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Influence of Incorporated Legumes, NPK 20-10-10 and Their Combination on Yield and Yield Attributes of Pearl Millet (*Pennisetum glaucum* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author AKI designed the study, performed the experiment and statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author NV assisted in the design of the study. Authors NV and AU supervised the study. Authors read and approved the final manuscript.

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ABSTRACT

Field experiments were conducted from 2015 to 2016 during wet seasons at the Teaching and Research of the Leventist Farm, Tumu, Akko local Government area, Gombe State, to evaluate the effects of incorporated legumes, NPK 20-10-10 and their Combinations on yield and yield attributes of pearl millet (*Pennisetum glaucum* (L.)). The treatments comprised of Centro alone (T_1); Centro + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_2); Lablab alone (T_3); Lablab + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_4); Mucuna alone (T_5); Mucuna + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_6); Sesbania alone (T_7); Sesbania + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_8); recommended N_{60} P_{30} K $_{30}$ kg ha^{-1} fertilizer (T_9) and Control (T_{10}) were tested in randomized complete block design (RCBD) and replicated three times. It can be seen that among the various treatments, the incorporation of Lablab + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_4) is resulted in significantly higher

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yield attributes (panicle length 24.99 cm, panicle girth 3.20 cm, 100 grains weight), grain yield (3631 kg ha^{-1}) and stover yield (7492 kg ha^{-1}). The findings of the study revealed that Lablab + N_{30} P_{15} K $_{15}$ kg ha^{-1} showed a better performance of pearl millet in terms of yielding, and yielding attributes.

Keywords: Incorporation; legumes; pearl millet; yield; stover.

1. INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is one of the most important staple food crops in hot and dry areas of arid and semi-arid climatic conditions [1]. Pearl Millet is the 6th most important cereal crop in the world; it is second most important only to Sorghum as a staple food in the Savanna area of Nigeria [2]. It is a staple cereal for over 40% of the populace in northern Nigeria especially in areas with 300-700 mm of annual rainfall such as the northern part of Borno State, Nigeria [3]. However, more than 40% of lands are sown annually to yield cereals in Nigeria's agro-ecological zones which are devoted to millet [4]. In Nigeria the grains are used primarily for human consumption, it is processed into 'tuwo', 'kunu', and 'akamu', while the stem is used for fencing, roofing, and stover is a valuable livestock feed. Pearl millet straw is used for a wide range of purposes, including the construction of granaries, hut walls, fences and thatches, and the production of brooms, mats, baskets, sunshades, etc. [5]. Nutritionally the crop is better to many cereals as it is a good source of a protein which is having higher digestibility (12.1%), fats (5%), carbohydrates (69.4%) and minerals (2.3%) [6].

Yielding of this crop is greatly influenced by organic and inorganic fertilizers under rainfed conditions. Main reasons for low productivity is attributed to unfavorable weather, low soil fertility status, the incidence of pests and poor soil nutrients availability due to intensive land cultivation coupled with poor soil management techniques among other problems that have been limiting the factors for its optimal production [7,8]. Thus, [1] one of the easiest ways to boost the productivity of pearl millet is the application of balanced fertilizers to the undernourished crop.

At present farmers are using inadequate and imbalance chemical fertilizers, which lead to a nutrient deficiency, other than applied and declined organic carbon level. An excessive use of chemical fertilizers deteriorates the structure and texture of the soil. Therefore, use of chemical fertilizer alone may not keep pace with time in maintenance of soil health for sustaining the productivity. So, adequate and balanced use of organic manure and fertilizer has been found quite promising not only in sustaining the soil health and productivity but also in stabilizing the crop production in comparison to the use of each component, separately. There is a paucity of information as regards pearl millet performance to combined application of organic manure and inorganic fertilizer in Gombe State, Nigeria. Hence, the objective of this study was to investigate the combined effects of green manure and inorganic fertilizer alone or in combination with yield and yield component of pearl millet.

2. MATERIALS AND METHODS

2.1 Experimental Site

A field study of two years was carried out at the Teaching and Research Farm of the Leventis Farm, Tumu Akko local Government area, Gombe State (9º 55′ N, 10º 58′ E at an altitude of 325m above sea level). The geology of the area is said to be comprised of tertiary continental sandstone to the west of the Kari Keri escarpment, clay and siltstone [9]. The Teaching and Research Farm is characterized by dry sub-humid zone [10]. According to annual rainfall recorded at Federal University Kashere meteorological station for the duration of the study in 2015 and 2016 were 369.4 mm and 2183.2 mm, with mean annual minimum and maximum temperatures were 30ºC and 32ºC respectively [11]. The previous crop grown on experimental site was soybeans.

2.2 Soil Sampling and Analysis

Soil sampling and analysis were done before planting (initial) soil samples were collected from five randomly selected spots on the field at the soil depth of 0-30 cm using a soil auger and bulked together. Random samples were taken at the establishment of the experiment in 2015 to determine initial physicochemical properties of the soil.

The processed soil fractions were subjected to laboratory analysis [12]. The texture was analyzed using Bouyoucos hydrometer [13]. Soil pH was determined in water at a 1:1 soil to water ratio using glass electrode pH meter. Organic carbon was determined using the wet oxidation method [14]. Micro-Kjeldahl digestion method [15] was used to determine total N and available P was analyzed by extraction with Bray II method [16] using 0.03 M NH4F and 0.10 M HCl solution. The exchangeable Ca, Mg, K and Na were extracted with 1 M NH4OAc at pH 7 by which exchangeable Ca and Mg in extracts was analyzed using atomic absorption spectrophotometer, while Na and K by flame photometer [17]. The CEC was determined by saturating the soil with 1NNH_4OAc solution, and all the cations displaced into the soil solution were summed up.

2.3 Treatments and Experimental Design

Total land area of 810m^2 was marked out and divided in to 30 plots of 20 m^2 with 1m spacing between plots. The experiment consisted of ten treatments which were laid out in a randomized complete lock design (RCBD) and replicated three times. The treatments comprised of Centro alone (T_1); Centro + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_2); Lablab alone (T_3); Lablab + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_4); Mucuna alone (T_5); Mucuna + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_6); Sesbania alone (T_7); Sesbania + N_{30} P_{15} K $_{15}$ kg ha^{-1} (T_8); recommended N_{60} P_{30} K $_{30}$ kg ha^{-1} fertilizer (T_9) and Control (T_{10}).

Sowing of Centro, lablab, Mucuna and Sesbania at two seeds per hole were done at spacing of 37.5cm x 25cm and incorporated into the soil at six weeks after sowing. A week after incorporation, the seeds of pearl millet (variety SOSAT-C-88) were dressed with Apron Star 42 WS at the rate of 10 g sachet per 4 kg seeds for protection against soil and seed borne pests and diseases. The seedlings were thinned to one plant per stand at two weeks after sowing (WAS). NPK fertilizers (20-10-10) were applied two weeks after sowing 2WAS at a rate of N_{60} P_{30} K $_{30}$ kg ha^{-1} in plots treated with fertilizer only and N_{30} P_{15} K $_{15}$ kg ha^{-1} in plots treated with green manure and fertilizer.

2.4 Data collection

Five tagged plants from each net plot i.e. the two inner rows of each plot were selected randomly for recording different observations. The data taken included panicle length, panicle girth, 100 grains weight, harvest index, grain and stover yields. The data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Duncan Multiple Range Test (DMRT) at 5% level of probability [18].

3. RESULTS AND DISCUSSION

The soil of the experimental site is sandy loam in texture, very strongly acidic in pH, low in organic carbon (<10 g kg^1 soil), total N (<1.5 g kg^1 soil), available P (<10 mg kg^1 soil), K^+ (<2 cmol kg^{-1} soil), Na^+ (<0.2 cmol kg^{-1} soil), and CEC (<2 cmol kg^{-1} soil) but medium in Ca^{2+} (2-5 cmol kg^{-1} soil), and Mg^{2+} (0.3-1.0 cmol kg^{-1} soil) according to [19] soil fertility ratings (Table 1). These findings confirm the earlier reports [9] that majority of soils in the study area is sandy and inherently low in fertility and organic matter. The low organic matter might be due to low turnover of plant residues which is due mainly to low rainfall and human and livestock activities coupled with widespread erosion [20].

3.1 Yield Attributes

The results of the experiment revealed that yield attributes and yields of pearl millet were significantly influenced by different sources of nutrients (Tables 2 and 3).

3.1.1 Panicle Length (cm)

Results presented in Table 2 shows that there was significant effect of organic and inorganic sources of nitrogen on pearl millet panicle length. Maximum panicle length (36.6) was found with treatment T_4 (Lablab plus N_{30} P_{15} K $_{15}$ kg ha^{-1}), while minimum panicle length (22.9) was observed in treatment T_{10} (control plot). This might be attributed to the fact that application of fertilizer make more availability of nutrients which provided higher availability of nutrient to the plant, while organic manure improves the soil physical properties, hydraulic conductivity of the soil and also the availability of NPK, which promoted plant growth and development and resulting in increasing yield attributes of pearl millet [21-24].

3.1.2 Panicle girth (cm)

Data presented in Table 2 shows that there was significant effect of organic and inorganic sources of nitrogen on panicle girth. Maximum panicle girth (9.6) was found with treatment T_4 (Lablab plus N_{30} P_{15} K $_{15}$ kg ha^{-1}), while minimum panicle girth (7.2) was observed in treatment T_{10} (control plot). Experimental findings showed that due to the application of organic manure might be attributed to the better nutrient availability and its favourable effect on physical and biological properties of soil resulting increased growth of plant and grain and straw yield [22,23,25].

3.1.3 100 grains weights (g)

The results revealed that different organic and inorganic treatments exerted their significant influence on pearl millet 100 grains weight. Perusal of mean data presented in Table 2 indicates that maximum 100 grains weight (19.7) was found with treatment T_4 (Lablab plus N_{30} P_{15} K $_{15}$ kg ha^{-1}), while minimum 100 grains weight (10.4) was observed in treatment T_{10} (control plot). However, the probable reason for increase in 100 grains weight ascribed to higher availability of nitrogen might be attributed to the better filling of grains resulting into bold sized seeds and consequently highest 100 grains weight [21- 24,26].

3.2 Yield

3.2.1 Grain yield (kg ha^{-1})

Data presented in Table 2 shows that there was significant effect of organic and inorganic sources of nitrogen on pearl millet grain yield. Maximum grain yield was found (2126 kg ha^{-1}) with treatment T_4 (Lablab plus N_{30} P_{15} K $_{15}$ kg ha^{-1}), while minimum grain yield (806 kg ha^{-1}) was observed in treatment T_{10} (control plot). Findings showed that due to the application of organic manure might be attributed to the better nutrient availability and its favorable effect on soil physical and biological properties resulting increased yield attributes and straw yield [27]. The relative yield increase under T_4 (Lablab plus N_{30} P_{15} K $_{15}$ kg ha^{-1}) may be attributed to marked increase in yield contributing components like panicle length, panicle girth, 100 grains weight, whereas control plots had lower yield attributing characters and finally a decrease in grain and stover yield was obtained [28]. However, the increase in yield with enhanced N application could be ascribed to increase the activity of cytokinin in plant which leads to increased cell division and elongation which leads to better plant growth, dry matter production and higher photosynthesis [29]. Similar result on beneficial effect of integration of inorganic and organic sources on crop production was also reported [23,26,30-32].

3.2.2 Stover yield (kg ha^{-1})

Data presented in Table 3 shows that there was significant effect of organic and inorganic sources of nitrogen on stover yield (kg ha^{-1}). Maximum stover yield (3677 kg ha^{-1}) was found with treatment T_4 (Lablab plus N_{30} P_{15} K $_{15}$ kg ha^{-1}), while minimum stover yield (1706.3 kg ha^{-1}) was observed in treatment T_{10} (control no fertilizer), respectively. The increase in stover yield might be due to increase availability of the nutrients like nitrogen and phosphorus, causing accelerator of the photosynthetic rate and thus leading to more production of carbohydrate resulted in more dry matter production. While organic manure increase the formation of the root hairs and lateral root which helps in higher nutrients uptake and resulted in more dry matter and ultimately better flowering and ear head development. The increase in yield might be due to the cumulative effect of increased growth and yield attributes noted under this treatment. The results obtained are in close agreement with the other [22].

3.2.3 Harvest index (%)

The data on economic and biological yield was used to calculate harvest index as per treatment. Maximum harvest index (42.1%) was found with treatment T_9 (N_{60} P_{30} K $_{30}$ kg ha^{-1}). However T_4 (Lablab+ N_{30} P_{15} K $_{15}$ kg ha^{-1}), T_6 (Mucuna+ N_{30} P_{15} K $_{15}$ kg ha^{-1}) were found statistically at par with T_9 (N_{60} P_{30} K $_{30}$ kg ha^{-1}). These results suggest that adequate and balanced supply of nutrients assured by integration of manuring and mineral N application may have increased utilization of relatively large proportion of assimilates throughout its development process. The harvest index in maize was positively affected by integration of organic and inorganic fertilizers [33,34].

Table 1. Pre-planting soil physical and chemical properties of the experimental site

Parameters	Description
Sand	76.5
Silt	12.5
Clay	11.0
Soil texture	Sandy Loam
pH (H_20)	5.00
Org. C (g kg^{-1})	5.40
Total N (g kg^{-1})	0.04
Available P (mg kg^{-1})	6.80
Exchangeable cations (cmol kg^{-1})	
K^+	0.15
Ca^{2+}	2.32
Mg^{2+}	0.50
Na^+	0.12
CEC (cmol kg^{-1})	4.00

Table 2. Combined effects of treatments on yield attributes of pearl millet

Treatments	Panicle length (cm)			Panicle girth (cm)			100 grains weight		
	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined
Centro	24.3^{g}	26.0^{d}	25.2^{f}	7.5^{e}	7.6^{d}	7.6^{e}	12.7^{d}	12.6^{dc}	12.6^{d}
Centro + N_{30} P_{15} K_{15} kg ha^{-1}	29.5^{d}	30.2^{bc}	29.9^{cd}	8.4^{c}	7.9^{dc}	8.2^{dc}	14.3^{c}	14.5^{c}	14.4^{c}
Lablab	28.2^{e}	28.5^{cd}	28.3^{de}	8.4^{c}	8.5^{bc}	8.4^{c}	13.3^{d}	13.8^{dc}	13.6^{dc}
Lablab+ N_{30} P_{15} K_{15} kg ha^{-1}	36.5^{a}	36.6^{a}	36.6^{a}	9.8^{a}	$\mathbf{9.3^{a}}$	9.6^{a}	19.1^{a}	20.4^{a}	19.7^{a}
Mucuna	26.8^{f}	27.4^{cd}	27.1^{e}	7.9^{d}	8.0^{dc}	8.0^{d}	12.9^{d}	12.7^{dc}	12.8^{d}
Mucuna+ N_{30} P_{15} K_{15} kg ha^{-1}	32.6^{b}	33.3^{ab}	33.0^{b}	9.2^{b}	8.7^{ab}	9.0^{b}	15.8^{b}	17.4^{b}	16.6^{b}
Sesbania	26.9^{f}	28.3^{cd}	27.6^{e}	8.2^{c}	8.5^{bc}	8.4^{c}	12.7^{d}	13.1^{dc}	12.9^{d}
Sesbania+ N_{30} P_{15} K_{15} kg ha^{-1}	30.09^{c}	30.6^{bc}	30.7^{c}	9.0^{b}	8.9^{ab}	8.9^{b}	16.0^{b}	17.5^{b}	16.8^{b}
N_{60} P_{30} K_{30} kg ha^{-1}	28.8^{dc}	27.9^{cd}	28.3^{de}	9.2^{b}	9.0^{ab}	9.1^{b}	16.0^{b}	18.0^{ab}	17.0^{b}
Control	21.2^{h}	24.6^{d}	22.9^{g}	7.0^{f}	7.3^{d}	7.2^{f}	9.8^{e}	10.9^{d}	10.4^{e}
SE±	0.30	1.19	0.61	0.11	0.21	0.11	0.26	0.90	0.46

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT

Table 3. Combined effects of treatments on yields of pearl millet

Treatments	Grain yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index (%)		
	2015	2016	Combined	2015	2016	Combined	2015	2016	Combined
Centro	1223^{h}	1271^{g}	1247^{g}	724^{b}	4333^{e}	2529^{bdc}	45.8^{d}	20.1^{bc}	32.9^{d}
Centro + N_{30} P_{15} K_{15} kg ha^{-1}	1717^{d}	1737^{bcd}	1727^{c}	746^{b}	5750^{abc}	3248^{ab}	53.5^{c}	21.3^{b}	37.4^{c}
Lablab	1441^{f}	1773^{bcd}	1607^{d}	748^{b}	5367^{bcd}	3057^{abc}	42.0^{de}	21.6^{ab}	31.8^{d}
Lablab+ N_{30} P_{15} K_{15} kg ha^{-1}	2081^{a}	2072^{a}	2076^{a}	979^{a}	6375^{a}	3677^{a}	57.4^{b}	23.8^{a}	40.6^{ab}
Mucuna	1385^{g}	1375^{ef}	1380^{f}	641^{b}	5175^{cde}	2908^{bdc}	46.3^{d}	20.3^{bc}	32.3^{d}
Mucuna+ N_{30} P_{15} K_{15} kg ha^{-1}	1956^{b}	1977^{ab}	1967^{b}	680^{b}	6267^{ab}	3474^{a}	59.0^{b}	22.3^{ab}	40.6^{ab}
Sesbania	1465^{f}	1494^{ef}	1486^{e}	644^{b}	4475^{de}	2560^{bdc}	44.7^{de}	21.6^{ab}	33.1^{d}
Sesbania+ N_{30} P_{15} K_{15} kg ha^{-1}	1670^{e}	1683^{de}	1677^{dc}	708^{b}	4867^{cde}	2788^{bdc}	46.8^{d}	22.5^{ab}	34.6^{d}
N_{60} P_{30} K_{30} kg ha^{-1}	1901^{c}	1919^{abc}	1910^{b}	538^{c}	6375^{a}	3491^{a}	62.6^{a}	21.6^{ab}	42.1^{a}
Control	818^{i}	795^{h}	806^{h}	569^{e}	2875^{f}	1706^{e}	43.2^{de}	18.3^{c}	30.8^{f}
SE±	11.1	69.2	34.7	18.4	290.4	147.7	0.67	0.72	0.55

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of probability using DMRT

4. CONCLUSION

On the basis of two years field experimentation, it seems quite logical to indicate that different treatments have a deviation in ability to produce the crop yield of pearl millet. It can be seen that among the various treatments, the incorporation of lablab along with N_{30} P_{15} K_{15} kg ha^{-1} half of recommended dose of fertilizer is identified as the best-integrated nutrient management treatment for pearl millet crop to secure higher production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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