Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.13, 2015

Response Of Linseed (*Linum usitatissimum* L.) To Seed Rates And Seeding Methods In South-Eastern Highlands Of Ethiopia

Abebe Delesa and Adane Choferie
Kulumsa Agricultural Research Center, P. O. Box 489, Asella, Ethiopia

Abstract
The effect of seed rates on yield and yield components of linseed were studied in South-Eastern Highlands of Ethiopia at four locations during 2012/13 and 2013/14 main-cropping seasons. Randomized complete block design with three replications was used for row planting and 10m by 10m plots were used for broadcasting. The linseed variety 'Kulumsa-1' was used and sown at seed rates (kg/ha) of nine levels for row planting and six seed rate (kg/ha) levels were used for broadcasting. Results indicated that significant ($P \leq 0.05$) effects of seed rates were observed on all yield components reflecting the importance of seeding rate for linseed growth, yield and yield components. However, significant ($P \leq 0.05$) effects of seed rates were not observed on all yield components except on number of pods/plant in the case of broadcasting. The highest seed yield was recorded from 40kg/ha (2019kg/ha) and 70kg/ha (1908kg/ha) for row planting and broadcasting, respectively. This data depicted that 6% (111kg/ha) seed yield advantage was obtained by using row planting method as compared to broadcasting. Likewise, using 30kg/ha and 40kg/ha seed rates increased seed yield/ha by 6% (110kg/ha) and 9% (162kg/ha), respectively as compared to 15kg/ha in the case of row planting. Similarly, using 70kg/ha seed rate for broadcasting resulted in 6% (102kg/ha) and 7% (126kg/ha) seed yield advantage as compared to 30kg/ha and 40kg/ha seed rates, respectively. The results of economic analysis indicated that the highest net benefits were obtained by using a seed rate of 30 to 40kg/ha for row planting and 70kg/ha for broadcasting.
Keywords: Broadcasting, Linseed, Row planting, Seed rate

INTRODUCTION:

Oilseeds are the second export products next to coffee and already more than 3 million small holders are involved in their production (Wijnands *et al*., 2007). Among oilseeds linseed (*Linum usitatissimum*) stands second next to noug (*Guizotia abyssinica*) in areas coverage and total production (Getinet and Nigussie, 1997). During 2008/09 cropping season 1.2 million subsistence farmers allocated 180, 873 hector of land for linseed production and produced 0.16 million tons of linseed with average yield of 0.863 t/ha (CSA, 2009). Similarly, 170, 341 subsistence farmers of Arsi zone ploughed 74, 176 ha of land and produced 72, 062 tons of linseed (CSA, 2009). Besides, linseed possesses great export potential like sesame (*Sesamum indicum*). Linseed is widely cultivated in higher elevations of Ethiopia where frost is a threat for other oilseeds (Getinet and Nigussie, 1997). It is an important pre-crop for cereal, pulse and potato crops in South-eastern highlands of Ethiopia.

Linseed oil is suitable for human consumption and is used as a nutritional supplement. It is rich in omega-3 fatty acids, especially alpha-linolenic acid (C18:3) that was beneficial for heart disease, inflammatory bowel disease, arthritis and a variety of other health conditions. It also contains a group of chemicals called lignans that play a significant role in the prevention of cancer (Budwig, 1994). The meal, which remains after oil extraction, is a valuable feed to animals as a protein supplement and is very good manure. Linseed oil is an excellent drying oil used in manufacturing paints, varnishes, soaps, printing inks, oil cloth and linoleum tiles (Rowland *et al*., 1995). Linseed is also used in making papers and plastics.

Despite its diverse use and wide production, linseed production in Arsi zone is characterized by low yield and poor product quality mainly due to poor management practices such as lack of proper weed management system, poor seed and field hygiene, poor seed bed preparation, inappropriate seeding rates and methods, improper threshing ground and improper cleaning.

Generally speaking, a more dense plant stand allows the crop to compete better with weeds. After a certain point, however, the benefits of an increased plant population do not outweigh the cost of additional seed, especially when seed cost is high. In certain cases, however, a high seeding rate may allow farmers to eliminate in-crop herbicide or reduce herbicide rates.

Current national seeding rate recommendations for linseed production is 25kg/ha for row planting and 30 to 40kg/ha for broadcasting in Ethiopia. The same recommendations have been followed for linseed production and trials execution under different research stations. But, several farmers often broadcast more than double and triple rates for linseed production (Abebe *et al.*, 2011). Farmers are using high seed rates certainly due to many reasons: in order to reduce weeds pressure for many farmers do not carry out weeding practices for they give priority to cereal and pulse crops than to oil crops; majority of farmers mostly use saved seed as seed source, which is relatively poor in quality as compared to certified seed of seed enterprises; farmers do not employ appropriate tillage frequencies and time.

Linseed is being produced under rain fed, low input and poor management. Concerning fertilizer

utilization for linseed production, 89% of the farmers in these zones applied neither organic nor inorganic fertilizer (Abebe *et al.*, 2011). On the other hand, national fertilizer recommendation for linseed production is 23/23 kg/ha N/P_2O_5.

The objective of this study was therefore, to determine optimum seed rate of linseed under row planting and broadcasting for linseed production.

MATERIALS AND METHODS

Experimental sites: This research was conducted at Kulumsa ($8^0 02^{'}$ N latitude and $39^0 10^{'}$ E longitude), Bekoji ($7^0 05^{'}$N latitude and $39^0 30^{'}$E longitude), Asasa ($7^0 08^{'}$N latitude and $39^0 13^{'}$E longitude) and Kofele (not available) research stations located in the South-Eastern highlands of Ethiopia with an altitude ranging from 2200m (Kulumsa) to 2780m (Bekoji). Mean annual rainfall ranges from 830mm (Kulumsa) to 1211mm (Kofele). Besides, mean annual minimum temperature varies from 5.8 (Asasa) to 10.5 (Kulumsa) degree celicus and mean annual maximum temperature varies from 18 (Kofele) to 23.6 (Asasa) degrees celsius. Chernozens, Nitosol, Loam and Luvisol are soil type characters of Asasa, Bekoji, Kofele and Kulumsa sites, respectively.

Experimental treatments and design

The experiment was conducted during the 2012/13 and 2013/14 main cropping seasons. The experimental fields were ploughed once and disced twice prior to planting using mold-board and disc ploughs, respectively at each on-station. Field was tilled two to three times on farmers fields for broadcasting experiment at each location. Randomized complete block design with three replications was used for row planting, and 10m by 10m plots were used for broadcasting and adjacent fields were used consistently for both methods of sowing. For the broadcasting trial prepared seed and fertilizer were evenly broadcasted on each plot and oxen plough was used to cover the seed at a depth of 3 cm. In addition to on-stations two on farms were used as a replication at each location for broadcasting experiment. The linseed variety 'Kulumsa-1' was used and sown at seed rates (kg/ha) of nine levels (1=15, 2=20, 3=25, 4=30, 5=35, 6=40, 7=45, 8=50, 9=60) for row planting and six seed rate (kg/ha) levels (1=30, 2=40, 3=50, 4=60, 5=70, 6=80) was used for broadcasting. Each treatment was planted in a plot consisting of ten rows of 5 m long with spacing of 20 cm between rows for row planting. The distance between replications was 2 meters. The germination rate and 1000-seed weight of the seed were 93% and 6.2 g, respectively. A fertilizer rate of 23/23 kg/ha N/P_2O_5 was consistently used for both methods of sowing at each location except at Kulumsa on-station where fertilizer was not used due to high soil fertility status of Kulumsa. Disease or insect control chemicals were not applied during the growth of linseed. On the other hand, all other recommended cultural practices were properly followed in order to successfully grow the crop. Sowing was done from second week of June to first week of July each season. As a crop rotation linseed followed either wheat or barley in both years. Data was collected both on plot and 10 plant basis. After threshing seeds were cleaned, weighed and adjusted to 7% moisture content. Total seed yield recorded on plot basis was converted to kg/ha for statistical analysis.

Analysis of variance was conducted using MSTATC and SAS software (SAS, 2004) and means were separated by Least Significance Difference (LSD) at 5%. Moreover, partial budget analysis was performed in order to evaluate the economic feasibity of the treatments (CIMMYT, 1988).

Partial Budget Analysis: Variable cost of seeding rates was used for partial budget analysis. Price fluctuations during the production season were considered. Marginal Rate of Return (MRR), which refers to net income obtained by incurring a unit cost of input, was calculated by dividing the net increase in yield of linseed due to the application of each input to the total cost of each input applied at each rate. This enables us to identify the optimum seeding rates for linseed production.

RESULTS AND DISCUSSION

Crop yield is a complex character depending upon a large number of environmental, genetic, morphological and physiological characters and their interactions. Present results of combined years over locations have shown that significant differences ($P \leq 0.05$) were observed for year, location, year by location interaction. But, significant differences ($P \leq 0.05$) were not observed for seed rates, for years by seed rates, locations by seed rates, and for years by locations by seed rates interactions (data not shown) in the case of row planting. In the case of broadcasting similar results were obtained except that years by locations by seed rates interacted significantly ($P \leq 0.05$).

Significant ($P \leq 0.05$) effects of seed rates were observed on all yield components, namely number of primary branches/plant, number of secondary branches/plant, number of pods/plant and number of tillers/plant, in the case of row planting except on plant height, reflecting the importance of seeding rate for flax growth, yield and yield components. Likewise, yield and yield components were significantly affected by seeding rates (Abd El-Mohsen *et al.*, 2013). According to these authors the variation in seeding rate is reflected mainly not only in the change in the number of plants per unit area, but also prevailed in the variation of the formation of yield and

its components. However, significant (P≤0.05) effects of seed rates were not observed on all yield components except on number of pods/plant in the case of broadcasting experiment.

Average linseed seed yield ranged from 1823kg/ha to 2019kg/ha for row planting and from 1750kg/ha to 1908kg/ha for broadcasting. The highest seed yield was recorded from 40kg/ha (2019kg/ha) and 70kg/ha (1908kg/ha) for row planting and broadcasting, respectively (Tables 1 and 2). This data depicted that 6% (111kg/ha) seed yield advantage was obtained by using row planting method as compared to broadcasting. However, combined years over locations results have shown that seed rates did not significantly (P≤0.05) affect seed yield under both seeding methods (Tables 1 and 2). Contrary to the present results increasing seed rate significantly increased seed yield (Emam and Dewdar, 2015). Yet, using 30kg/ha and 40kg/ha seed rates increased seed yield/ha by 6% (110kg/ha) and 9% (162kg/ha), respectively as compared to 15kg/ha in the case of row planting (Table 1). Similarly, using 70kg/ha seed rate for broadcasting resulted in 6% (102 kg/ha) and 7% (126kg/ha) seed yield advantage as compared to 30kg/ha and 40kg/ha seed rates, respectively (Table 2).

Table 1. Effect of seed rates on yield of linseed under row planting at Kulumsa, Bekoji, Asasa and Kofele in 2012/13 and 2013/14

Seed rate	Seed yield (kg/ha)		Mean Seed yield (kg/ha)
	2012/13	2013/14	
1	1850	1865	1857
2	1751	1896	1823
3	1839	1916	1878
4	1923	2010	**1967**
5	1965	1919	1942
6	**2038**	**2000**	**2019**
7	1955	1944	1949
8	2022	1983	2002
9	2010	1987	1998
Mean	1928	1947	1937
LSD (5%)	NS	NS	NS
CV	14.2	11.3	12.8

Where, Seed rate (kg/ha) 1=15, 2=20, 3=25, 4=30, 5=35, 6=40, 7=45, 8=50, 9=60

Table 2. Effect of seed rates on yield of linseed under broadcasting at Kulumsa, Bekoji, Asasa and Kofele in 2012/13 and 2013/14

Seed rate	Seed yield (kg/ha)		Mean seed yield (kg/ha)
	2012/13	2013/14	
1	1892	1719	1806
2	1744	1820	1782
3	1752	1749	1750
4	1821	1823	1822
5	**1951**	**1865**	**1908**
6	1877	1877	1877
Mean	**1840**	**1809**	**1824**
LSD (5%)	NS	NS	NS
CV	10.1	11.9	11.0

Where, Seed rate (kg/ha) 1=30, 2=40, 3=50, 4=60, 5=70, 6=80

Linseed showed a little yield response to changes in seeding rate from 30 to 40kg/ha. Present results revealed that seed rate had significantly (P≤0.05) influenced all yield components except 1000-seed weight under row planting (Table 3). There was linear increase in plant stand with increased seed rate and the highest seed rate gave significantly higher plant stand, followed by next rates. These findings are in agreement with the reports of Bekele *et al.* (2002) and Iqbal *et al.* (2010) who reported that increasing seed rates resulted in increased plant population. Results indicated that there was no linear increase or decrease in case of many yield components. The results further depicted that the lowest seed rate (15kg/ha) produced significantly higher yield components namely number of primary branches/plant, number of secondary branches/plant, number of pods/plant and number of tillers/plant as compared to the highest seed rate (60kg/ha). These findings confirmed the reports of Kraft and Spiss (1988). Likewise, varying seed rates significantly influenced plant population, pods/plant and grain yield/plant (Achakzai and Taran, 2011). According to several authors (Gubbels and Kenaschuk, 1989; Mostafa and El-Deeb, 2003; Lal *et al.,* 2012; Abd El-Mohsen *et al.,* 2013) increasing seed rate significantly decreased growth and yield attributes of linseed crop. On the other hand, seed rate did not show significant influence on all yield components considered under broadcasting (Table 4). Similar to these findings

Njuguna *et al.* (2008) reported that seed rates had no significant effects on plant height, spikes/m^2 and 1000-seed weight.

Table 3. Effect of seed rates on yield and yield components of linseed under row planting at Kulumsa, Bekoji, Asasa and Kofele in 2012/13 and 2013/14

Seed rate	DM	PH (cm)	Stand (%)	TSW (g)	NPBPP	NSBPP	NPPP	NTPP	Seed yield (kg/ha)
1	159	99	68	5.30	5.73	8.38	95.2	1.93	1857
2	160	101	73	5.44	4.84	6.62	71.1	1.56	1823
3	159	100	81	5.39	4.93	7.09	71.7	1.91	1878
4	159	101	85	5.46	4.91	7.47	69.7	1.44	**1967**
5	160	99	85	5.48	4.51	6.89	55.6	1.40	1942
6	**160**	**100**	**89**	**5.45**	**4.78**	**7.02**	**69.9**	**1.51**	**2019**
7	159	99	90	5.41	4.80	5.82	60.1	1.31	1949
8	156	98	90	5.38	4.58	6.42	53.0	1.13	2002
9	156	98	93	5.38	4.51	6.84	46.6	1.13	1998
Mean	159	100	84	5.41	**4.84**	**6.95**	**65.9**	**1.48**	1937
LSD (5%)	NS	2.5	4.3	NS	0.6	1.0	23.2	0.4	NS
CV	2.8	3.3	7.6	3.8	14.4	19.2	27.2	25.1	12.8

Where, Seed rate (kg/ha) 1=15, 2=20, 3=25, 4=30, 5=35, 6=40, 7=45, 8=50, 9=60; DM=Days to mature; PH=Plant height; TSW=1000-seed weight; NPBPP=Number of primary branches/plant; NSBPP=Number of secondary branches/plant; NPPP=Number of pods/plant; NTPP=Number of tillers/plant

Table 4. Effect of seed rates on yield and yield components of linseed under broadcasting at Kulumsa, Bekoji, Asasa and Kofele in 2012/13 and 2013/14

Seed rate	DM	PH (cm)	Stand (%)	TSW (g)	NPBPP	NSBPP	NPPP	NTPP	Seed yield (kg/ha)
1	159	94	74	5.76	6.1	6.0	58.0	1.8	1806
2	159	94	80	5.77	5.0	7.2	62.3	2.2	1782
3	156	93	85	5.68	4.5	5.0	54.3	1.9	1750
4	156	94	89	5.75	4.3	6.1	62.0	2.6	1822
5	156	94	93	5.77	5.6	4.9	45.9	1.4	**1908**
6	156	93	95	5.74	4.6	4.9	51.3	1.8	1877
Mean	**157**	**94**	**86**	**5.74**	**5.0**	**5.6**	**55.6**	**2.0**	**1824**
LSD (5%)	NS	NS	3.1	NS	**NS**	**NS**	**NS**	**NS**	NS
CV	4.2	3.4	3.8	2.5	24.3	22.4	25.5	27.6	11.0

Where, Seed rate (kg/ha) 1=30, 2=40, 3=50, 4=60, 5=70, 6=80; DM=Days to mature; PH=Plant height; TSW=1000-seed weight; NPBPP=Number of primary branches/plant; NSBPP=Number of secondary branches/plant; NPPP=Number of pods/plant; NTPP=Number of tillers/plant

Partial and marginal budget analysis

For a treatment to be considered as a worthwhile option to farmers, the marginal rate of return (MRR) needs to be at least between 50% and100% (CIMMYT, 1988). However, for the present study, 100% MRR was considered as a reasonable minimum acceptable rate since farmers in the study areas usually use double or triple amount of seed rate of the national recommendation for linseed production (Abebe *et al.*, 2011). The partial budget analysis in the present study indicated that high MRR (192% to 211%) was obtained by using a seed rate of 30 and 40kg/ha for row planting (Table 5). Besides, 50% MRR was obtained when a seed rate of 70kg/ha was used for broadcasting (Table 6). This means that the income obtained by using 30 to 40kg/ha for linseed was more than 1.92/2.11 times a unit total of seed cost. This analysis was done by considering only grain yield of linseed. If we add the value of the chaff, the straw, meal, pests cycle break, the return will obviously become more than the already estimated income.

Table 5. Partial and marginal budget analysis for row planting

Seed rates (kg/ha)	3	**4**	5	**6**	7
Average yield (qt/ha)	1878.0	1967.0	1942.0	2019.0	1949.0
Correction factor (deduct 10%)	187.8	196.7	194.2	201.9	194.9
Adjusted yield (qt/ha)	1690.2	1770.3	1747.8	1817.1	1754.1
Gross field benefits (birr/ha)	30424	31865	31460	32708	31574
Total cost that vary (seed cost)	575.0	690.0	805.0	920.0	1035.0
Net benefits (birr/ha)	**29849**	**31175**	**30655**	**31788**	**30539**
Gain in net benefits	0.0	1326.8	806.8	1939.2	690.2
Net benefit/cost that vary		**1.92**	1.00	**2.11**	0.67

Where, Seed rate (kg/ha) 3=25, 4=30, 5=35, 6=40, 7=45; price of linseed grain per 100kg=1800 birr and price of linseed seed per 100kg=2300birr

Table 6. Partial and marginal budget analysis for broadcasting

Seed rate (kg/ha)	1	2	3	4	**5**
Average yield	1806.0	1782.0	1750.0	1822.0	1908.0
Correction factor (10%)	180.6	178.2	175.0	182.2	190.8
Adjusted yield	1625.4	1603.8	1575.0	1639.8	1717.2
Gross field benefits (birr/ha)	29257.2	28868.4	28350.0	29516.4	30909.6
Total cost that vary	690.0	920.0	1150.0	1380.0	1610.0
Net benefits (birr/ha)	**28567.2**	**27948.4**	**27200.0**	**28136.4**	**29299.6**
Gain in net benefits	0.0	-618.8	-1367.2	-430.8	732.4
Net benefit/cost that vary					**0.5**

Where, Seed rate (kg/ha) 1=30, 2=40, 3=50, 4=60, 5=70; price of linseed grain per 100kg=1800 birr and price of linseed seed per 100kg=2300birr;

CONCLUSION AND RECOMMENDATIONS

From the two years results, 30 to 40kg/ha and 70kg/ha seed rates were optimum for row planting and broadcasting, respectively for linseed production and recommended for South-eastern highlands of Ethiopia depending on seed size, germination rate, soil fertility and weediness. Besides, it is recommended that this experiment would be further confirmed in other areas and soil types, and in combination with other agronomic practices under rain-fed, irrigation, treated and untreated. Excessively high seeding rate should be avoided where lodging may be a problem.

Acknowledgment

The authors are grateful to Mrs Shimelis Mebrate and Solomon Atinafu and Mss Tizita Mekonin for their assistance in trials management and data collection. The research was funded by Ethiopian Institute of Agricultural Research.

REFERENCES:

Abd El-Mohsen AA, Abdallah AM, Mahmoud GO (2013). Optimizing and describing the influence of planting dates and seeding rates on flax cultivars under Middle Egypt region conditions. *World Essays Journal/1 (2): 28-39.*

Abebe D, Birhane A, Workiye T, Adane C (2011). Prevalence of Weeds in Linseed Fields and Farmers Cultural Practices in Producing Linseed. *In*: Terefa G, Wakjira A and Gorfu D (eds.). Oilseeds: Engine for Economic Development.

Achakzai AK, TARAN SA (2011). Effect of seed rate on growth, yield and yield components of Mash Bean grown under irrigated conditions of Arid Uplands of Baluchistan, Pakistan. *Pak. J. Bot*., 43(2): 961-969.

Bekele G, Atak M, Baenziger PS, Nelson LA, Baltenesperger DD, Eskridge KM, Shipman MJ, Shelton DR (2002). Seeding rate and genotype effect on agronomic performance and end-use quality of winter wheat. *Crop Sci. 42(3):827-832.*

Budwig J (1994). Linseed and Linseed Oil. An internet record from http://www.numark harmacist.com/hn/Supp/Flaxseed.htm.

CIMMYT (1988). From agronomic data to farmers recommendations: An economic training manual. Completely revised edition. Mexico, D.F.

CSA (Central Statistical Agency of Ethiopia) (2009). Agricultural sample survey report on area and production of crops. Stat. Bul. Vol. 1. No. 446.

Emam SM, Dewdar MH (2015). Seeding rates and phosphorus source effects on straw, seed and oil yields of flax (*Linum usitatissimum* L.) grown in newly-reclaimed soils. *Int. J. Curr. Microbiol. App. Sci* (2015) 4(3): 334-343.

Getinet A, Nigussie A (1997). Highland oil crops: A three decade research experience in Ethiopia. Research report No. 30. Institute of Agric. Res. Addis Ababa, Ethiopia.

Gubbels GH, Kenaschuk EO (1989). Effect of seeding rate on plant and seed characteristics of new flax cultivars. *Canadian J. Plant Sci. 69(3): 791-795.*

Iqbal NN, Akbar M, Sattar AM, Ali L (2010). Effect of seed rates and row spacing on yield and yield components of wheat (*Triticum estivum* L.). *J. Agric. Res. 48(2): 151-156.*

Kraft I, Spiss L (1988). Relationship between stand density and yield components in wheat. Zbornik Biotechniske Fakultete Universe Advent Kardel No. 5:27-33 [Field Crops Absts. 43(7):4592; 1990].

Lal MR, Singh TK, Kumar R, Singh AK, Hari OM (2011). Production performance of linseed to fertility levels and seed rates in dry land conditions of Eastern Upper Pradesh. *Ind. J. of Soil Conservation. 39(3): 230-235.*

Mostafa SH, El-Deeb EI (2003). Response of flax and quality to seeding rates and micronutrients. *Alex. J. Agric. Res. Egypt 24: 425-442.*

Njuguna MN, Munene M, Mwangi HG, Akuja AK (2008). Effect of seeding rates and nitrogen fertilizer on wheat grain yield on marginal areas of eastern Kenya. Kenya Agricultural Research Institute -Njoro NPBRC. P.O. Njoro, Kenya.

Rowland GG, McHughen A, Gusta LV, Bhatty RS, Mackenzie SL, Taylor DC (1995). The application of chemical mutagenesis and biotechnology to the modification of linseed (*Linum ustatissimum* L.). *Euphytica 85: 317-321.*

SAS Institute (2004). SAS/STAT guide for personnel computers, version 9, edition. Cary, NC: SAS Institute Inc.

Wijnands J, Biersteker J, Hiel R (2007). Oilseeds business opportunities in Ethiopia. Ministry of Agric., Nature & Food Quality, Hague, The Netherlands.

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