Journal of Sustainable Agriculture and Biosystems Engineering
Journal homepage: https://talenta.usu.ac.id/jsabe

Interactive Effects of sowing methods, Phosphorus Fertilization and Varieties on Chickpea (Cicer erietinum L.) Yields Growth in Vertisols

Julius Jackson Nyaombo*[1], Amos Enock Majule[2]

[1]Department of Geography, Archbishop Mihayo University College of Tabora (Constituent College of St. Augustine University of Tanzania), P. O Box 801, Tabora, Tanzania
[2]Institute of Resources Assessment, University of Dar es Salaam, P.O Box 35097, Dar es Salaam, Tanzania
*Corresponding Author: juliusnyaombo@gmail.com

ARTICLE INFO

Article history:
Received 10 July 2024
Revised 11 November 2024
Accepted 18 November 2024

E-ISSN: 3026-4065

How to cite:
J. J. Nyaombo and A. E. Majule, "Interactive Effects of sowing methods, Phosphorus Fertilization and Varieties on Chickpea (Cicer erietinum L.) Yields Growth in Vertisols", Journal of Sustainable Agriculture and Biosystems Engineering, Vol. 02, No. 01, 2024.

ABSTRACT

Field experiments were conducted in farming seasons 2020/2021 2021/2022 and 2022/2023 to investigate the effects of fertilization, varieties and sowing methods and their interactions on yield attributes of chickpea on vertisols in Tanzania. Three desi type chickpea varieties (Local check-1, Mwanza-1 and Ukiriguru-1), two fertilizer rates sources (50 and 60 kg P_2O_5 and control fertility) and three sowing methods (Spacing [30x10]cm, sowing behind plough and broadcasting) and their interactions were evaluated. Experiments were conducted in a factorial arrangement of three replicated randomized complete block design. The size of each plot was (3x3) m. At Tukey's 95% confidence interval, results reveled that fertilization was significant at ($p<0.001$) on plant population at harvest, biological yield and grain yield while varieties were significant at ($p<0.001$) on number of seeds per pod and 500 seeds weight as well as at ($p=0.002$) on grain yield. 50 kg/ha of 60 kg P_2O_5 Kg/ha and 50 kg P_2O_5 kg/ha resulted to 1,255 kg/ha and 709 kg/ha with a least performance recorded on control fertility resulting to 616 kg/ha. On varieties, Ukiruguru-1 resulted to 1,040 kg/ha while Local variety and Mwanza-1 resulted to 735kg/ha and 804 kg/ha respectively. It was concluded that yield attributes of chickpea improved with seed varieties and fertilizer use whereby Ukiruguru-1 resulted to maximum yield per ha as well as 60 kg P_2O_5 Kg/ha resulted to maximum yield per ha. Therefore, Ukriguru-1 may be cultivated along with 60 kg P_2O_5 for maximum chickpea yield. Further studies are recommended for appropriate spacing.

Keyword: Chickpea, Phosphorus, Sowing methods, Fertilization, Vertisols

10.32734/jsabe.v2i01.17313

1. Introduction

Currently chickpea (Cicer arietinum L.) is grown and utilized in semi-arid areas as among the primary source of human and animal food providing high level of protein nutrients [1] and also enhancing the productivity of agricultural cropping system [2]. Chickpea is a legume crop with high tolerance ability to drought condition grown largely in semi-arid and arid areas across continents and countries including India, Asia and Africa [3, 4]. Despite of having higher nutrient and economic value, chickpea is climate resilient crop grown in low cost compared to other crops [5]. Since its roles in improving soil quality by nitrogen fixation, its adaptive role in climate change, and its nutritional value, income generation the rate of adoption in various regions is rapidly growing [4, 6]. Large producer of chickpea in Africa and sub-Saharan region is Ethiopia with promising expansion in terms of production in other countries including Tanzania, Kenya, Malawi, South Sudan and Niger [7]. In Tanzania, almost 105,000ha of arable land is used for cultivating chickpea in the semi-arid areas of Shinyanga, Kigoma, Mwanza, Mara, Tabora, Singida, Manyara and Kagera [8].

Improvement in chickpea production including quantity and quality has been accounted over various factors in which the use of fertilizers, irrigation, use of improved varieties, appropriate spacing and timely sowing have shown significant contribution in various global locations. Improved seeds in agricultural production have been showing good response for better yields though their response is much dependent to local agro ecological condition. Improved chickpea seeds have shown potential influence on grain yield when utilized in appropriate environment [9]. Chickpea farmers in Tanzania are dominantly using local seeds which are readily available and accessible among them though the National Agricultural Research Institute in its Ukiriguru Research Centre has managed to produce one improved variety of large desi type seeds (Ukiriguru 1) which have gained little usage among farmers in lake zone areas where the crop is cultivated.

Fertilizer application in dryland farming is inevitable. Since chickpea is largely grown in semi-arid and arid areas it is therefore crucial to use fertilizer for deeper roots penetrations, increasing water extraction by the crop and enhancing proper growth attributes of the crop [10]. Studies indicate the optimum production of chickpea is 4 ton/ha when application of fertilizer is appropriately done [11, 12]. The study by [13] indicated that fertilization of Phosphorus with little Nitrogen proved higher production of chickpea in which level of phosphorus varies based on soil condition and locality.

Sowing methods poses a great influence over agricultural production. Over others, appropriate spacing has proved to be much potential enhancing better growth and yield attributes of various agricultural crops. Spacing in chickpea has currently shown positive contribution based on agro ecological regions and locality [12].

Various studies carried, focused on one of the selected methods while few considered the interaction effect of the practices and in particular in the region where this study was carried, there is no prior study which examined the influence of the selected practices and their interaction effects over yield attributes of chickpea plant. This study was therefore conducted to examine the effect of the interaction of seed varieties, sowing methods and fertilizer application on yield attributes under agro-environment on vertisols of Itigi in Tanzania.

2. Methods

The trial was carried at Itigi District involving three farmers' fields found in central parts of Tanzania. Field one was located in 5°45'22" S and 34°29'5" E while the second field was located in 5 41' 3" S and 34 30' 39" E and third field was located in 5 44' 51" S and 34 28' 59" E having a minor varied elevation of 1300, 1310, and 1290m respectively. The physical and chemical properties of study soils were examined and the status is presented in Table 1. The area experiences rainfall season from the late of December to early March in which the annual average range is 500 to 700mm. The area experience longer dry season as from April to early December [4, 5]. An experiment was carried from March to August in all three seasons as from sowing to harvest in which temperature and Rainfall were observed and recorded in each site as presented in Table 1.

Selected farmers' fields for trial were subjected to two times tillage followed by hallowing done by tractor. The first tillage is normally done by burying weeds which is locally known as Kuvundika. Block ridges and preparation of flat seedbed for experiment were prepared by hand hoes.

Split-plot design was used in three replications. The three sowing methods including broadcasting, sowing behind plough and spacing (30 x10) cm were used in main plots while seed varieties (Local variety, Mwanza-1 and Ukiriguru-1 and fertilization (Control fertility, 50 and 60 kg P_2O_5 kg/ha) were applied in sub-plot. The size of each subplot was 3m x 3m. seed sowing was done by hand in all three methods. In each subplot, harvesting was done in inner rows leaving each bordering row. Yield attributes observed and recorded by the study included number of grains per capsule, plant population at harvest, seed index, biological and grain yield. The attained data were subjected to Analysis of Variance (ANOVA) using the Genstat procedure statistical version 18.2. Data were sorted, quantified and filled in excel sheet for analysis.

Table 1. Physical and chemical soil properties (0 – 40 cm depth) of trial farms at Itigi, Tanzania.

Parameter			Minimum	Maximum
Physical parameters	Sand	%	15	29
	Silt		11	17
	Clay		54	72
	Depth	cm	110	144
Chemical parameters	Ph	H_20	6.37	8.00
	EC	ms/cm	0.16	0.83
	OC	%	1.01	1.59
	OM		1.74	2.73
	N		0.05	0.08
	Av. P	mg/kg	0.54	2.10
	Ca	cmol(+)/kg	13.34	19.35
	Mg		0.35	13.34
	K		0.56	17.52
	Na		0.02	0.85
	CEC		25.46	167.42

Source: IITA Dar es Salaam Soil Lab (2021/2022).

3. Figure Placement

3.1. Weather

The study area is located in semi-arid agro ecological environment. The observed weather parameters during the study were temperature and rainfall (Table 2). In terms of rainfall, the experimental area received total amount of 161.70mm of rainfall during the experimental period as from the march to august in which from May to August there was rainfall while the recorded amount was received in march and April only. The areas experiences experience minimal variation in terms of monthly maximum and minimum temperatures as indicated in Table 2. Generally, the climatic condition of the study areas provides supportive environment for the cultivation of the chickpea.

Table 2. Monthly total rainfall, monthly mean, maximum and minimum temperature in the study sites.

Month	Total Rainfall (mm)	Maximum Temperature (℃)	Minimum Temperature (℃)	Mean Temperature (℃)		
				Monthly	Maximum	Minimum
March	100.45	32	18	25	29.5	19.7
April	61.25	32	17	24.5	29.8	19
May	00	30	15	22.5	28.4	17.2
June	00	29	13	21	26.5	16.5
July	00	29	12	20.5	26.3	14.9
August	00	29	13	21	27.1	15.3

Source: Tanzania Meteorological Authority.

3.2. Sowing method, varieties and different phosphorus levels on chickpea yield attributes.

Different levels of phosphorus and sowing methods were highly significant ($p<0.001$) on plant population at harvest while seed varieties were not significant ($p=0.894$) on the respective attribute (Table 3). levels of phosphorus and varieties were highly significant ($p<0.001$) on biological yield while sowing method was insignificant ($p=0.063$). Grain yield was significantly influenced by phosphorus levels ($p<0.001$) and seed varieties ($p=0.002$) while less significant to sowing method ($p=0.334$). seed varieties and sowing method were highly significant ($p<0.001$) on seed index while levels of phosphorus were not significant ($p=0.280$) on seed index (Table 4).

3.3. Analysis of Variance (ANOVA) of variety (V), Fertilization (F) and Sowing method (S) and their interaction response of chickpea yield attributes at Tukey's 95% confidence interval.

The effect of two factors interaction of levels of phosphorus and seed varieties were not significant ($p=0.731$,

Journal of Sustainable Agriculture and Biosystems Engineering Vol.02, No.01 (2024) 034–040

p=0.571, p=0.120) on plant population at harvest, biological yield and seed index respectively while highly significant ($p<0.001$) on grain yield (Table 3 and 4). The interaction of phosphorus levels and sowing methods was highly significant ($p<0.001$) on plant population at harvest while less significant (p=0.077, p=0.557, p=0.993) on biological yield, grain yield and seed index respectively. Two factors interaction effects of seed varieties and sowing methods was significant (p=0.002) on plant population and less significant (p=0.854, p=0.269, p=0.229) on biological yield, grain yield and seed index respectively.

Table 3. Analysis of Variance (ANOVA) of variety (V), Fertilization (F) and Sowing method (S) and their interaction response of chickpea yield attributes at Tukey's 95% confidence interval.

Source	PPH	SPP	BY	GY	SI
Fertilizers (F)	<0.001	0.524	<0.001	<0.001	0.280
Variety (V)	0.183	<0.001	<0.001	0.002	<0.001
Sowing method (S)	0.001	0.728	0.063	0.334	<0.001
F x V	0.731	0.451	0.571	<0.001	0.120
F x S	<0.001	0.909	0.077	0.557	0.993
V x S	0.002	0.451	0.854	0.269	0.229

Note: PPH = Plant population at harvest, BY = biological yield, GY = grain yield, SI = seed index, SPP = number of seeds per pod. Analysis at Tukey's 95% confidence Intervals.

Table 4. Mean of yield attributes of chickpea as influenced by fertilizer use, variety and sowing method.

Factor		PPH	SPP	BY	GY	SI
Fertilizer (F)	Fert. Control	165.6	1.40	1295	615.5	101.1
	P_2O_5 (60 kg/ha)	205.1	1.51	1314	708.9	102.7
	P_2O_5 (50 kg/ha)	157.6	1.48	2295	1254.6	107.5
Variety (V)	LV1	164.5	1.07	1480	735.1	70.1
	MWZ 1	176.2	1.40	1525	803.6	83.8
	UK1	178.6	1.92	1899	1040.3	157.4
Sowing method (S)	Broadcasting	150.7	1.40	1603	795	96.8
	Spacing	175.7	1.51	1742	926	113.4
	SBP	192.9	1.48	1559	858	101.1

Note: DAP = Diammonium Phosphate, LV1 = Local variety 1, MWZ 1 = Mwanza variety, UK1 = Ukiriguru variety, SBP = Sowing behind plough, PPH = Plant population at harvest, BY = Biological yield, GY = grain yield, SI = seed index.

3.4. Other observed parameters

The study observed growth attributes of the chickpea plant as per experimental plots. Chickpea growth attributes observed included germination percentage, number of leaves, number of branches, pods per plant, seeds per pod, plant height, plant population at germination and at harvest, biological yield, grain yield and 500 seed weight. Statistically at Tukey's 95% confidence interval as indicated in Table 5, phosphorus levels were significant ($p<0001$) to germination percentage, number of leaves, number of branches, number of pods per plant, plant population at harvest, biological yield, grain yield and (p=0.006) on plant height. For seed varieties, they were significantly influencing ($p<0.001$) number leaves, number of seeds per pod, plant height, biological yield, 500 seeds weight and (p=0.002) on grain yield. On sowing methods, they were significant ($p<0.001$) on number of pods per plant, plant population at harvest and 500 seed weight.

Table 5. Analysis of Variance (ANOVA) of variety (V), Fertilization (F) and Sowing method (S) and their interaction response of chickpea growth attributes at Tukey's 95% confidence interval.

Source	GP	NL	NB	NPP	NSP	PH
Fertilizers (F)	<0.001	<0.001	<0.001	<0.001	0.524	0.006
Variety (V)	0.422	<0.001	<0.001	0.894	<0.001	<0.001
Sowing method (S)	>0.05	0.515	0.824	<0.001	0.728	0.013
F x V	0.927	>0.05	<0.001	<0.928	0.451	0.002
F x S	<0.001	>0.05	0.172	<0.001	0.909	0.248
V x S	0.59	>0.05	0.371	0.999	0.451	<0.001

Note: GP = Germination Percentage, NL = Number of Leaves, NB = Number of Branches, NPP = Number of Pods per Plant, NSP = Number of Seeds per Pod, PH = Plant Height, F = Fertilizer, V = Variety, S = Sowing Method. Analysis at Tukey's 95% confidence Intervals.

The interaction effect of levels of phosphorus and seed varieties was significant ($p<0.001$) on number of branches and grain yield, and significant ($p=0.002$) on plant height. Interaction effect of phosphorus levels and sowing methods was significant ($p<0.001$) on germination percentage, number of pods per plant and plant population at harvest. Interaction of variety and sowing method was significant ($p<0.001$) on plant height.

3.5. Discussion

In Tanzania particularly in agro-ecological zones where chickpea is grown is normally cultivated immediate after the end of the rain seasons utilizing retained moisture as in other countries like Ethiopia and India as reported by [14]. Largely, the crop is grown under rainfed condition affected by shifting rainfall season, deteriorating of soil fertility, un-mechanization, inappropriate farming practices and use of local seed varieties and therefore such factors lowering chickpea production in vertisols of Tanzania [5].

Primary and secondary soil nutrients determine and enhances agricultural productivity of various crops in which various studies indicated that limited availability of soil nutrient and micronutrients leads to underproduction of agricultural crops [5, 15]. Soil nutrient insufficient is a notable abiotic factor affecting yield attributes of chickpea grown in varied agro ecological zones [16]. Chickpea responds well in terms of growth and yield attributes when applied with P fertilizers as revealed by the study of [17]. The study by [18] revealed that, chickpea agronomic characteristics including number of branches, pods and plant population at harvest responded positively when fertilized with Phosphorus compared to other fertilizer components. The advantage of P fertilizer over control and other fertilizer elements is indicated in the study by [13] and [2] that higher biological and grain yields were experimentally found with P fertilizer at a rate of 24 – 60 Kg/ha. Long term experiment conducted to test the effect of P on growth and yield attributes of chickpea suggest further on the interaction effect of P and K on chickpea due to the fact that the interaction has been leading to higher positive response of the agronomic of chickpea plant [2].

The study by [14. 19] emphasizes the advantage of appropriate sowing method and proper timing in sowing in which spacing enhances chickpea germination percentage, plant population during growth and at harvest. Spacing provide adequate growth space for chickpea growth parameters in which literature reveals that appropriate spacing in chickpea enhances number of branches, leaves, pods and determines the number of chickpea plant arriving to full maturity in harvesting stage [20]. Also, seed index, grain yield and biological yields are enhanced positively by the date of sowing and spacing over other sowing methods [21].

Studies of chickpea varieties have recently shown significant variation in production. Improved varieties are currently enhancing higher agricultural production in varieties of crops when grown under optimum conditions. Several studies carried indicate that variety respond differently and significantly particularly in plant phenology, components of chickpea yield and yield itself where by improved varieties show more promising production comparatively to local varieties [22]. Variety has further affected significantly on seed index and number of days to maturity as improved varieties are showing better results in terms of seed index and grows in fewer number of days to maturity comparatively to local varieties [23].

4. Conclusion

The effect of phosphorus rates and seed varieties differed significantly on growth and yield attributes and potentially P_2O_5 fertilization at a rate of 60 kg/ha influenced higher plant population at harvest and resulted to higher biological and grain yields. Also, Ukiriguru 1 variety leads to higher yields including biological and grain. Interaction effects results conclude higher yields 60 kg/ha of P_2O_5 and Ukiriguru-1 variety. Spacing (30x10)cm could not provide significant variation on yield attributes of chickpea in comparison to other sowing methods and therefore the study recommends for other long-term experiments for other spacing ratio suitable to the study area agro-ecological zone.

5. Acknowledgements

Authors wish to thank Mr. Wilson Maselle (Agronomist) from College of Agricultural Sciences and Food Technology of the University of Dar es Salaam for his technical assistance during carrying out of the study.

6. Conflict of Interest

Authors have declared that no competing interests exist.

References

[1] C. L. Amaral, B. Pavan, F. C. M. Pereira and P. L. C. Alves, “Periods of weed interference in chickpea grown under different does of nitrogen fertilizer topdressing,” Acta scientiarum Agronomy. Vol. 40: 10pp. 2018.

[2] S. A. Badini, M. Khan, S. U. Baloch, S. K. Baloch, H. N. Baloch, W. Bashir, A. R. Badini and M. A. Badini, “Effect of phosphorus levels on growth and yield of chickpea (Cicer arietinum L.) varieties,” Journal of Natural Sciences Research Vol.5 no. 3, pp. 169-176. 2015.

[3] J. J. Nyaombo, “Pulses farming: an adaptive strategy to climate change in arid and semi-arid regions, A case study of Itigi District in Singida Region, Tanzania,” IntechOpen. 2022.

[4] J. J. Nyaombo, “Vertisols Pedological characterization: Soil morphology, properties, classification and fertility levels,” Asian Journal of Soil Science and Plant Nutrition, Vol. 10 no. 3, pp. 208-221. 2024.

[5] J. J. Nyaombo and A. E. Majule, “Characterization of vertisols fertility status and their implications on chickpea (Cicer arietinum L.) farming in semi-arid areas of Itigi District in Tanzania,” Indonesian Journal of Agricultural Research, Vol. 5, no. 2, pp. 109-120. 2023.

[6] S. Elis, S. Ipekesen, F. Basdemir, M. Tunc and B. T. Bicer, “Effect of different fertilizer forms on yield and yield components of chickpea varieties,” International Journal of Agriculture, Environment and Food Sciences, Vol. 4, no. 2, pp. 209-215. 2020.

[7] A. Fikre, H. Desmae and S. Ahmed, “Tapping the economic potential of chickpea in Sub-Saharan Africa,” Agronomy, pp. 22. 2020.

[8] S. Rasool, A. H. Abdel and P. Ahmad, “Chickpea: Role and responses under abiotic and biotic stress,” John Wiley and Sons Ltd, pp. 67–79. 2015.

[9] S. Verkaart, B. G. Munyua, K. Muasch and J. D. Michler, “Welfare impacts of improved chickpea adoption: A pathway for rural development in Ethiopia?” Food Policy, vol.66, pp. 50-61. 2017.

[10] D. K. Kamithi, A. M. Kibe, and T. E. Akuja, “Effects of nitrogen fertilizer and plant population on growth, yield and harvest index (HI) of chickpea (Cicer arietinum L.) under dryland conditions in Kenya,” Journal of Applied Biosciences, Vol. 22, pp. 1359-1367. 2009.

[11] ICRISAT, “Annual Report 1988. International Crop Research Institute for Semi-Arid Tropics,” Patancheru, India. 57-82. 1988.

[12] A. A. Bahr, “Effect of plant density and urea foliar application on yield and yield components of chickpea (Cicer arietinum L.),” Research Journal of Agriculture and Biological Sciences. Vol. 3, no. 4, pp. 220-223. 2007.

[13] A. Ali, Z. Ali, J. Iqbal, M. A. Nadeem, N. Akhtar, H. M. Akram and A. Sattar, “Impact of nitrogen and phosphorus on seed yield of chickpea,” Journal of Agricultural Research vol. 48 no. 3, pp. 335-343. 2010.

[14] G. Agegnehu and W. Sinebo, “Drainage, sowing data variety effect on chickpea grown on a Vertisol in Ethiopia,” Archives of Agronomy and Soil Science, Vol. 58, no. 1, pp. 101-113. 2012.

[15] E. Drostkar, R. Talebi and H. Kanouni, “Foliar application of Fe, Zn and NPK nano-fertilizers on seed yield and morphological traits in chickpea under rainfed condition,” Journal of Research in Ecology, vol. 4, no. 2, pp. 221-228. 2016.

[16] D. Dutta and P. Bandyopadhyay, "Performance of chickpea (Cicer arietinum L.) to application of phosphorus and bio-fertilizer in laterite soil," Archives of Agronomy and Soil Science, vol. 55, no. 2, pp. 147-155. 2009.

[17] L. R. Meena, R. K. Singh and R. C. Gautam, "Yield and nutrient uptake of chickpea (Cicer arietinum) as influenced by moisture conservation practices, phosphorus levels and bacterial inoculation," Legume Res. Vol. 26, pp. 109–112. 2003.

[18] A. Akay, "Effect of zinc fertilizer applications on yield and element contents of some registered chickpeas varieties," African Journal of Biotechnology, Vol. 10, no. 60, pp. 12890-12896. 2011.

[19] J. J. Nyaombo, "The effect of selected agronomic practices on chickpea (Cicer arietinum L.) production in vertisols and farmers livelihood in Itigi District, Tanzania", PhD thesis, University of Dar es Salaam, Dar es Salaam, Tanzania, 2023.

[20] J. Amin, K. Mubeen, M. Ahmad, M. Aziz and M. Arif, "Strip intercropping system of chickpea, lentil and arugula crop as a promising option in spate irrigated area of Punjab, Pakistan,". Asian Journal of Agriculture and Biology, vol. 7, no. 2, pp. 224-233. 2019.

[21] B. R. Ayana, "Response of chickpea (Cicer arietinum L) to land preparation methods and sowing dates on vertisols of Southern and southeastern Ethiopia," vol. 4, no. 5, pp. 17-26. 2014.

[22] T. Mekuanint, Y. Tsehaye and Y. G. Egziabher, "Response of wo chickpea (Cicer arietinum L.) varieties to rates of blended fertilizer and row spacing at Tselemti District, Northern Ethiopia," 2018.

[23] R. Purushothaman, H. D. Upadhyaya, P. M. Gaur, C. L. L. Gowda and L. Krishnamurthy, "Kabuli and desi chickpeas differ in their requirement for reproductive duration. Field Crop Research," 163: 24-31. 2014.