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REVIEW PAPER OPEN ACCESS

Palm oil mill effluent, nitrogen and phosphorus management on growth and yield of bambara groundnut (*Vigna subterranea*) - A review

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Abstract

Bambara groundnut (*Vigna subterranea*) has characteristics to grow in the marginal soil and also tolerant into the drought condition and also have potential of nitrogen fixation. Using POME as organic soil amendment was found to improve the soil fertility by providing plant nutrient and organic matter contents to plants, as well as increase the plant growth and yield. Nitrogen is the key plant nutrient that stimulates root and shoot growth. Phosphorus application significantly improves many aspects of plant physiology including photosynthesis, flowering, fruiting and maturation which ultimately result in better yield. Symbiotic nitrogen fixation is a complex process, in which *Rhizobium* bacteria form a beneficial interaction with a legume crop to fix atmospheric nitrogen and convert it to ammonium for plant uptake. Nitrogen and phosphorus enhance soil fertility status and productivity. Application of nitrogen and phosphorus fertilizer exerted significant effect on root development, photosynthesis, yield contributing character and pod yield of the crop. Bambara groundnut yields are low due to abiotic and biotic stresses. But with application of nitrogen and phosphorus increase the yield of this crop. Its seeds contain 63 percent carbohydrate, 19 percent protein and 6.5 percent oil and good source of fibre, calcium, iron and potassium.

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Introduction

Bambara groundnut (*Vigna subterranean*) belongs to the genus *Vigna* and family Papillionaceae (Baudoin and Mergeai, 2001). The potential use of POME as an organic fertilizer may also substitute the excessive application of chemical fertilizers. The heavy metal of POME sludge could be accumulated in plant and soil. Generally all fixed nitrogen goes directly in the plant. At the time of the dies and decomposes of the vegetative part of the plant like roots, leaves, fruits etc. Returning most of the nitrogen in the soil is supply to nearest plant (Hasan *et al.*, 2018).

Atmospheric nitrogen in the legume will satisfy the nitrogen requirements. For the successful crop production phosphorus is considered as second essential mineral fertilizer after nitrogen. Phosphorus helps in root system and many aspects of plant physiology. On the plant height it was reported by Hasan *et al.,* (2010) that different levels of phosphorus have threateningly affected. *Rhizobium* bacteria form a beneficial interaction with a legume crop to fix atmospheric nitrogen and convert it to ammonium for plant uptake.

It improved the nodulation and also development of shoot/root with the effect of rhizobia inoculation. Soil microorganism involves in nitrogen cycling. Grain legumes increase the biological diversity in the ecosystem (Sharma *et al.,* 2005). The simple propagation method for cultivation of bambara groundnut is through the seeds. In the day, 30 to 35°C temperature is considering the optimum for the growth of Bambara groundnut. The ideal soil pH range is 5.0 to 6.5. It seeds contain carbohydrate 63%, protein 19% and oil 6.5% and also as good source of fiber, calcium, iron and potassium. For completing a balanced food the ripe seeds of bambara groundnut contain protein 16 to 21%, fat 4.5 to 6.5% and carbohydrate 50 to 60%. POME, containing large amounts of organic material, is a suitable feedstock for digestion.

As a leguminous crop, *bambara* groundnut is useful crop rotations because it may improve the *nitrogen* status of the soil. The function of phosphorus in plants is to convert other nutrients into usable building blocks with which to grow. Hence, this study was aimed to investigate the effects of POME, nitrogen and phosphorus on growth and yield of bambara groundnut.

Taxonomy

Bambara groundnut belonging to the family of fabaceae (Bamshaiye *et al.*, 2011), is a grain legume cultivated primarily by subsistence farmers in sub-Saharan Africa, with a lesser extent in some Asian countries including India, Malaysia, Philippines and Thailand.

Fig. 1. Bambara groundnut with pod.

Botanical description

According to Bamshaiye *et al.,* (2011) bambara groundnut is a herbaceous, intermediate, annual plant that can grow around 0.30-0.35m height with bunched 5cm long trifoliate leaves attached by 15cm long, stiff and grooved petioles to branched short lateral stems of 20cm long that arisen from a well-developed tap root, forming a crown on the soil surface. Flowering starts 30 to 35 days after sowing. The colour of the flower is pale yellow. Bambara groundnut pods are approximately 1.5cm long, wrinkled, rounder slightly oval shaped, each containing mostly one or rarely two seeds that are up to 1.5cm in diameter, round, smooth and hard when dried. Bambara groundnut matures in three to six months depending on climatic conditions and the cultivar (Brink *et al.*, 2006). Usually the pod contains single seed but sometimes there are two (Gibbon and Pain, 1985). Harvesting is usually done by uprooting the plant and picking the individual pods.

Agronomic characteristics

Bambara groundnut is widely known as a hardy plant with several advantages including high tolerance to drought, ability to yield on lands that are not fertile enough for the cultivation of many other crops, and good nutritional characteristics (Bamshaiye *et al.*, 2011). Bambara needs high temperatures, bright sunshine, and frequent rain for best growth. It grows well under an average temperature of 20°C to 28°C (Goli, 1995). Photoperiod control of bambara groundnut is also essential for proper growth, as it mostly affects pod set and filling (Kendabie *et al.*, 2012). Generally, bambara groundnut requires a frost-free period of at least 3 to 5 months and is a typical short-day plant.

Besides, bambara groundnut requires moderate rainfall of 500 to 600mm per year from stages of sowing until flowering. It has been stated that this crop can produce yields where rainfall is below 500 mm annually and the ideal annual rainfall is between 900–1000mm (Bamshaiye *et al.*, 2011). It requires a soil pH from range of 5.0 to 6.5. It develops well on well-drained soil and can also be planted on poor marginal soils that are not suitable for other leguminous crops. Bambara groundnut has a very low insect pest and disease susceptibility (Tweneboah, 2000) that it is not attacked by disease and pests in any of its production regions. However, it may be susceptible to different kinds of fungal diseases in damp conditions (Hossain *et al.*, 2014).

Production of bambara groundnut

The highest recorded seed yield of bambara groundnut under field condition is around 4 t ha^{-1}. Average yields of dry seeds are usually range between 300 and 800kg/ha in traditional farming but the average yields may exceed 3,000kg ha^{-1} in intensive farming (Hasan *et al.*, 2018).

Palm oil mill effluent effect

POME used as organic amendment

In palm oil processing, large amounts of water is used in mills where crude palm oil is extracted from the fresh fruits. Ahmad *et al.,* (2003) estimated that for one ton of crude palm oil produced, around 5-7.5 t of waste water was generated from palm oil processing, which is known as palm oil mill effluent (POME). Raw POME with highly polluting properties is said to be the most environmental damaging waste from the milling process as it is usually discharged into the environment.

In general, utilization of POME sludge for plant growing and as amendment for agricultural soils is considered as one of the best waste management options as it improves the soil's aggregate stability, porosity and water infiltration rate, and supplies organic matter and major nutrients, such as nitrogen and phosphorus to the soil (Gandahi, 2014).

Akinyele *et al.,* (2013) found that the application of POME showed a considerable increased in available nitrogen, phosphorus, organic carbon and organic matter, potassium and other essential nutrient. They also observed that grains yield increased by 50.20% in the POME treated soil, 59.80% in N.P.K amended soil while it was 39.71% in fibre treated soil. This indicates that POME can be used as alternative to inorganic fertilizer for plant growth and yield (Law-Ogbomo *et al.*, 2011). Although agricultural application of POME sludge is commonly considered as a beneficial choice in the waste management, the toxicity effects of POME due to the presence of phenol and other organic acids should be carefully examined as they can accumulate in soils and plants (Eneje Roseta and Ifenkwe Innocent, 2012). Furthermore, excessive application of POME sludge results in runoff of organic loads and nutrients may also pollute water bodies and reduce soil fertility (Mohammad *et al.*, 2012).

POME effect on growth and yield

Several researches have been done to determine the effect of POME on plant growth and most of them showed that POME had significantly increased plant growth (Osubor and Oikeh, 2013). Palm oil mill sludge will slowly release adequate amount of organic mattersand nutrient elements that are needed for plant growth over time. In 2008, Ekwuribe *et al.*, reported that application of high palm oil sludge content improved the plant growth of cowpea. They stated that the number of cowpea root nodules has

significantly increased with palm oil sludge application. Gandahi *et al.,* (2014) observed that after 30 days from sowing, there was a significant increase in the plant height of water spinach from 53mm to 240mm as POME sludge application was doubled from 25% to 50%. Nwoko and Ogunyemi, (2010) has also shown that the growth and yield of maize (*Zea mays.* L) increased with the application of fermented POME to soil. Agamuthu, (1994) also stated that POME has composition of all the major and minor elements that areessential for growth of napier grass (*Pennisetum purpureum*), which resulted in the highest yield for up to 3276kg ha^{-1} with the use of POME as fertilizer. In addition, Kanakaraju *et al.,* (2016) found that the crop yield of water spinach had accumulated from 58.6kg ha^{-1} to 228.7kg ha^{-1} after 30 days from sowing with POME sludge application up to 50%.

Nitrogen effects

Use of nitrogen as fertilizer

Sufficient supply of nitrogen is useful for carbohydrate and protein metabolism that encourages cell division and enlargement which will lead to higher yield (Shehu *et al.*, 2010). Nitrogen deficiency in plants makes them become stunted and yellow in appearance. The older or lower leaves will first show the deficiency symptoms of yellowing, or known as chlorosis, while the upper leaves remain green because nitrogen is mobile in the plant. The leaves will turn brown and die with severe N shortage (Mills and Jones, 1996).

Effects of nitrogen on plant growth

By application of nitrogen fertilizer all bambara groundnut varieties had a good and positive effect on agronomic parameters like plant height, number of leaves etc. Application of 100kg N ha^{-1} increased the total dry matter per plant compared with no application or with 50kg N ha^{-1} (Uchhara *et al.*, 2013). Their results were in agreement with the findings of Wamba *et al.,* (2012), suggesting that plant dry weight and plant height parameters were positively influenced by N application in bambara groundnut landraces including white seed coat, black seed coat and light red seed coat.

Effects of nitrogen on yield

In addition, Wamba *et al.*, (2012) stated that application of N fertilizer had a positive effect on yield parameters of bambara groundnut cultivars. It significantly increased the numbers of pods and seeds per plant, the weight of 100 grains, and yields of grain and pod of all landraces including white seed coat, black seed coat and light red seed coat. N fertilizer of 100kg ha^{-1} resulted in highest increase of number of pods per plant (16.96 to 39.20), number of seeds per pod (1.02 to 1.49), grain yield (5.11 to 7.49) and pod yield (5.22 to 7.77t ha^{-1}) in red seed coat landrace compared to control. The supply of N at 100kg ha^{-1} also significantly increased the 100 grain weight from 0.32 to 1.00kg in white seed coat landrace. In the other hand, fertilization rates above 100kg ha^{-1} N led to decline in yield in all the bambara groundnut landraces compared to the optimum 100kg ha^{-1} N (Akpalu *et al.*, 2012)

Phosphorus effects

Phosphorus on growth

Findings of Nweke and Emeh, (2013) were reported that application of 165kg P ha^{-1} is adequate and therefore recommended for the growth and yield of bambara groundnut in Igbariam South eastern, Nigeria agro-ecological zone. They proved that phosphorus application at different levels (55, 110 and 165kg P ha^{-1}) had significantly higher in growth aspects of bambara groundnut such as plant height, number of flowers, branches, leaves and leave area as compared to control treatment, hence phosphorus is said to improve the vegetative growth of the bambara groundnut. Among the phosphorus levels, 165kg P ha^{-1} level is found to be most effective as it produced the highest value in each of the parameters measured while control plots had the least value. According to Salve and Gunjal, (2011) with changing levels of phosphorus significant variation in plant height was found. For the fixation of nitrogen and also uptake of nutrient and water from the soil phosphorus play a vital role by developing the root concentration and also lateral, fibrous and healthy roots are formed with the help of phosphorus fertilizer (Bhuiyan *et al.*, 2008; Niu *et al.*, 2012).

In addition, Wamba *et al.,* (2012) also stated that the plant dry weight and plant height parameters were positively influenced by P application in bambara groundnut landraces including white seed coat, black seed coat and light red seed coat. P fertilizer of 100kg ha^{-1} had significantly higher dry weight accumulation in black seed coat landrace and highest value of plant height in white seed coat landrace compared to control. However, Effa *et al.,* (2016) claimed that no significant effect of different levels of P_2O_5 (0, 45, 60 and 75kg ha^{-1}) on growth attributes of bambara groundnut such as plant height, number of leaves, number of branches, canopy diameter and total dry matter.

Effects of phosphorus on yield

A field experiment was conducted in Nigeria with different combinations of nitrogen, phosphorus and potassium. Hasan *et al.,* (2018) had evaluated five levels single super phosphate fertilizers at 0 (control), 40, 50, 60 and 70kg ha^{-1} against the growth and yield parameters of bambara groundnut. Seed yield per plot showed a highly significant difference, especially 60kg P_2O_5 ha^{-1} gave the highest seed yield per plant and seed yield per plot. Therefore, application of 60kg P_2O_5 ha^{-1} was recommended for optimum production of bambara groundnuts in the study area. According to Zafar *et al.,* (2013) reported that with improving root arrangement phosphorus provides greater root and soil contact which results the higher receiving of phosphorus and other important and low suppleness nutrients and fascination of superior absorption of mineral nutrients. According to Kamanga *et al.,* (2010) phosphorus fertilizer increased legume grain and biomass yields of bambara groundnut in Chisepo. Bambara groundnut applied with 20kg P_2O_5 ha^{-1} gave 1.0t ha^{-1} extra grain yield than unfertilized plots.

In terms of percentage response, bambara groundnut had the second strongest response to applied P, after cowpea. In contrast, Effa *et al.,* (2016) found that different levels P_2O_5 (0, 45, 60 and 75kg ha^{-1}) not only had no significant effect on growth of bambara groundnut, but also on yield attributes such as dry pod yield, combined pod yield, seed yield and combined seed yield.

Fig. 2. Pod with bambara ground Fig. 3. Pod of bambara groundnut.

Conclusion

By application of POME, nitrogen and phosphorus on growth and yield of bambara groundnut has increased. All bambara groundnut varieties application of nitrogen fertilizer had a good and positive effect on agronomic parameters like plant height, number of leaves etc. With the help of proper rhizobia number of nodules is form by roots in order to fix nitrogen. Phosphorus helps to root formation and early growth of the plant and also enhance the seed production capacity. Phosphorus not only hastens maturity but also gives constancy of the stem and to the plant it contributes general durability. Application of POME, nitrogen and phosphorus fertilizer makes bambara groundnut is a complete food because all the nutrition such as carbohydrate, fat and protein are remains in sufficient proportions in the seed.

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