Nourrir le Monde sans l'empoisonner

FEEDING THE WORLD WITHOUT POISONING

Scientific Track Proceedings of the 6th West African Organic Conference/
6ème Conference Ouest Africaine De L'agriculture Biologique
November 23-26, 2021, Royal Beach Hotel,
Ouagadougou, Burkina Faso

EDITORS
ADEOLUWA, O.O.
OLOGUNDUDU, O.M.
OLOORE, N.O.

Published by

NOARA
Network of Organic Agriculture Researchers in Africa

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Burkina Faso 2021

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Objectives of the Conference

The potential of organic agriculture in the transformation of national and regional economies, ecologies and livelihoods through income growth, climate change adaptation, food sovereignty and trade is explored and showcased.

The sharing of knowledge, information, experiences and skills among all stakeholders in the organic sector is facilitated, especially between West-African farmers and their national and sub-regional representations is facilitated.

Scientific evidence is presented on the capability of organic agriculture in contributing to the transformation of national and continental economies, enhancement of systems resilience and mitigation of climate change, among others.

The uptake of organic alternatives through south-south collaboration, especially, in the sharing of experiences is encouraged. Organic produce and products are exhibited to stimulate national, regional and international trade and link producers to markets. The conference is showcased and publicised to create awareness, obtain support and buy in among policy makers, organic stakeholders and the general public.

6TH WEST AFRICAN ORGANIC CONFERENCE Burkina Faso 2021

About US

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NOARA

Network of Organic Agriculture Researchers in Africa

RESEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE

شبكة الباحثين في الزراعة العضوية بإفريقيا

The Network of Organic Agriculture Researchers in Africa (NOARA) was established to unite and coordinate African organic and ecological agriculture scientific and technical researchers within and outside Africa. The network is an African initiative.

NOARA is a network independently established by African organic researchers that met at Modena, Italy, in 2005 but was later launched in 2009, during the 1st African Organic Conference in Kampala. During the 2nd African Organic Conference (2nd AOC) held in Lusaka, Zambia, in May 2012, a side event brought together participants from almost all regions of Africa and Europe to discuss how to develop organic agriculture research agenda. Research was underscored as a critical component of any initiative designed to promote ecologically sustainable development of agriculture in Africa.

The 4th AOC in 2018 General Assembly at Saly, Senegal, recommended AfrONet to revive NOARA and probably re-organize the Network for effectiveness in its expected roles. A Coordinator was therefore appointed in March 2019 to build NOARA and ensure proper functionality of the Network.

NOARA VISION

Africa with zero hunger, poverty eradicated, improved livelihoods and sustained ecosystem through innovative organic and ecological agriculture research.

NOARA MISSION

To generate and disseminate sound evidence-based scientific organic agricultural knowledge that can ensure healthy, ecological, fairness and care of organic agriculture actors in Africa for sustainable livelihood and ecosystem, leading to food security, income and sustainable development.

NOARA SPECIFIC OBJECTIVES AND RESEARCH PRIORITIES

Thematic area 1: Research and Training

i. Lead research agendas on organic and ecological agriculture in Africa.
ii. Coordinate organic and ecological agriculture training and research in Africa.
iii. Support or initiate research activities that will contribute to the social, cultural and economic productivity of Africa's smallholder farmers, processors and marketers, particularly, women and youths who have been largely marginalized.
iv. Demonstrate success stories useful for up scaling organic and ecological agricultural practices.

Thematic area 2: Policy and Stakeholders' Engagements

i. Promote collaboration among organic and ecological agriculture researchers, practitioners, farmers and policy makers in Africa.
ii. Foster improved ecological organic agriculture database, to influence policy development in Africa.
iii. Advocate for the mainstreaming of organic and ecological agriculture into agricultural research and innovation to enhance food security in Africa.
iv. Engage organisations producing organic and ecological inputs in confirmatory and adaptive research for possible recommendation of their products to end users in Africa and beyond.

Thematic area 3: Conferences and Information Dissemination

i. Organize conferences and meetings for the exchange of information on organic and ecological agriculture.
ii. Publish research and technical results on organic and ecological agriculture.
iii. Organise consortia of experts to address specific or emerging issues relating to organic and ecological agriculture in Africa.

Thematic area 4: Networking, Advocacy and Awards

i. Enhance partnerships for organic and ecological agriculture research in Africa and beyond.
ii. Map out like-minded organisations.
iii. Honour distinguished members as fellows of the network.
iv. Represent the interest of organic and ecological agriculture researchers within and beyond Africa.

NOARA KEY SERVICES

Some of NOARA key functions to meeting the stated objectives includes to: (within and outside Africa)

a. Undertake lobbying and advocacy on organic and ecological agriculture research at high levels.
b. Support capacity building for key players in organic and ecological agriculture across the continent.
c. Mobilize resources for NOARA's endeavours in promoting organic agriculture on the continent.
d. Spearhead organic agriculture research, extension, training and value chains and market development.
e. Provide management and administrative consultancy to like-minded programmes and partners on organic agriculture research; and,
f. Undertake any other functions as deemed necessary to address NOARA's objectives.

Membership

NOARA is a membership Network that draws members from national, regional, continental and international organic agriculture organisations, associations, networks and companies within and outside Africa, but whose aims and goals are in support of organic and ecological agriculture.

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY (ISSN: 2734-2913)

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

African Journal of Organic Agriculture and Ecology (AJOAE) is a journal of Organic Agriculture and Ecology published biannually to create an effective medium for dissemination of information on organic agriculture research findings in all areas of Agriculture, Food sciences and Ecology. The Journal International Standard Serial Number (ISSN) is 2734-2913.

Scope

Contributions may be on Agricultural Economics, Agricultural Engineering, Agricultural Extension, Agroforestry, Animal science, Crop/Environmental protection, Crop science, Environmental Sciences, Fishery/Aquaculture, Pharmacy, Soil science, Veterinary Medicine, Wildlife Management.

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The Editor-in-Chief
African Journal of Organic Agriculture and Ecology
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Residual Effect of Different Phosphorus Sources on Growth and Nodulation of Soybeans

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Keywords:
Growth, Location, Nodulation, Phosphorus, Source, Soybeans

Access online at:
www.waoc.bio OR
www.noara.bio

Published by
NOARA
Network of Organic Agriculture Researchers in Africa

Abstract

A pot experiment was carried out at the screen house of the School of Agriculture and Agricultural Technology, Gidan Kwano campus, Minna during the cropping season of 2020. The research aimed at evaluating the effect and residual effect of different phosphorus sources on the growth and nodulation of soybean. Four seeds of TSB 4810 variety of soybean were planted per pot containing 2 kg of soil collected from 3 locations. A week after sowing plant was thinned to two seedings per pot. This was followed with the application of N, P, K, Mg and micro nutrients (B, Mo, Zn). Thereafter, the crop was fertilized as follows: control at 0 kg P ha^{-1}, organic P of bone meal source at 30 kg P ha^{-1}, inorganic P of Single Super Phosphate at 30 kg P ha^{-1} and AMF *Glomus Intaradices* (4 g pot $^{-1}$) received by soils obtained from Maikunkele, Maitumbi and Gidan Kwano. Treatments were then arranged in a Completely Randomized Design (CRD) replicated three times. Data collected were subjected to Analysis of Variance (ANOVA). Means were separated using Least Significant Different (LSD). Results obtained at first planting showed that the best shoot and root weights and the second best nodulation characteristics were obtained when organic P of bone meal source was applied. The second planting did not receive fresh doses of fertilizer treatments and the result obtained at the second planting showed that, except for of root weight, inorganic P improved growth and nodulation of the TSB 4810 soybean variety while organic P could not improve any of the growth characteristics compared to the control. Since soybeans performed significantly better at first planting with the application of fertilizer than second planting with residual fertilizer effect. As a recommendation, farmers should therefore apply fresh doses of phosphorus fertilizer yearly.

Effet résiduel de différentes sources de phosphore sur la croissance et la nodulation du soja dans

Résumé

Une expérience en pot a été réalisée à la serre de l'École d'agriculture et de technologie agricole, campus Gidan Kwano, Minna pendant la saison culturale de 2020. La recherche visait à évaluer l'effet et l'effet résiduel de différentes sources de phosphore sur la croissance et la nodulation de soja. Quatre graines de la variété de soja TSB 4810 ont été plantées par pot contenant 2 kg de terre collectée à 3 endroits. Une semaine après le semis, la plante a été éclaircie à deux semis par pot. Cela a été suivi par l'application de N, P, K, Mg et de micronutriments (B, Mo, Zn). Par la suite, la culture a été fertilisée comme suit : témoin à 0 kg P ha-1, P biologique de source de farine d'os à 30 kg P ha-1, P conventionnelle de Super Phosphate Simple à 30 kg P ha-1 et AMF Glomus Intaradices (Pot de 4 g -1) reçu par les sols obtenus de Maikunkele, Maitumbi et Gidan Kwano. Les traitements ont ensuite été disposés dans un plan complètement randomisé (CRD) répliqué trois fois. Les données recueillies ont été soumises à une analyse de variance (ANOVA). Les moyennes ont été séparées à l'aide de la différence la moins significative (LSD). Les résultats obtenus à la première plantation ont montré que les meilleurs poids des pousses et des racines et les deuxièmes meilleures caractéristiques de nodulation ont été obtenus lorsque le P biologique de la farine d'os a été appliqué. La deuxième plantation n'a pas reçu de nouvelles doses de traitements d'engrais et le résultat obtenu à la deuxième plantation a montré que, à l'exception du poids des racines, le P conventionnelle améliorait la croissance et la nodulation de la variété de soja TSB 4810 tandis que le P biologique ne pouvait améliorer aucune des croissances. caractéristiques par rapport au témoin. Étant donné que le soja a obtenu de meilleurs résultats lors de la première plantation avec l'application d'engrais que lors de la deuxième plantation avec un effet d'engrais résiduel. Comme recommandation, les agriculteurs devraient donc appliquer de nouvelles doses d'engrais phosphoré chaque année.

Mots-clés:
Croissance, Localisation, Nodulation, Phosphore, Source, Soja

Introduction

Soybean (*Glycine max* L) is an annual herbaceous plant in the Fabaceae (legume or bean family) (Tefera, 2011). It is reported as the legume with the highest protein content and vegetable oil among the other crops produced (IITA, 2009). Soybean is an important crop component in the farming system of most parts of Nigeria (Olufajo, 1992). According to Olufajo (1992) in the traditional soybean growing areas of Nigeria, soybean is most commonly intercropped with cereal crops like maize, sorghum and millet. Soybeans contribute to enhancing the sustainability of intensified cropping system by improving soil fertility through nitrogen fixation, and soybeans are capable of fixing between 60kg and 168kg of nitrogen per year under suitable conditions (Rienke and Joke, 2005) thereby cutting down on the amount of nitrogen fertilizer to apply on the field in order to improve productivity.

Phosphorus (P) is one of the most important nutrients for soybeans crops, being absorbed from 0.2 to 0.4 kg ha^{-1}. The nutrient participates in many metabolic processes, such as in energy transfer [adenosine triphosphate (ATP)], photosynthesis, respiration and synthesis of nucleic acids and glucose. There are several sources of P in the soil. In this research, we are considering four sources of P namely soil P, organic P (bone meal), inorganic P (SSP) and bio-available P (Arbuscular Mycorrhizal Fungi). Tropical soils are deficient in P due to the poor parent material and strong fixation of P to colloids. Less than 0.1 % of the total is found in solution thereby limiting biomass productivity and adequate levels of available P in the soil. Therefore, phosphate fertilization is paramount in these soils (Akinrinde and Okeleye, 2005). The most important phosphorus sources in arable soils are chemical fertilizers, though 75 to 90 percent of the phosphorus is fixed with iron, calcium and aluminium in soil (Turan *et al.*, 2006). In surface horizons of most soils, P also occurs in organic forms in amounts that can vary widely (from 20% to 90% of the total P). Phosphorus solubilizing bio fertilizers are carrier-based preparations containing living or dormant cells of micro-organisms like Arbuscular mydorrhizal fungi (AMF). AMF helps in increasing crop production by aiding solubilization of insoluble phosphorus and supply of other nutrients, vitamins and other growth factors thereby increasing plant growth (Gaur and Sunita, 2009).

Soybean is essentially sensitive to low phosphorus availability because the biological nitrogen fixation requires high levels of phosphorus. The phosphorus deficiency can limit the nodules formation while the phosphorus fertilization can overcome the deficiency (Akinrinde and Adigun, 2005). Hence this research set out to evaluate the growth and nodulation response of soybean to different phosphorus sources. The objectives are to:

i. Assess the effect and residual effect of phosphorus sources on the growth of soybean
ii. Determine the effect and residual effect of phosphorus sources on the nodulation of soybean

Materials and Methods

Study Area

The experiment was carried out in the screen house of the School of Agriculture and Agricultural Technology, Federal University of Technology Minna. Minna lies within the Southern Guinea Savannah Zone of Nigeria. Minna has a sub-humid climate with a mean annual rainfall of 1284 mm. Minna has an elevation of about 258.5m above sea level (Ojanuga, 2006).

Soil Sampling and Analysis before the first planting

Soils were sampled from three different locations (Maikunkele, Maitumbi, and GidanKwano) and from five farmers' plot per location with the aid of a sterilized auger at 10 points per plot and at 0-15cm soil depth. Soils per location were bulked, homogenized and a large portion was prepared for pot filling while 125g of soil per location was sieved through a 0.5 and 2mm sieve in preparation for physical and chemical properties determination according to standard methods described by ISRIC/FAO (2002).

Soil Sampling and Analysis before the second planting

Two kilograms (2kg) of soils in pots that were used for the first planting were sampled with the help of a sterilized spoon and bulked according to treatment. Bulked soil was air dried in preparation for physical and chemical properties determination according to standard methods described by ISRIC/FAO (2002).

Treatments and Experimental Design

Experiments for both plantings was a 3 x 4 factorial arrangement that is 3 locations (Maikunkele, Maitunmbi and GidanKwano) that received four sources of phosphorus as follows: 30 kg P ha^{-1} of organic phosphorus (0.2 g of bone meal), 30 kg P ha^{-1} of inorganic phosphorus (0.3 g of Single Super Phosphate), Arbuscular mycorrhizal fungi (4 g pot^{-1}) and 0 kg P ha^{-1} (control) fitted to a Completely Randomized Design (CRD) replicated three times. Note that the soils for the second planting were not treated afresh.

Seed Sowing and Crop Management

Planting of TSB4810 was done by sowing four seeds per pot. This was later thinned to two seedlings per pot a week after planting. These pots had earlier received a basal application of 30kg P ha^{-1} as SSP, KCl at the rate of 60kg K ha^{-1}, $MgSO_4$ at the rate of 5kg Mg ha^{-1}, $ZnSO_4$ at the rate of 10kg Zn ha^{-1}, $(NH_4)_2MoO_4$ at the rate of 0.1kg Mo ha^{-1}, $Na_2 B_4 O_7.5H_{20}$ at the rate of 0.1 kg B ha^{-1}, Urea at the rate of 20 kg N ha^{-1} at first planting. Seedlings in the pots were watered with 50-100ml of water when necessary and weeds were hand-picked continuously till termination at 6 weeks after planting.

Harvesting and Data Collection

Harvesting for both first and second planting was done by removing the whole plant from the pot while nodules were detached and counted. The shoots were separated from the roots and the roots was rinsed in water. The shoots and roots were oven-dried to constant weight within 3 days at 65°C

Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) Treatment means were separated using LSD (Least Significant Difference) at a 5% level of probability.

Results

Table 1: Physical and Chemical Properties of Experimental Soil before 1st planting and before 2nd planting

	Before 1st Planting			Before 2nd Planting		
	Maikunkele	Maitumbi	GidanKwano	Maikunkele	Maitumbi	GidanKwano
Soil Parameter						
Particle Size distribution (gkg^{-1})						
Sand	768	778	798	768	778	798
Silt	120	100	80	120	100	80
Clay	112	122	122	112	122	122
Textual Class	SL	SL	SL	SL	SL	SL
pH in H_20 (1:2.5)	5.6	5.0	4.8			
Control				6.40	6.27	6.27
AMF				6.13	6.18	6.38
SSP				5.26	5.10	5.27
BM				7.26	7.18	7.17
Available P	18.55	17.73	13.87			
Control				9.10	13.3	16.8
AMF				15.05	18.9	21.0
SSP				21.05	24.5	25.2
BM				15.05	18.9	21.0
Organic Carbon	3.5	3.4	1.4			
Control				3.36	2.76	3.30
AMF				3.24	3.18	3.48
SSP				3.30	3.60	3.30
BM				3.30	3.18	3.12

SL= Sandy loam, O. C= organic carbon, Available P= available phosphorus, pH in H2O
AMF=Arbuscular mycorrhizal fungi, SSP=Single super phosphate, BM= Bone meal

Table 2: Main Effect of P-sources and Location on Growth and Nodulation of soybean at first planting

Treatment	Shoot Weight (g) $plant^{-1}$	Root Weight (g) $plant^{-1}$	Nodule Number (g) $plant^{-1}$	Nodule Weight (g) $plant^{-1}$
P sources(P)				
Control	1.32	0.44	6.0	0.05
AMF	1.38	0.39	6.0	0.06
SSP	1.47	0.46	13.0	0.10
Bone Meal	1.59	0.72	8.0	0.07
LSD (0.05)	0.34	0.21	3.97	0.04
Location (L)				
Maikunkele	1.48	0.59	9.0	0.07
Maitumbi	1.43	0.47	9.0	0.08
GidanKwano	1.41	0.44	6.0	0.06
LSD (0.05)	0.29	0.18	3.44	0.03
Interaction				
P * L	*	**	NS	NS

Means with the same letters are not significantly different at P > 0.05
NS = Not significant at P > 0.05
*= Significant at P < 0.05
**= highly significant at P < 0.01

Table 3: Effect of interaction between P-sources and Location on Shoot weight (g/plant-1) at first planting

P Source	Location		
	Mainkunkele	Maitumbi	GidanKwano
Control	1.22	1.24	1.51
AMF	1.68	1.34	1.13
SSP	1.07	1.83	1.52
Bonemeal	1.95	1.33	1.48
LSD		0.35	

Table 4: Effect of Interaction between P-source and Location on Root weight (g/plant-1) at first planting

P Source	Location		
	Mainkunkele	Maitumbi	GidanKwano
Control	0.35	0.51	0.45
AMF	0.35	0.45	0.36
SSP	0.38	0.54	0.47
Bone meal	1.29	0.38	0.50
LSD (0.05)		0.22	

Table 5: Main Effect of P-sources and Location on Growth and Nodulation of soybean at second planting

Treatment	Shoot Weight (g) plant^{-1}	Root Weight (g) plant^{-1}	Nodule Number (g) plant^{-1}	Nodule Weight (g) plant^{-1}
P sources(P)				
Control	1.18	0.60	4.0	0.03
AMF	1.12	0.48	1.0	0.01
SSP	1.22	0.34	5.0	0.04
Bone Meal	1.18	0.36	2.0	0.02
LSD (0.05)	0.34	0.15	.154	0.02
Location (L)				
Maikunkele	1.14	0.38	6.0	0.05
Maitumbi	1.22	0.43	1.0	0.01
GidanKwano	1.16	0.53	2.0	0.02
LSD (0.05)	0.29	0.13	1.33	0.02
Interaction				
P * L	NS	NS	*	NS

Means with the same letters are not significantly different at P > 0.05
NS = Not significant at P > 0.05
* = Significant at P < 0.05

Table 6: Effect of Interaction between P- sources and Location on Nodule number plant -1 at second planting

P Source	Location		
	Maikunkele	Maitumbi	GidanKwano
Control	7.0	0.0	3.0
AMF	4.0	1.0	0.0
SSP	9.0	2.0	3.0
Bone meal	4.0	1.0	2.0
LSD (0.05)		0.91	

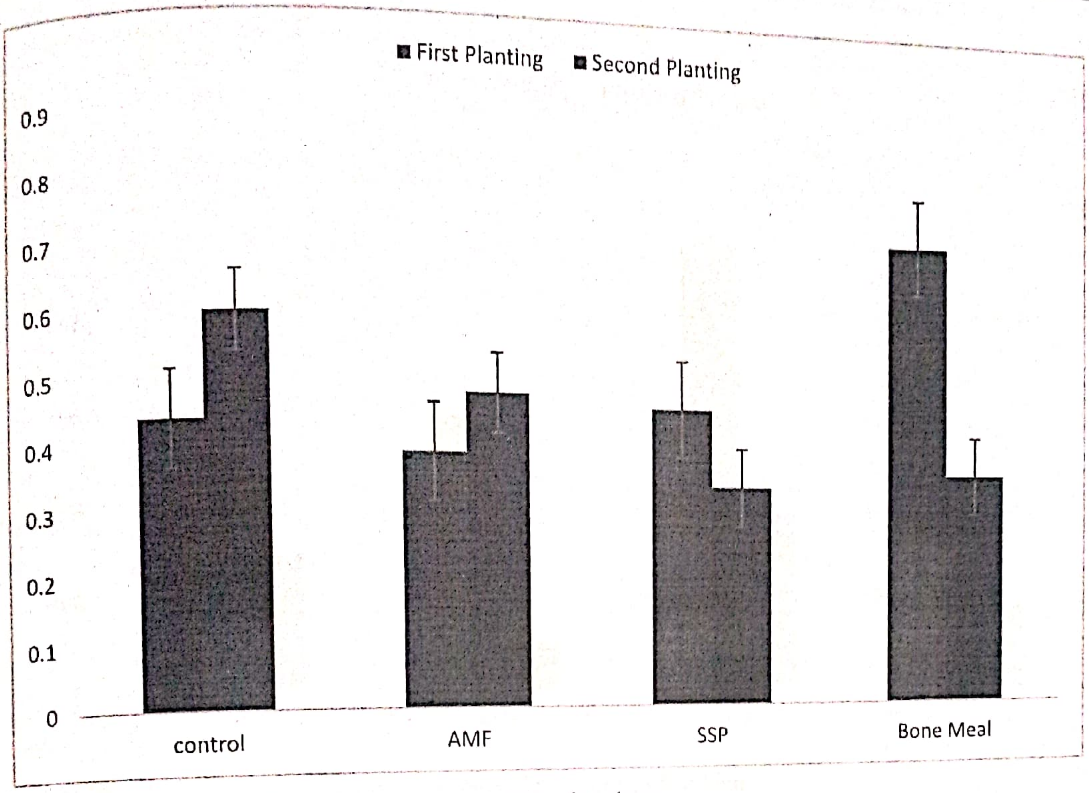

Figure 1: Residual effect of P sources on root weight of soybean

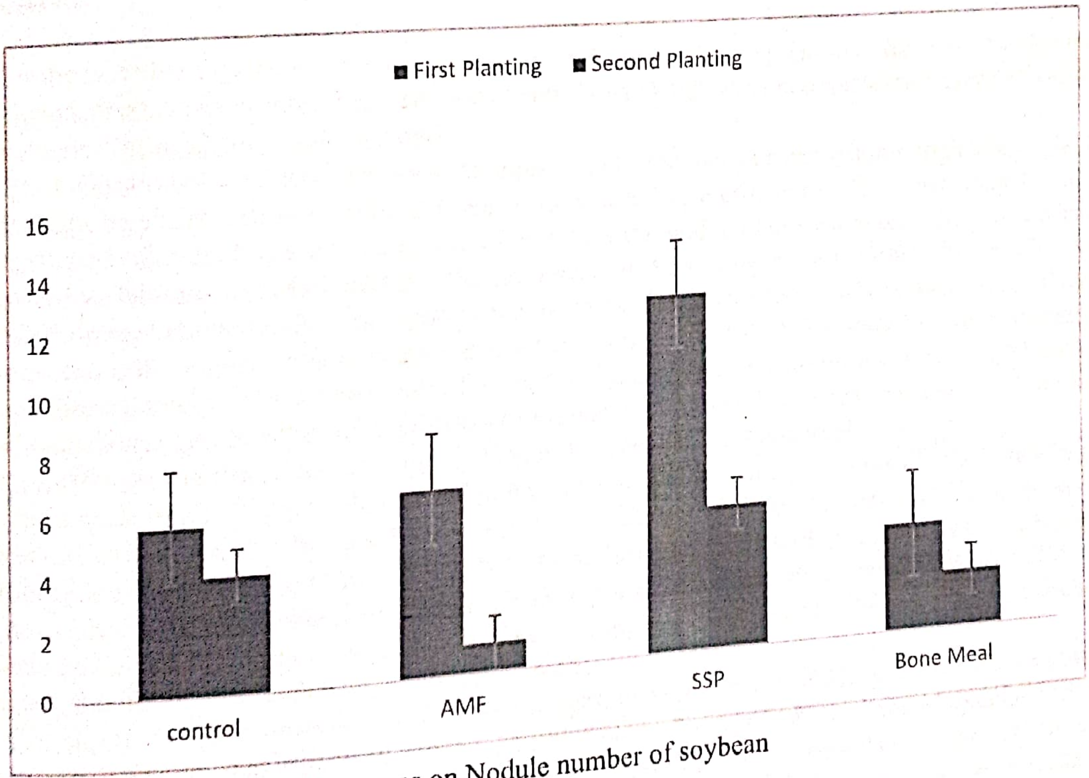

Figure 2: Residual effect of P sources on Nodule number of soybean

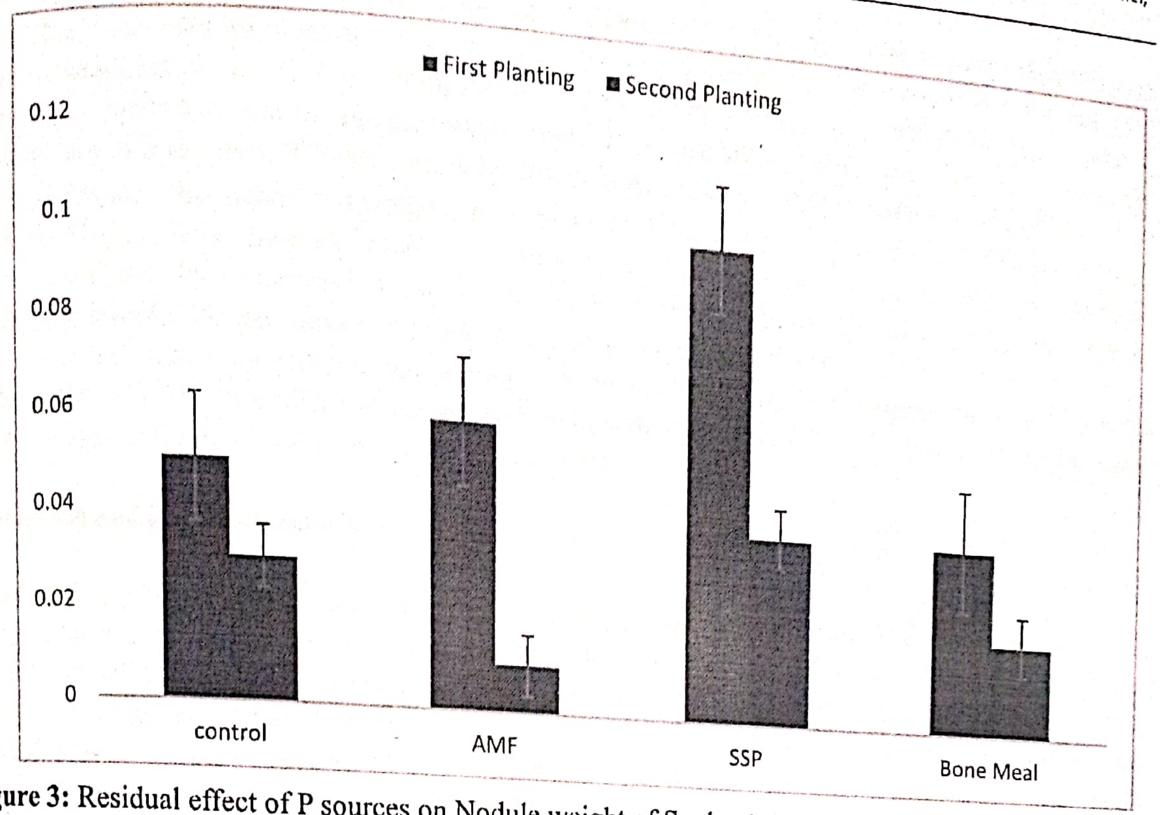

Figure 3: Residual effect of P sources on Nodule weight of Soybean

Discussion

Before the first planting, the soil textural class was sandy loam (Table 1). The textural class of soil before the second planting represented was also sandy loam(Table 1) indicating that soil texture may be fixed for a short period (https://biocyclopedia.com).

The highest shoot weight of plants was obtained in pots receiving no phosphorus application (Table 3). It might be an indication that the soybean variety was P-use efficient (PUE). This result has also demonstrated that the P-use efficiency varied with location with Gidan Kwano recording the highest, followed by Maitumbi and Maikunkele in that arrangement. According to Smith (2003), P-use efficiency is 15-20% in agricultural fields. The highest shoot weights of plants treated with bone meal (Table 3) may be an indication that organic P was most solubilized probably by natural AMF or some kinds of Phosphorus Solubilizing Microbes (PSM). Our result showed that Organic P solubilization also varied with location with Maikunkele recording the highest followed by Gidan Kwano and Maitumbi in that order. Gaur and Sunita (2009) also confirmed the activities of PSM in the release of P in bone meal.

The highest shoot weight of plants receiving inorganic phosphorus application (Table 3) may be an indication that their soil was the most P sufficient. This result has demonstrated that P sufficiency varied with location and also suggested that Maitumbi soil was the most P sufficient, followed by Gidan Kwano and Maikunkele in that arrangement. Smith (2003) reported that P-use efficiency (PUE) of 15-25% in agricultural fields was an indication that most of the soil- applied P remain unavailable to plant and leaches into ground and surface water leading to eutrophication.

Contrary to the trend observed under shoot weight, inoculation with AMF and zero P application produced root weights that were highest at Maitumbi, followed by Gidan Kwano and Maikunkele while the application of inorganic P reversed the order (Table 4). It is worthy to note that the application of P whether organic, bio-available or inorganic source did not always produce superior root weights compared to the control (Table 4). Rather, it was the application of bone meal at Maikunkele and Gidan kwano and the application of SSP at Maitumbi that did (Table 4). Root weights were highest in Maikunkele as a result of bone meal application for the same reason as shoot weight and also because the lowest clay content of Maikunkele soil (Table 1) reduced the binding capacity of its soil, hence improving solubility. Root weights were heaviest in Gidan Kwano (Table 4) as a result of bone meal application probably because of the efficient use of P in the bone meal due to the more acidic nature of their soil (pH in H_20 of 4.8) (Table 1). On the other hand, root weights were heaviest in Maitumbi as a result of the SSP application (Table 4). This might be because leaching was most minimized by the narrower ratio between sand and clay (6:1). Generally, an increase in root weight as a result of P application is because P increases energy storage and transfer via carbohydrate production and accumulation (Rasaq *et al.*, 2017). Similar to the trend observed under shoot weight, application of bone meal produced root weights that were highest at Maikunkele, followed by Gidan Kwano and Maitumbi in that sequence (Table 4). Reasons were the same as for those given for shoot weight response to bone meal.

Conclusion and Recommendations

Figures 1, 2 and 3 showed the residual effect on root weight, nodule number and weights respectively. The second planting produced the best root weights when no P and AMF were supplied to the plants respectively while the first planting produced the best root weights when SSP and bone meal were applied respectively (Figure 1). Regardless of the P source, the 1st planting produced the best nodulation (Figures. 2 and 3). This is surprising, since our results have demonstrated that the 1st planting resulted in improvement of the soil properties (Table 1) so that the 2nd planting was supposed to produce better plants at harvest. This suggested that regardless of P source, P was not efficiently used at the second planting. Although Kep *et al.* (2006) observed that one year after application of SSP in 4 soils, 58% of P application were available, 38% after 2 years and 20% after 3 years, our result has demonstrated that soil Available P was improved by 1st planting at Maikunkele by the addition of SSP, at Maitumbi by the application of SSP, AMF and bone meal respectively and at Gidan Kwano by all the P sources. The second planting could however not take advantage of it. Therefore farmers should continuously apply P fertilizer each time they plant. This is not because of the low residual effect per se, rather because of the low efficiency in the use of P applied in the first planting by crops planted after.

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