cow dung}, three cropping densities (50,000, 100,000, and 200,000 plants ha^{-1}) and three cropping patterns (sole groundnut, sole cassava and cassava-groundnut intercrop) were arranged in a 4x3x3 factorial experiment

with a randomized complete design in three replicates. Cassava (*Manihot esculenta* Crantz) and groundnut (*Arachis hypogea* L.) were intercropped in the ratio 1:2 for all densities. Improved cassava (var.TMS 30572) and groundnut (var. Spanish 205, early maturing 100-110 days) were planted on 6 x 4.5m^2 plots.

Data for number of nodules was collected at 50 days after sowing. Nodule efficiency was determined using the methods described by Omokaro (1990), by recognizing three colour classes: *Red (R-type) nodules*;bacterial filled nodules with leghaemoglobin pigmented bacterial tissues; *White (W-type) nodules*; small young nodules with cream coloured contents marking the site of recent infection on root system; and *G (G-type) nodules* ;senescent nodules, showing leghaemoglobin decomposition. Nodules of groundnut were oven dried at 80^{0}C for 48 hours, cooled and weighed. Plant height and leaf number were collected at harvest. Seed and haulm dry matter yield were obtained from per m^2 of plot at harvest. Freshly harvested haulms of groundnut and fresh root tubers of cassava were oven dried at 65^{0}C until constant weight was attained.

Crop productivity in the intercropping systems was assessed using the following indices:

(i) Land equivalent ratio, LER of each component crop, LER, [where , LER=Y_{ab}/Y_{aa}]

(ii) Land equivalent coefficient, LEC, proposed, by Adetilaye et al (1983) is a product of the LERs of the crop components.

LEC = $[(Y_{ab}/Y_{aa})*(Y_{ba}/Y_{bb})]$ where, Y_{aa} and Y_{bb} are yield of sole crops, Y_{ab} and Y_{ba}, are yield of intercrops.

LEC is a measure of the association or interaction which deals with the strength of relationship between crop mixtures. Before a yield advantage can be obtained from a crop mixture, a minimum LEC of 0.25 is required. An LEC value of 1.0 is an indication of ideally complementary mixtures.

(iii) Area harvest equivalent ratio (AHER) is practical measure of intercrop productivity especially in multiseason associations since it combines the area and time factors in a practical sense for qualifying intercrop yield advantages. AHER was estimated using the formula suggested by Balasubramanian and Sekayange (1990).

$$AHER = \sum_{i=1}^{n} [Y_{ab}/(Y_{bb}*n)]$$

Where:

n = total number of possible harvests of crop *b* that could be obtained during the full intercrop period, if crop *b* was monocropped (n is taken as 4)

Y_{ab} = Yield of crop *b* in intercrop

Y_{bb} = Yield of crop *b* in sole crop

Data on crop parameters and yield were subjected to appropriate analysis of variance (ANOVA) for factorial and randomized complete block designs (Gomez and Gomez, 1984).

RESULTS AND DISCUSSIONS

Table 1 shows the vegetative parameters of groundnut as influenced by nutrient sources, cropping density and cropping system. Plant height was significantly (P<0.05) increased by organic manures in form of vermicomposts resulting in higher vegetative performance of groundnut and cassava relative to mineral fertilizer and control. Water hyacinth/poultry manure- based vermicomposts (VP) resulted in slightly higher vegetative growth than the cow dung based (VC), while in cassava, cow dung based vermicomposts (vc) was slightly higher than that of poultry manure based vermicompost (VP) Although vegetative attributes of groundnut increased with lower density of intercropped cassava, results were not significant, except in leaf number which was significantly reduced at intercropping density of 200,000plants^{-1}. Plant height and leaf number consistently reduced with increasing intercropping density. Lower intercropping densities of 50,000 plants^{-1} resulted in plants with better vegetative attributes. Intercropping groundnut with cassava significantly (P<0.05) reduced vegetative performance of groundnut. Intercropping with cassava significantly reduced plant height, leaf number and leaf area of groundnut relative to the sole cropping by 13.6%, 24.4% and 3.26% respectively.

The interactive effects of nutrient sources x density were significantly different for all vegetative attributes. The tallest plants, with higher foliage were obtained with groundnut applied with 40 tons of water hyacinth/poultry manure based vermicompost and cropping density of 50000 plants^{-1}, while plants with no applied mineral or organic amendment with 200,000plants^{-1} recorded the lowest plant height. Interaction of cropping density x cropping systems also significantly decreased vegetative characters. Groundnut intercropped with cassava at planting density of 200,000 plants^{-1} had lower values of plant height, leaf number and leaf area.

Results from the study highlights the significance of organic nutrition in improving growth and yield of crops and made clear the ineffectiveness of mineral fertilizer alone in enhancing yield of crops especially in degraded tropical soils. The higher yield of vermicomposts compared to inorganic fertilizer was due to better soil properties, enhanced nutrient availability and better uptake of nutrients. In addition the release of nitrogen from the vermicomposts throughout the growing period might have contributed to considerable vegetative growth and yield of groundnut. Results are consistent with other researches (Manisha et al. 2000; Otieno et al. 2009).

The probable cause of taller groundnut plants with larger leaves and leaf number in sole cropping and

plants with lower spacing may be due to reduced/absence of interspecies competition with cassava which helped to promote vigorous growth, hence allowing the crop to enjoy more solar radiation than intercropping treatments and crops with higher planting density. Earlier reports (Wahua 1983; Stirling et al. 1990) confirm these findings. However in cassava,

Nodule formation was more intensive in vermicomposts than in mineral fertilizer (Table 2), resulting in higher number of nodules with more dry weight and better efficiency indicated by increased percentage of pink colour nodules. Number of nodules per plant increased by 14.2% (VP) and 17.2% (VC) over the mineral fertilizer, with water hyacinth-cow dung vermicompost recording higher nodule number.

Increasing intercropping density significantly reduced nodule number and nodule weight, although had no significant effect on nodule efficiency. Intercropping groundnut with cassava significantly reduced number of nodules per plant and nodule dry weight per plant by 18.8% and 17.4% respectively over sole groundnut. Intercropping groundnut with cassava showed no significant effect on nodule efficiency. Interactive effects of all treatments significantly affected nodule number, but only nitrogen x density and density x system interactions affected nodule weight per plant.

The increased nodule number and weight, and associated higher nodule efficiency confirmed by more pink colour (active) nodules with application of vermicompost was probably due to the slow mineralization of vermicompost resulting in slow nitrogen release. In addition, phosphorus present in the vermicompost may have also contributed to its positive effect on nodulation. Phosphorus and organic manures have been reported to improve both the total and active nodules and nodule dry weight of legumes (Ganesharmurtthy and Rammi-Reddy, 2000; Otieno et al. 2009).

Seed yield and haulm dry matter yield of groundnut significantly increased with application of water hyacinth-animal manure based vermicompost over mineral fertilizer and the control (Table 3). The water hyacinth/poultry manure-based vermicompost (VP) resulted in higher seed and dry matter yield relative to vermicompost based on water hyacinth/cow dung (VC). An increase of 24.9% in seed yield was observed with application of VP over mineral fertilizer. Application of vermicompost resulted in 29% and 16% increase in haulm dry matter yield over the control and mineral fertilizer treatments respectively.

Increasing sole and intercropping density of groundnut per unit area resulted in higher seed and haulm dry matter yield. Intercropping of groundnut with cassava significantly reduced seed and haulm dry matter yield of groundnut by 7.7% and 15.7% respectively. Relative water content of cassava root tubers as indicated by percentage succulence was lower in vermicompost application, an indication of more dry matter. Interactive effects of nitrogen x density, nitrogen x cropping system and density x cropping system were significant for seed yield and haulm dry matter yield Development of individual characters declined as the population density increased in this study. Conversely, dry and fresh root tuber yield of cassava, and seed and haulm dry matter yield of groundnut increased with planting population per unit area. This indicates that in spite of the fierce competition for resources at high population density, utilization of available land space was still optimal at high population.

The LERs of the individual crop components in the mixture generally deceased with cropping density, with higher values in cassava. The LEC values showed a strong interaction between cassava and groundnut (Table 4) with an inverse relationship with cropping density. The AHER values within the range of 1.00 and 1.18 recorded in this study agrees with reported values of 1.05 to 1.08 (Amanullah et al. 2006) and 1.14 (Balasubramanian and Sekayange, 1990) for cassava + cowpea mixture. Higher LEC and AHER in vermicompost treatments may be attributable to higher production in these treatments

CONCLUSION

It is clearly shown from this study that the intercropping of groundnut with cassava increased crop productivity as shown in the LEC and AHER. The use of vermicomposts from *Eichhornia crassipes* + animal manures vermicomposting provided source of nutrients that resulted in increased number of nodules and nodulation efficiency of groundnut. It also contributed to improved plant morphological characters (leaf number and plant height) and biological yield (haul dry matter and root dry weight) and economic yield parameters (seed yield and fresh tuber yield). Other average vermcompost with poultry manure gave better vegetative and yield attributes with groundnut while cassava was better with that containing cow dung.

ACKNOWLEDGEMENT

This research was supported by the International Foundation for Science (IFS), Stockholm, Sweden through a grant to the author.

REFERENCES

Adetiloye, P.O., Ezedinma, F.O.C. and Okigho, B.N. (1983).A land equivalent coefficient concept for the evaluation of competitive and productive interactions on simple complex crop mixtures. Ecol.

Modelling ,19: 27-39

Amanullah, Mohamed M;, K. Vaiyapuri, A. Alagesan,E. Somasundaram, K. Sathyamoorth's and S. Pazhanivelan (2006) Effect of Intercropping and Organic Manures on the Yield and Biological Efficiency of Cassava Intercropping System (*Manihot esculenta* Crantz.) Research Journal of Agriculture and Biological Sciences, 2(5): 201-208

Balasubramanian, V. and Sekayange, L.(1990). Area Harvests Equivalency Ratio for measuring efficiency in multiseason intercropping. Agron.J., 82: 519-522

Chukwuka, K.S & Omotayo, O.E. (2009). Soil fertility restoration potentials of *Tithonia* green manure and water hyacinth compost on a nutrient depleted soil in Southwestern Nigeria using Zea mays L. as a test crop. *Research Journal of Soil Biology* 1(1): 20-30

Daniel J., Dhar-S & Desai, J. (2005). Improving livelihoods through vermicomposting. *LEISA Magazine* (September): 12-13

Ganeshamurthy, A.N. & Sammi-Reddy, K. (2000). Effect of integrated use of farmyard manure and sulphur in a soybean and wheat cropping system on nodulation, dry matter production and chlorophyll content of soybean on swell-shrink soils in central India. *India Journal of Agronomy and Crop Science* 185: 91-97

Gashamura, F.R. (2009). Effects of manure on from water hyacinth on soil fertility and maize performance under controlled conditions in Rwanda. Master Thesis No. 56 Swedish Biodiversity Centre, Upsala Universitit pp.51

Gomez, K. A & Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research* London : John Wiley and Sons

Ikeorgu, J.E.G. and Odurukwe, S.O. (1990). Increasing the productivity of cassava/maize intercrop with groundnut. *Trop. Agric. (Trinidad)* 67:164-168.

Kathirvelan, P. & Kalaiselvan, P. (2007). Groundnut (*Arachis hypogea* L.) leaf area estimation using allometric model. *Research Journal of Agriculture and Biological Sciences* 3(1): 59-61

Leihner, D. (2002). Agronomy and cropping systems. In: Hillocks, Rory J., Thresh, J.M. and Bellotti, A. (Ed.). *Cassava: Biology, production and utilization*. CABI.

Mbah, E.U., Muoneke, C.O. and Okpara, D.A. (2010). Evaluation of cassava (*Manihot esculenta* Crantz) planting methods and soybean [*Glycine max* (L.) Merrill] sowing dates on the yield performance of the component species in cassava/soybean intercrop under the humid tropical lowlands of southeastern Nigeria. *Afr. J. Biotechnol.* 8(1): 42-47.

Manisha, B., Bhadoria, P.B.S. & Mahapatra, S.C. (2007). Role of soil amendments in improving groundnut productivity of acid lateritic soils. *International Journal of Agricultural Research* 2 (1): 87-91

Omokaro, D. N. (1990). Comparative studies on nodulation, chlorophyll content growth, dry matter production and forage quality in two cowpea cultivars. *Nigerian Journal of Science* 24:20 – 24

Otieno, P.E., Muthomi, J.W., Chemining'wa, G.N. & Nderitu, J.H. (2009). Effect of rhizobia inoculation, farmyard manure and nitrogen fertilizer on nodulation and yield of food grain legumes. *Journal of Biological Sciences* 9(4): 326-332

Polthanee, A., Wanapat, S., Wanapat, M. and Wachirapokorn, C. (2001). Cassava-Legumes intercropping: A potential food-feed system for dairy farmers. In: International Workshop on Current Research and Development on Use of Cassava as Animal Feed, Khon Kaen University, Thailand, pp. 23-24.

Stirling , C.M., Williams, J.H., Black, C.R & Ong, C.K. (1990). The effect of timing of shade on development , dry matter production and light-use efficiency in groundnut (*Arachis hypogea* L.) under field conditions. *Australian Journal of Agricultural Research* 41: 633-644

Umar, U.A., Mahmud, M., Abubakar, I.U., Banaji, B.A. and Idris, U.D. (2012). Effect of nitrogen fertilizer level and intra row spacing on growth and yield of sesame (*Sesamum indicum* L.) varieties. *Technical J. Engineering and Applied Sci.* 2(1): 22-27.

Wahua, T.A.T. (1983) Nutrient uptake by intercropped maize and cowpea and a concept of nutrient supplementation index (NSI). *Experimental Agriculture* 19: 263-275

Table 1. Response of vegetative attributes of groundnut and cassava to vermicompost, mineral fertilizer and cropping density

	Groundnut		Cassava	
Treatment	Plant height (cm)	Number of leaves/plant	Plant height (m)	Number of leaves/plant
Nutrient sources				
0	41.0	46.9	1.37	35.2
200kg NPKMg	42.2	51.9	1.77	40.3
40 tons VPM	49.1	57.4	2.15	51.0
40tons VCD	48.5	57.1	2.27	53.7
SE	1.4	2.6	1.3	1.2
F-test	**	**	**	**
Cropping density				
50000	46.1	55.5	1.84	42.1
100000	45.0	53.9	2.04	48.1
200000	44.5	52.1	1.79	44.9
SE	0.1	1.1	1.3	1.4
F-test	ns	*	ns	ns
Cropping System				
Sole	48.5	61.3	1.86	44.3
Mixed	41.9	46.3	1.92	45.8
SE	2.24	8.09	1.5	0.4
F-test	**	**	ns	ns
Interactions				
Nutrient x density	3.05	76.18**	2.11	3.01ns
Nutrient x system	1.30ns	0.59ns	7.22**	1.6sns
Density x system	10.73**	47.25**	12.05**	11.09**
Nutrient x density x system	0.02ns	2.01ns	1.31ns	0.45ns

** significant at 1%, *significant at 5%, ns- not significant
VPM- water hyacinth/poultry manure vermcompost, VCD water hyacinth/cow dung vermcompost

Tables 2. Response of nodulation of groundnut to vermicompost, mineral fertilizer and density of intercropped cassava

	Number of nodules/plant	Nodule dry weight/plant (g)	Percent nodule efficiency		
Treatment			% pink nodules/plant	% white nodules/plant	% green nodules/plant
Nutrient sources					
0	59.58	0.33	71.1	12.9	16.0
200kg NPKMg	60.59	0.39	77.3	12.2	10.5
40 tons VPM	69.17	0.44	81.7	9.6	8.7
40 tons VCD	71.02	0.46	81.6	9.7	8.7
SE	3.88	2.86	2.87	1.32	5.15
F-test	**	**	**	**	**
Cropping density					
50000	68.92	0.44	77.9	10.9	11.2
100000	65.22	0.41	78.1	11.6	10.3
200000	61.13	0.40	77.8	11.4	10.8
SE	2.99	1.74	0.07	0.03	0.01
F-test	**	**	ns	ns	ns
Cropping System					
Sole	71.84	0.46	78.2	10.9	10.9
Mixed	58.33	0.38	77.7	11.3	11.0
SE	8.97	6.03	0.27	0.31	0.01
F-test	**	**	ns	ns	ns
Interactions					
Nutrient x density	117.69**	48.18**	4.14*	1.52ns	4.14*
Nutrient x system	27.56**	9.09**	8.57**	2.77ns	8.57**
Density x system	86.94**	54.55**	131.87**	27.64**	131.87**
Nutrient x density x system	6.72*	2.27ns	1.56ns	0.52ns	1.56ns

** significant at 1%, *significant at 5%, ns- not significant
VPM- water hyacinth/poultry manure vermcompost, VCD water hyacinth/cow dung vermcompost

Table 3. Response of yield attributes of cassava and groundnut to vermicompost ,mineral fertilizer and density of intercropping

	Groundnut		Cassava		
Treatment	Haulm dry matter yield (gm^{-2})	Seed yield (gm^{-2})	Root dry matter yield (gm^{-2})	Fresh root yield (gm^{-2})	% Root succulence
Nutrient sources					
0	222.43	108.26	575.0	1090.0	52.8
200kg NPKMg	246.60	116.69	795.0	1560.0	51.0
40 tons VPM	286.90	145.60	931.7	1938.3	48.1
40tons VCD	285.99	144.73	980.0	2021.7	48.5
SE	3.39	4.98	6.8	10.3	
F-test	**	**	**	**	
Cropping density					
50000	211.52	102.34	690.0	1377.5	50.1
100000	229.18	128.69	962.5	1973.8	48.8
200000	341.99	155.47	808.8	1611.3	50.2
SE	8.84	7.94	7.7	9.1	
F-test	**	**	**	**	
Cropping System					
Sole	283.17	133.98	783.3	1628.3	48.1
Mixed	238.63	123.66	857.5	1680.0	51.0
SE	4.82	2.69	16.6	5.2	
F-test	**	**	**	*	
Interactions					
Nutrient x density	106.6**	15.6**	23.89**	18.5**	
Nutrient x system	168.6**	150.0**	134.1**.	67.9**	
Density x system	70.2**	32.8**	46.5**	24.1**	
Nutrient x density x system	2.3ns	1.4ns	1.7ns	2.5ns	

** significant at 1%, *significant at 5%, ns- not significant
VPM- water hyacinth/poultry manure vermcompost, VCD water hyacinth/cow dung vermcompost

Table 4. Intercrop productivity indices in cassava + groundnut under vermicompost and cropping density

Nutrients sources and cropping density	LERg	LERc	LEC	AHER
0 kg ha^{-1} (control)				
50000 plants ha^{-1}	0.86	0.97	0.83	0.88
100000 plants ha^{-1}	0.85	0.96	0.82	1.18
200000 plants ha^{-1}	0.85	0.92	0.78	1.17
200 kg ha^{-1} NPKMg				
50000 plants ha^{-1}	0.89	0.99	0.88	1.13
100000 plants ha^{-1}	0.95	0.97	0.92	1.16
200000 plants ha^{-1}	0.86	0.98	0.84	1.17
40 tons ha^{-1}VPM				
50000 plants ha^{-1}	0.89	1.09	0.97	1.12
100000 plants ha^{-1}	0.88	1.07	0.94	1.00
200000 plants ha^{-1}	0.86	1.03	0.86	1.13
40 tons ha^{-1}VCD				
50000 plants ha^{-1}	0.96	1.18	1.13	1.05
100000 plants ha^{-1}	0.90	1.04	0.94	1.11
200000 plants ha^{-1}	0.85	1.02	0.87	1.18

LER: land equivalent ratio; LEC::land equivalent coefficient; AHER: area harvest equivalent ratio; g: groundnut, c: cassava;
VPM- water hyacinth/poultry manure vermcompost, VCD water hyacinth/cow dung vermcompost

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar