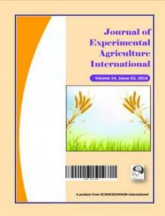

Journal of Experimental Agriculture International

16(3): 1-6, 2017; Article no.JEAI.33136
Previously known as American Journal of Experimental Agriculture
ISSN: 2231-0606

Effects of NPK Fertilizer Application Rates and Intra-row Spacing on Yield of Radish (*Raphanus sativus* L.)

A. H. Umar[1], A. K. Ibrahim[2*] and I. Alhassan[3]

[1]Department of Agricultural Technology, Federal College of Horticulture Dadin-Kowa, Gombe State, Nigeria.
[2]Department of Soil Science, Federal University, Kashere, Gombe State, Nigeria.
[3]Department of Soil Science, Federal University, Gashua, Yobe State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author AHU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AKI reviewed the experimental design and all drafts of the manuscript. Author IA managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2017/33136
Editor(s):
(1) Mariusz Cycon, Department and Institute of Microbiology and Virology, School of Pharmacy, Division of Laboratoty Medicine, Medical University of Silesia, Poland.
Reviewers:
(1) Moses Ahmed Daramy, Sierra Leone Agricultural Research Institute, Sierra Leone, Africa.
(2) K. N. Swamy, Indian Institute of Rice Research, Hyderabad, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/19103

Original Research Article

Received 31st March 2017
Accepted 21st April 2017
Published 17th May 2017

ABSTRACT

Field experiments were conducted during 2013 rainy season at the Kano State Institute of Horticulture Bagauda, Kano and Federal College of Horticulture Research and Training Farm Dadinkowa, Gombe State. The experiment investigated the effect of NPK fertilizer application rates and intra-row spacing on yield of radish (*Raphanus sativus* L.). The treatments were six level of NPK fertilizer (0, 40, 80, 120, 160 and 200 kg/ha) and three levels of spacing (10, 15 and 20 cm). The treatments were laid down in a randomized complete block design (RCBD). Yield and yield components were measured and data were analyzed using ANOVA. Intra-row spacing significantly affected root diameter and root length. The result of the study indicated that increasing level of NPK fertilizer from 0 to 200 kg/ha increased significantly yield components. Increasing intra-row spacing

**Corresponding author: E-mail: ibrahima764@gmail.com;*

from 10 to 20 cm had produced significant increase in yield characters, including root yield in both locations. The significant interactions were recorded on yield characters such as root diameter and root length. Finally 120 kg with 20 cm intra-row spacing appeared optimum for good yield of radish.

Keywords: Radish; fertilizer; spacing; seed; stalk.

1. INTRODUCTION

Radish (*Raphanus sativus* L.) belongs to the family Brassicaceae. The area of maximum diversity of radish lies between the eastern Mediterranean and Caspian Sea, which is the original gene center for this species [1]. Radish was cultivated usually in ancient times in the Mediterranean, from where it spread to China in about 500 BC and to Japan in about 700 AD. It is also a crop that has been cultivated in the oases of the Sahara and in Mali. Radish is a popular root vegetable in both tropical and temperate region. Radish has a very short life cycle (35 to 60 days), which provides a rapid return of capital [2]. World production of radish was estimated at 7 million tons per year; accounting for about 2% of the total world production of vegetables [3]. Radish is a cool season annual crop (depending on when it is planted). Radish has been cultivated for thousands of years in both China and the Mediterranean area [4]. Radish was a common food in Egypt before the building of the pyramids and is one of the most ancient cultivated plants. Generally, commercial radish is approximately 2 cm in diameter and is either red or white. It reaches market size in 21 to 28 days (or longer in cool weather), there is also a radish group called daikon, which is the Chinese Oriental radish. It may grow up to 75 cm long with a diameter of up to 25 cm [2]. It may weigh several kilograms and radish varies in color from white to black [5].

Radish is useful in the treatment of liver, gall bladder troubles, sleepless, chronic diarrhea, neuralgic headaches, urinary complaints, piles and gastrodyria [6].

NPK fertilizer, generally, has its most profound influence on the vegetative development of crops. When supplied in adequate quantity NPK fertilizer ensures a healthy plant growth, which is manifested by the increased vigor, size and the deeper green colour of the foliage. The effect of N fertilizer on the general vigor of crops is as a result of its positive effects on cell division, cell elongation and cell expansion, synthesis of amino acids, enzymes and chlorophyll [7]. Unfortunately, most tropical soils are deficient or low in recorded Nitrogen. Consequently most workers have recorded positive responses by most crops (including radish) to NPK fertilizer applications.

The lack of awareness on the consumption and productivity of the crop due to low inherent fertility of the soil and inadequate plant nutrients application especially the NPK fertilizer or wrong timing of their applications, use of low yielding varieties, improper spacing, pest and disease prevalence, soil and climatic condition, technical knowhow of crop production by farmers and above all market for the crop. Despite the importance of radish to human and Nigerian economy, very little work on the crop was done. Fertilizer applications are important determinants of growth and yield of Radish production.

Inadequate soil fertility more especially Nitrogen, Potassium and Phosphorus can hinder the production of radish leading to low yields and total failure. The application of the appropriate or optimum rate of fertilizer can increase the soil fertility, thereby, increasing production of radish. This study was conducted to determine optimum rates of NPK fertilizer for efficient radish production and to increase awareness of radish production as an alternative economic crop to the farmers in the study area that could help them to reduce the poverty among them.

2. MATERIALS AND METHODS

Field experiment was conducted during the rainy season of 2013 at the Kano State Institute of Horticulture (KIHORT) Bagauda, Kano and Federal College of Horticulture Research and Training Farm, Dadinkowa. The study area (Bagauda) lies between latitudes 8° 41^1 N and 9° 30^1 and between longitudes 9° 30^1 E and 12° 30^1 E with a mean annual rainfall range of 787 mm to 960 mm, a mean annual minimum temperature range of 20℃ to 24℃ and a mean maximum temperature range of 21℃ to 39℃ [8]), In the Sudan Savannah ecological zone. The second study area (Dadinkowa) lies between the latitudes 11°.23 ^{1} and 10°18 ^{1} N and

Table 1. Chemical properties of soil of the study area

Soil properties	Bagauda	Dadin-Kowa
PH in water	5.9	6.5
Organic carbon (g/kg)	0.72	0.66
Total nitrogen (g/kg)	0.08	0.07
Available P (mg/kg)	5.27	6.25
Exchangeable cations (cmol/kg)		
Ca	2.01	2.63
Mg	0.36	0.63
K	0.21	0.18
Na	0.05	0.08
CEC	7.67	9.25

Table 2. Effect of NPK fertilizer application rates and intra-row spacing on root diameter of radish plant at Bagauda and Dadinkowa during 2013 rainy season

Treatments	Bagauda (Weeks after sowing)				Dadinkowa (Weeks after sowing)			
NPK (Kg ha $^{-1}$)	**2**	**4**	**6**	**8**	**2**	**4**	**6**	**8**
0	3.29c	7.37c	11.09b	14.33e	3.16c	6.30c	10.58d	14.33e
40	3.23c	7.80c	12.69b	17.68d	4.09c	7.61c	13.16c	17.68d
80	8.06b	20.54a	24.89a	29.38bc	8.30b	21.54a	25.00ab	26.38bc
120	12.61a	18.12b	25.04a	34.24a	12.97a	18.19b	26.04a	34.26a
160	12.76a	19.08ab	23.63a	27.60c	12.99a	19.01b	23.86b	27.64c
200	11.83a	18.02b	26.58a	32.24ab	12.31a	19.09b	25.01ab	32.22ab
SED	0.364	0.524	1.153	0.998	0.425	0.524	0.695	0.961
Spacing (cm)								
10	7.30c	12.92c	18.33b	23.02c	7.55c	12.12c	18.58c	23.61c
15	8.33b	14.17b	20.92a	26.09b	8.68b	14.91b	20.74b	26.07b
20	10.26a	17.84a	22.71a	28.65a	10.67a	17.99a	22.80a	28.65a
SED	0.257	0.371	0.815	0.706	0.3	0.371	0.491	0.756
Interaction								
F x S	NS	*	*	NS	NS	NS	*	NS

SED = Standard Error of Difference, F = Fertilizer, S = Spacing, means followed by same letter within a set of interaction are not statistically different at 5% level of significance using Tukey's (HSD)

longitudes 11° 31[1] E with a mean annual rainfall 1029.2 mm, a mean annual minimum temperature of 25℃ and a mean maximum temperature of 32℃ [9], in the Northern Guinea Savannah ecological zone.

The experiment comprised of 18 treatments with six levels of NPK fertilizer 15-15-15 (0, 40, 80, 120, 160 and 200 kg NPK/ha), and three intra-row spacing's of (10, 15, and 20 cm). The parameters taken are Plant height, Leaf length, Number of leaves per plant, Fresh weight of leaves, Dry weight of leaves, Leaf are per plant, Root length, Root diameter, Fresh weight of root, Dry weight of root, Number of days attain edible size and Yield tone per hacter. The experiment was laid out in a randomized complete block design. Treatments were factorial combinations and assigned to plots and replicated three times. [10] Gens tat (2007) Statistical Software was used in analyzing the data.

3. RESULTS AND DISCUSSION

The increase in dry matter production per plant of radish with increasing rate of NPK fertilizer up to 120 kg/ha could be attributed to the positive influence of nitrogen on cell division, cell elongation, cell expansion synthesis of amino acids enzymes and chlorophyll which might increase the growth, the vigour of the crops.

Root diameter exhibited significant variation with NPK fertilizer level (Table 2 above). The biggest root diameter (34.26 cm) resulted from 120 kg/ha which was significantly greater than those of the remaining doses of NPK fertilizer, these results were in agreement with [10] who reported that application of Organic matter with NPK increased the diameter of root per plant, in general the treatments produced taller plant height and higher number of leaves per plant and higher roots diameter.

Table 3. Effects of NPK fertilizer application rates and intra-row spacing on Root Length of Radish plant at Bagauda and Dadinkowa during 2013 rainy season

Treatments	Bagauda (Weeks after sowing)					Dadinkowa (Weeks after sowing)				
NPK (Kg ha $^{-1}$)	**2**	**4**	**6**	**8**	**10**	**2**	**4**	**6**	**8**	**10**
0	2.02b	3.11c	5.23d	7.10d	9.51e	2.11bc	3.19b	5.11d	7.10d	9.51c
40	2.35ab	4.06c	8.21c	10.30c	16.28d	2.40abc	4.14b	7.92c	10.12c	15.48b
80	2.32ab	8.94a	11.16ab	10.28b	23.27a	2.58ab	8.88a	11.16ab	14.76ab	26.02a
120	1.80b	6.20b	9.58bc	13.08bc	20.02b	1.95c	7.24a	9.46bc	13.08b	25.23a
160	2.19b	7.70ab	12.21a	13.88b	17.31cd	2.27bc	7.92a	12.01a	13.51b	22.63a
200	2.64a	6.74b	9.92abc	16.81a	19.17bc	2.94a	6.74a	9.40abc	16.91a	22.82a
SED	0.211	0.513	0.735	0.763	0.659	0.1876	0.712	0.711	0.728	1.333
Spacing (cm)										
10	1.71c	4.79c	7.11c	10.52c	15.20c	1.878c	5.13b	7.11c	10.67c	18.04c
15	2.23b	5.94b	9.43b	12.26b	17.12b	2.378b	6.17b	9.43b	12.26b	20.17b
20	2.82a	7.64a	11.46a	14.98a	20.46a	2.878a	7.77a	11.46a	14.98a	22.64a
SED	0.149	0.363	0.52	1.501	0.466	0.132	0.504	0.52	5.15	0.942
Interaction										
F x S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SED = Standard Error of Difference, F = Fertilizer, S = Spacing, means followed by same letter within a set of interaction are not statistically different at 5% level of significance using Tukey's (HSD)

The root length increased at different level of NPK fertilizer application (Table 3). The higher root was obtained from 200 kg/ha and the lowest root length obtained from control. The results are in agreement with the findings of [11,12,13,14] who noted that the application of NPK fertilizer significantly increased the root length in radish.

Time taken by the roots to attain edible size, the number of days to reach edible size of radish plant due to NPK fertilizer application ranges from 38.63 to 68.11 days (Table 4). Application of NPK fertilizer at 200 kg/ha significantly influenced attaining edible size earlier at 38..63 days in Bagauda and similarly76 in Dadinkowa, 200 kg/ha is the least days. These results are in conformity with the findings of [15,16,17] that the minimum time is 5.56 weeks and the slight difference can be attributed to differences in ecological as well as climatic conditions.

Table 4. Effects of NPK fertilizer application rates and intra-row spacing on total number of days attain edible size of radish plant at Bagauda and Dadinkowa during 2013 rainy season

Treatment NPK (Kg ha $^{-1}$)	Bagauda	Dadinkowa
0	68.11a	66.87a
40	60.43b	60.21ab
80	42.12c	55.19b
120	40.09c	53.60b
160	38.93c	41.82c
200	39.29c	38.63c
SED	1.58	21.98
Spacing (cm)		
10	50.27a	53.67a
15	47.76ab	52.98a
20	46.46b	51.51a
SED	1.117	1.554
Interaction		
F x S	NS	NS

The Radish yield result is presented in Table 5. The highest Yield (8.83 t/ha) was attained from 200 kg/ha. The increased in yield of radish root might be attributed to higher individual root weight, higher number of leaves per plant and higher dry matter content of root. [18] reported that NPK fertilizer at 180 Kg/ha gave the best yield and quality in radish [13] mentioned that maximum yield of 35.9 t/ha was obtained when NPK was applied at the ration 120:120:60 kg/ha to carrot. Similarly, [14] also found that the highest yield (27.82) t/ha was obtained from nitrogen applied to carrot at 150 kg/ha which was significantly different from other nitrogen levels [19]. Also found that combination of fertilizer 120-45-120-30 kg/ha of NPKS 5 t/ha could produce the highest root yield of 27.22 t/ha.

Table 5. Effects of NPK fertilizer application rates and intra-row spacing on yield of radish plant at Bagauda and Dadinkowa during 2013 rainy season

Treatment NPK (Kg ha $^{-1}$)	Bagauda	Dadinkowa
0	4.15b	4.21b
40	6.08ab	6.29b
80	8.44a	8.48a
120	7.84a	8.05a
160	7.08ab	7.15b
200	8.83a	8.54a
SED	1.044	1.097
Spacing (cm)		
10	5.41b	5.45b
15	7.55a	7.63a
20	8.26a	8.27a
SED	0.738	0.776
Interaction		
F x S	NS	NS

SED = Standard Error of Difference, F = Fertilizer, S = Spacing, means followed by same letter within a set of interaction are not statistically different at 5% level of significance using Tukey's (HSD)

The increase in plant height, leaf number per plant, leaf length and dry matter production per plant of radish with increasing intra-row spacing from 10 or 15 to 20 cm, could be probably due to the fact that, radish plants grown at wide intra-row spacing are less expose to intra-specific competition for nutrients, moisture, height and spaces, therefore tended to grow vigorously. High plant populations associated with narrow intra-row spacing tended to exert pressure on scarce growth resources such as light and nutrients there by leading to poor growth. This agreed with the findings of [7,20].

4. CONCLUSION

In conclusion, the results of the study indicated that applications of NPK fertilizer 120 kg and with 20 cm intra-row spacing appeared to be optimum for good yield of radish. From the result obtained in the study, it may be recommended that the use of NPK fertilizer 120 kg with intra-row spacing of 20 cm will lead to better yield and quality of radish.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sounda G, Ghanti P, Ghatak S. Effect of levels of nitrogen and different spacing on the vegetative growth and yield of radish. Horticultural Abstract. 1998;59(9):846.
2. Juen H. Ahmad M, Guho G. Effect of nitrogenous fertilizer on growth and yield of Radish. Asian Journal of Plant Science 2010;1(5):544-545.
3. Hogland W, Bramryd T, Marques M, Nimmermark S. Physical, chemical and biological processes for optimizing decentralized composting. Compost Science Utilization. 2003;11:330-336.
4. Sharma S, Gulshanlal N. Effect of organic matter on quantity and quality of roots in radish (*Raphanus sativa* L) Seminar (Londrina). 1990;16:80-85.
5. Singh AP, Singh MK, Singh JP, Singh SB. Effect of nitrogen and spacing on seed production of radish. Vegetable Science. 1990;17:210-212.
6. Sadhu MK. Root crops. In. Boss (Ed), Vegetable Crops, Naya Prokash, India. 1993;470-488.
7. Muhammad AA, Muhammad A. Influence of mother root size and planting spacing on carrot seed production. Pakistan Journal of Research in Sciences, Pakistan. 2002; 13(2):105-112.
8. KNARDA. Kano State Agricultural Development Agency, Year Book; 2003.
9. UBRBDA. Upper Benue River Basin Development Authority, Annual Statistics; 2013.
10. Parraga MS. Effect of organize matter on quantity and quality of roots in radish (*Raphanus sativus* L) Seminar (Londrina). 1995;16:80-85.
11. Huchmuth GJ, Brecht JK, Bassett JK. NPK fertilizer to maximize radish yield on a sandy soil. Horticultural Science Journal. 1999;34(4):641-645.
12. Balooch B. Study of the relationship between relative growth rate and NPK content during Radish (*Raphanus sativus* L) growth: Effects of nutrient and radiation levels. Journal of Agronomy. 1998;16:529-539.
13. Sarker NK. Effect of NPK fertilizer growth and yield of radish. Journal of Progressive Agricultural Science. 1989;1(5):544-545.
14. Ali MA, Hossain MA, Mondal MF, Farooque AM. Effect of nitrogen and potassium on yield and quality of radish. Pakistan Journal of Biological Science. 2003;6(18):1574-1577.
15. Banga O. Field trials with round red radish. Horticultural Abstract. 1953;23(4):626.
16. Yousaf M, Shafi M. Evaluation of some exotic varieties of radish. Horticultural Abstract. 1971;41(12):476.
17. Shoe Maker JS. Vegetable growing. John Wiley and Sons, Inc., N.Y.P. 1949;15.
18. Sharma AK. Effect of nitrogen and phosphorus on seed yield in reddish. Agricultural Science Digest. 20: 46 - 49
19. Uddin GR, Bodnar WH. Some growth response of radish (*Raphanus sativus* L) to different nutrient. Horticultural Abstracts. 2004;44(4):209.
20. Jadhao BJ, Kulwal LV, Mahakal KG. Effect of nitrogen, phosphorus and potassium on growth and seed yield of radish (*Raphanus sativus* L.). Vegetable Science Journal. 1999;26(1):95-96.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/19103