Growth and Seed Yield Response of *Aeschynomene histrix* to Cattle Manure and Plant Row Spacing in Southern Benin

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Abstract: ***Scarcity of legume forage seeds in Benin contribute to their low adoption by farmers. The effects of animal manure/phosphorus fertilizer and row spacing on growth and seed yields of Aeschynomene histrix was studied (over a period of 3 years) in University of Abomey-Calavi (Benin). The experimental design was a split plot with 4 row spacing (20, 40, 60 and 80 cm) as the main plots and 6 sources of fertilizers (40 kg P_2O_5.ha^{-1}, dry cattle manure rates of 0, 4, 8, 12, and 16 t.ha^{-1}) as subplots. Onset of branching, plant height, onset of flowering, onset of podding, pod filling were assessed from selected plants on weekly basis starting from 4 WAS, seed yield and forage production at maturity. The results showed that an increase in cattle manure rates significantly ($P<0.05$) increased seed and forage yields of up to 307.48 kg ha^{-1} and 4.34 tons.ha^{-1}, respectively. Over three years, plant spacing of 40 cm produced significantly ($P<0.05$) more seed than seed yield obtained from 20 cm, 60 cm and 80 cm. Regard to fertilizers, 12 tons cattle manure produced significantly more seed than seed yield through 0, 4, 8 and 16 tons.ha^{-1} cattle manure and 40 kg P_2O_5 kg.ha^{-1}. Based on findings 12 t.ha^{-1} of cattle manure spread uniformly two weeks before sowing in rows 40 cm apart, should provide a satisfactory of A. histrix seed production in Southern Benin.***

Keyswords: *Aeschynomene histrix*, seed, forage, cattle manure, row spacing, phosphore, Benin

1. Introduction

In West Africa, poor ruminant production has largely been attributed to the extensive production system based on grazing of natural grasslands. The most limited factor in animal production is low feed supply in quantity and quality especially in dry season (Maliki *et* al. 2012; Lesse 2016; Koura 2015; Houndjo *et* al. 2018a). Some of the major causes of low yields are declining soil fertility and insufficient use of fertilizers resulting in severe nutrient depletion of soils. In the past, a long fallow period (5-10 years) allowed natural restoration of soil fertility. However, because of pressure on land to increase food production and other socio-economic activities, the fallow period is almost nonexistent in many farming communities in Benin. Fertilizer/manure has been shown to be an effective means of enhancing crop performance for more than a century. It has contributed largely to the major increase in yields which have been achieved worldwide and for the substantial improvement of human and animal health.

Organic manure is a cheap and readily available source of essential nutrients to the plants. Conversely, the high cost of inorganic fertilizers and their scarcity during peak season are some factors hindering their use as most farmers function with limited financial resources (Mkhabela et al. 2003). Organic manure is used primarily as a source of plant nutrients (Samia et al. 2015). Naturally, the use of organic manure can improve soil properties and maintain the quality of soil fertility. Organic manures act not only as a source of nutrients, but also increase microbial biodiversity and activity in soil, influence structure, nutrients get turnover and many other changes related to physical, chemical and biological parameters of the soil (Muzafer et al. 2015). The soil having higher organic matter concentrations have been proved to enhance the growth and yield of different crops (Muzafer et al. 2015) as well as soil aeration, soil density and maximizing water holding capacity of soil for seed germination and plant root development (FAO 2000; Udoh 2005; Ademiluyi and Omotoso 2008; Duncan et al. 2013).

On the other hand, forage legumes can play an important role in cropping systems. Their integrating in grassland or into the agricultural systems will not only provide nutritious forage to supplement grass or residues of cereals crops but also provide a nitrogen source to promote crops and grass growth (Hare *et* al. 2004). Under-sowing legumes into native pasture or introducing legumes into cereals crop could be a cost-effective method for smallholder farmers to improve ruminant productivity and also to complement dry season grazing (Tarawali *et* al. 1988; Adjolohoun 2008). After evaluation of five accessions of tropical pasture legumes for fodder banks in sub-humid Nigeria, Peters *et* al. (1994) recognized that *A. histrix* is the most promising accession. Establishment of *A. histrix* after sowing is generally good and even in the absence of nodulation plants can produce readily with the native rhizobia (Peters et al. 1994). *A. histrix* had ability to stay green during dry season. Several studies in West Africa highlight the high crude protein content (13-28%), good dry matter production (Aboh et al. 2005; Zampaligre 2007) and good palatability of *A. histrix* when consumed by cattle (Tarawali 1988; Peters et al. 1994;

Merkel et al. 2000; Adjolohoun 2008). In degraded soil in the center of Benin, incorporation of *A. histrix* residues improved the maize grain dry matter (DM) yields from 458 kg DM ha^{-1} to 1374 kg DM ha^{-1} and the straw DM yields of 968 DM ha^{-1} to 1863 kg DM ha^{-1} (Kouelo et al. 2013).

Most of legume pasture establishment need seed availability and pasture seed production in West Africa especially in Benin received very little attention. Seed yield is usually limited to government farms and research institutes (Ogedegbe et al. 2012; Maliki et al. 2011). Consequently unavailability of *A. histrix* seeds in quantity and quality in Benin lead to its low adoption by farmers. Also the complexity of forage legume seed production has discouraged farmers, and there is little guidance available to farmers in comparison with other crops (Rincker et al. 1988; Chloupek and Simon 1997).

The seed yield of *A. histrix* is affected by many factors such as row spacing, fertility status of the soil, the fertilizer applied and crop management (Boonman 1972; Adjolohoun et al. 2013). Very low density is known to reduce seed yield, also dense stands produce lower levels (or number) of flower, thus attracting fewer pollinators and increasing the rate of floral abortion (Rincker et al. 1988).

The aim of this study was to determine the effect of row spacing and cattle manure levels on the vegetative growth, seed yield and yield components of *A. histrix* grown in Southern Benin.

2. Materials and Methods

2.1 Description of experimental site

The experiment was carried out in 2016, 2017, 2018 cropping seasons at the experimental field of the Faculty of Agricultural Sciences of the University of Abomey-Calavi (Latitude 06°30' N, Longitude 2°40' E, 50 m above sea level) in the Soudano-Guinean region of Benin. The area is characterized by a bimodal rainfall pattern with peaks in Jun and October and a dry spell between August to mid-September and December to March. The average annual rainfall levels during the study period were 1,238 mm (2016), 1,107 mm (2017), and 1,197 mm (2018) (Table 1). The area is dominated by ferralitic soil. Prior to the study soil sites, were sampled (0-10cm) and analyzed for texture, carbon, total nitrogen, organic matter, pH, exchangeable cations (van Reewijk, 1992). Sand, loam and clay represent 84, 8, and 8 %, respectively (Houndjo et al. 2018b). The main chemical characteristics of the experimental soil are presented in Table 2.

2.2 Experimental design and cultural practices

The experimental site was manually cleared and the plots were laid out according to the design of the work before sowing. Four replicates of a split-plot experiment were used with row spacing (20, 40, 60 and 80 cm) as the main plots in a randomized complete block design (RCBD), fertilizer (40 kg P_2O_5 .ha^{-1} or, dry cattle manure rates of 0, 4, 8, 12 and 16 tons.ha^{-1}) as the subplots combined to give a total of 24 treatments with 96 plots. Elementary plot size was 5 m × 4 m with 1 m spacing between plots and 2 m between replications. These spaces were maintained by regular hand hoeing. The choice of 40 kg P_2O_5.ha^{-1} was based on phosphorus content of cattle manure [approximately 1.44‰ reported by Gbenou et al. (2018), recommendations of Adjolohoun (2008) and to obtain the equivalent rate of approximately 17 kg P.ha^{-1} with 12 t.ha^{-1} of cattle manure which is in the range recommendation for phosphorus fertilization for most West Africa soil concerning legume production (Agishi and Asare 1980). The same site was used in 2016, 2017 and 2018 cropping seasons. The cattle manure was spread uniformly on the appropriate plots two weeks before sowing and manually incorporated to the soil (Amodu et al. 2004). *A. histrix* accession used in this trial was ILRI 12463 provided by the International Livestock Research Institute (ILRI-Nigeria). Scarification of seeds was done by soaking in hot water at 80 ºC for 4 min to reduce hardseededness. Seeds were sown manually on March 20, 2016; March 19, 2017 and March 17, 2018 at 1 cm depth as recommended by (César and Gouro 2004). The amounts of seed sown for each row spacing (20, 40, 60 and 80 cm) which are recommended for fodder production were 7 kg.ha^{-1} (Adjolohoun 2008; Aboh et al. 2005). Plots were thinned to have 100 plants per meter linear. Seedlings emerged 4-5 days after sowing, and by day 8 the missing plants were reseeded. The trial was kept weed-free throughout by manual hoeing. Insect pest was not a major problem, thus no control measure was taken.

2.3 Measurements

Due to the varying row spacing, a net plot sampling area of 2.4 m × 2 m (12 rows), 2.4 m × 2 m (6 rows), 2.4 m × 2 m (4 rows), 2.4 m × 2 m (3 rows), was selected for measurements. An establishment plant count was done 28 days after sowing by placing a 1m^2 quadrat twice in each net plot sampling. Each year, three plants from a 1 m^2 quadrat in each plot were randomly selected and tagged with sample card. Phenological observations including onset of branching, onset of flowering, plant height at onset of flowering, onset of pod ripening, were recorded from selected plants. The plant height was measured from the ground to the tip of plant excluding the flower buds. Onset of flowering was determined as the date of the year that plant started to flower. The pick flowering (number of days to 50% flowering) was recorded as the number of days taken from sowing to when approximately half of the number of plant had flowered. Onset of pod ripening was assessed as the date of the year when the first pod began to brown (symptom of ripening).

2.4 Seed yield and yield components

Ripened seed were collected twice a week from the beginning to the end of December. The following data were collected on seed yield and yield contributing characters of *A. histrix* during the study: Seed yield (kg.ha^{-1}), 1000-pods weight (g), 1000-seeds weight (g). Pods from each plot were sundried during 15 days and separately weighed to determine the seed yield per hectare. Four replications per treatment were considered during statistical analysis of pod yield harvest. Pods from the same treatment were thereafter pulled. For the assessment of 1000 pods and 1000 seeds weight, 10 replications of 100 pods from each treatment pod lot were randomly selected, weighted separately and thereafter shelled. The number of seeds from each replication were then counted and weighed separately. Seed weight/shell weight ratio was also calculated. Ten replications per treatment were considered during statistical analysis of pod or seed quality characteristics.

2.5 Biomass production

Dry matter production was measured at the end of the pod harvest. Sampling involved cutting plant material in a randomly located 1 m^2 of the pre demarcated area at 15 cm above ground after pod harvest. The sample of each replication was weighed fresh using a spring balance in the field. Sub-samples of approximately 200 g of the fresh material were taken and oven-dried at 65°c for 48h and reweighed to calculate dry matter percentage of each replication.

2.6 Data Analysis

Twenty four treatments (4 row spacing × 6 levels of fertilizers) were considered in the trial. The General Linear Model procedure of SAS 8.02 software (SAS Inc., Cary, NC) was used for the analysis of variance of the data. Duncan's Multiple Range Test (Steele and Torrie 1980) was used to compare treatment effects. The statistical model used to perform the analysis by location was as follows: $Yij= \mu + Di + Fj +Yk + (D*F)ij + (D*Y)jk + (F*Y)jk +(D*F*Y)ijk + eijk$. Where μ = mean, *Di* = row spacing effect, *Fj* = fertilizer effect, *Yk* = year effect, *(D*F)ij, (D*Y)jk, (F*Y)jk,* and *(D*F*Y)ijk* their two or three ways interactions and *eik* the error term.

3. Results

3.1 Growth and development attributes

A. histrix had poor soil cover during the establishment phase of the 8 WAS. Row spacing, cattle manure and phosphore fertilizer application did not affect significantly onset of flowering, number of days to 50% flowering, onset of pod ripening of *A. histrix* in 2016-2018 and therefore, only means by year of those development characteristics are presented (Table 3) nor did their two or three-way interactions. During the three cropping seasons, the first flower of *A. histrix* had ranged from 110 to 166 days after sowing with mean of 137 day after sowing (DAS) (Table 3). Approximately half percent of plants flowered on 148 DAS but podding began 138 DAS (Table 3). The beginning of pod ripening was earliest in year 2 (181 DAS) and latest in year 3 (230 DAS), (Table 3).

Row spacing had no significant effect on *A. histrix* number of day to start branching nor had on plant height at 8 or 16 WAS even if some tendency of increasing plant branching was observed with increasing plant row spacing (Table 4). On the contrast, it was observed that fertilizer had significant effect *A. histrix* growth parameters. Cattle manure application lead to increase plant height at 12 WAS. The tallest plant height was recorded at the highest level of cattle manure (16 $t.ha^{-1}$) and the shortest plants were formed in the control (0 $t.ha^{-1}$ cattle manure).

3.2 Seed yield

Field observation showed that, plant peaked seed production approximately 26 to 32 weeks after sowing et correspond to period of August to September for March sowing. Table 5 shows data on the effect of plant density, cattle manure and phosphore fertilizer application on seed yield ($kg.ha^{-1}$) of *A. histrix* in 2016-2018 growing seasons. Anova revealed statistically significant differences ($P<0.05$) in seed production between years, row spacing and fertilizer on ferralitic soil in Southern Benin. The average seed yield over three years was 307.48 $kg.ha^{-1}$ (Table 5). The seed yield achieved in the first and second years (298.20 and 315.27 $kg.ha^{-1}$, respectively) was significantly lower ($P<0.05$) than that achieved in the second year (315.27 $kg.ha^{-1}$) for the area (Table 5). Over three years plant spacing of 40 cm produced significantly more seed (389.2 $kg.ha^{-1}$) than seed yield obtained from 20 cm, 60 cm and 80 cm (336.6 $kg.ha^{-1}$, 299.1 $kg.ha^{-1}$ and 205.1 $kg.ha^{-1}$ respectively) (Table 5). Fertilizer significantly affected the average seed yield (Table 5). In the second year of experimentation the highest seed yield was obtained in 381.5 $kg.ha^{-1}$ after application of 12 $t.ha^{-1}$ cattle manure and the lowest yield was obtained in 212.2 $kg.ha^{-1}$ in the 0 $t.ha^{-1}$ cattle manure application that is the control (Table 5). Overall, seed yield at the application of cattle manure at the equivalent rate of 17 kg $P.ha^{-1}$ (12 $t.ha^{-1}$) was 76.94% greater than that at the control (0 $t.ha^{-1}$ cattle manure) (Table 6). While application of mineral fertilizer P_2O_5 at the equivalent rate of 17 kg $P.ha^{-1}$ have increased seed yield to 58.85 % over the control (Table 6). Plant density and fertilizer interaction was statistically significant ($P<0.05$). It was evident that when a P fertilizer application rate of 40 kg P_2O_5 $.ha^{-1}$ which corresponded to dry cattle manure rate 12 $t.ha^{-1}$, seed yield was significantly higher when a row spacing of 40 cm was adopted. The highest seed yield (443.73 $kg.ha^{-1}$ mean of three years) was observed from a combination of 40 cm row spacing with application of 12 $t.ha^{-1}$ dry cattle manure through three years (Table 5). While the lowest seed yield (166.4 $kg.ha^{-1}$) was observed from a combination of 80 cm spacing with application of 0 $t.ha^{-1}$ cattle manure.

3.3 Yield components

1000 pods weight
The 3-year average 1000 pods weight was 1.84 g and there was a significant fertilizer effect, ranging from 1.65 g in application of 0 $t.ha^{-1}$ cattle manure to 1.99 g in application of 12 $t.ha^{-1}$ cattle manure (Table 7). The row spacing had no significant impact on the 1000 pods weight.

1000 seeds weight
The weight of 1000 seeds was not influenced by both row spacing but fertilizer application had significant effect ($P<0.05$) on this parameter (Tables 7) with mean ranging from 1.17 g in application of 0 $t.ha^{-1}$ cattle manure to 1.36 g for 12 $t.ha^{-1}$ cattle manure (Table 7). For 1000-seeds weight, treatments with 12 or 16 tons per ha of dry cattle manure or mineral fertilizer application produced similar results (Table 6). The increase in P mineral fertilizer by application of cattle manure at 12 $t.ha^{-1}$ or application of mineral fertilizer (40 kg P_2O_5 $.ha^{-1}$) increased 1000-seed weight by 16% or by 14% in *A. histrix* respectively (Table 7).
1000 shells weight

3.4 Dry matter production

Forage production are significantly affected (P<0.05) by row spacing and fertilizer levels (Table 8). However, a significant interaction between row spacing and fertilizer (P<0.05) was observed. The 3-year average values for row spacing 20, 40, 60 and 80 cm was 4.62 $t.ha^{-1}$, 4.53 $t.ha^{-1}$, 4.30 $t.ha^{-1}$ and 3.93 $t.ha^{-1}$ respectively (Table 8). The 3-year average values on dry matter yields showed that an increase in cattle manure rates significantly increased *A. histrix* dry matter yields. The dry matter yield of *A. histrix* was increased from 2.55 $t.ha^{-1}$ in combination of 80 cm row spacing with 0 $t.ha^{-1}$ cattle manure to 5.99 $t.ha^{-1}$ when 16 $t.ha^{-1}$ cattle manure was applied on plots of 20 cm plant spacing (Table 7).

4. Discussion

A widespread adoption of forage legumes depends on regular supplies of seed reaching the market at affordable prices. This can only be achieved if crops are grown in regions conducive to seed production. The forage legumes used in tropics and subtropics covers a diverse range of attributes and adaptation, such that, no single region can cater adequately for seed production for them all. This study is useful as it permit to that *A. histrix* can be grown in soudanian region of Benin. It also allows appreciating flowering phenology and seeding production of *A. histrix* in particular environment of this area.

Row spacing and fertilizer had not significantly influenced development attributes of *A. histrix* (onset and 50% of flowering, and pod ripping) (P>0.05). Ferguson et al. (1990) reported that, most of tropical legume plants flowering is under the control of two major stimuli which are photoperiod (in which plants can be classified as short-day plants, day-neutral or long-day plants) and stress in which temperature plays an important role. de Andrate (1999) observed that daylength (or photoperiod) varies with latitude. Near the Equator, annual changes in daylength are minimal, but as latitude increases, so does the difference between the longest and the shortest days of the year. For short-day, long-short-day and long-day species, suitable regions occur at latitudes where there is sufficient daylength variation to induce a concentrated and profuse period of flowering. However, for day-neutral plants insensitive to daylength changes, latitude is not an important criterion in regional selection. Cook et al. (2005) noted that *A. histrix* is primarily a short day plant with considerable variation in critical photoperiod within the varieties. In this study, *A. histrix* was sown on March 20, March 19 and March 17, in 2016, 2017 and 2018, respectively and plants had shown first flower on 135, 110 and 166 days after sowing, respectively with significant days difference of flowering between them showing that, for the same site and for the same plant, date of first flowering can significantly differed according to the sowing year. Most of the legumes in tropical regions are short day plants and, under field conditions, tend to flower during late August or early October as daylength decreases (de Andrate 1990; Cook et al. 2005). This result has a practical application as it is possible to delay the sowing with probably no significant influence on the plant flowering. But this recommendation needs further trial. Other implication of this result is that, when this plant had been early sown (at the beginning of the rain), it is possible to harvest the forage to feed animal before let the plant for reproductive phase. This recommendation needs also investigation before application.

During 2016, 2017 and 2018, *A. histrix* plants flowered 135, 110 and 166 days after sowing. Merkel (2000) and Kretschmer and Bullock (1980) reported that time from sowing to flowering of *A. histrix* varies between 43 to 306 days after planting depending to the latitude of the site and the particular environment factors of this site. Studying collection of 64 accessions of *A. histrix* in Ibadan (South-West Nigeria), Merkel et al. (2000) found that, those accessions can be divided to three different flowering groups: early flowering (plants which flower less than 100 days after sowing), intermediate group (flowering between 100 and 143 days after sowing) and late flowering group (later than 143 days). Those authors classified accession ILRI 12463 in intermediate group. Our results agree in some stand with these findings and confirm that, particular climate conditions of area can modify in some stand the phonological characteristics of plants. According to Sanfo (2008), *A. histrix* flowered approximately about 98 days after sowing. In West Africa, Peters *et al* (1994) observed that *A. histrix* flowered mainly in the transition between the wet and dry seasons (July-September). Our results agree in some stand with these findings. According to Merkel et al (2000), *A. histrix* flowering is induced by low temperature during plant development corroborate with our finding as, in the study area, August and December months are the lowest cool in the year Merkel et al. (2000) noted that, flowering is induced by low temperature during plant development de Andrate (1999) reported that the start of the reproductive phase does not coincide with the visible commencement of flowering but occurs approximately one month earlier when the first reproductive buds are formed. The early changes are not obvious to the naked eye and their detection requires dissection of growing points under magnification.

Statistical analysis showed significant influence of year, row spacing and fertilizer on seed production of *A. histrix* (P<0.05) (Table 3). The average seed yield over three years was 307.48 $kg.ha^{-1}$. This seed yield is higher than those reported by Aboh et al. (2005) where the seed yield averaged 248.33 $kg.ha^{-1}$ in northern Benin. Merkel *et al.* (2000); Dembele (2006 and Zampaligre (2007) reported a range of 90-200 $kg.ha^{-1}$ for *A. histrix* seed yield. Also Abayomi (2001) found that under careful management *A. histrix* can yield more than 500 $kg.ha^{-1}$ in the southern Guinea savanna ecological zone of Nigeria. The annual seed yields ranged from 298.2 $kg.ha^{-1}$ in the first year to 315.27 $kg.ha^{-1}$ in the second year representing a significant year effect. Seed production can be affected by variations in the annual growing conditions because the average temperature and rainfall in the growing season differed from year to year, thus affecting the seed set (Chocarro *et al.*, 2015). The results on seed yields showed that an increase in cattle manure rates significantly increased *A. histrix* seed yields (P<0.05). The average 77% increase in average seed yield and the 16 % increase in average 1000 seed weight for application of 12 $t.ha^{-1}$ of cattle manure over the control (0 $t.ha^{-1}$ of cattle manure) can be attributed to the enhancement of soil nutrient supply and availability and also soil physical conditions improvement and moisture retention. Those conditions promoted plant growth and ultimately, enhanced flowering and pod development (Amodu *et al.*, 2004; Gbenou et al. 2018). Average seed yields of *A. histrix* were approximately 11% greater with application of cattle manure (12 $t.ha^{-1}$) than inorganic fertilizers at the equivalent rate of 17 kg P ha^{-1}. Reddy *et al.* (2000) found that soybean (*Glycine max*) was increased over the mineral fertilizer by 06% when amount of cattle manure (16 $t.ha^{-1}$) at the equivalent rate of 22 $kg.ha^{-1}$ of mineral fertilizer (P) was applied. Thus cattle manure has yield-enhancing factors other than P. Since cattle manure contains most of the secondary and micronutrients (S, OM, N, K, Zn, Ca, Mg) required for seed crop (Shuan *et al.*, 1989), increased *A. histrix* seed yield with cattle manure relative to mineral fertiliser at equivalent P rates could be related to the availability of macro- and micronutrients along with available P in the manure. The only limiting factor in the utilization of cattle manure is the rather large quantities needed to meet the requirements of *A. histrix* seed crops for nutrients (Amodu *et al.*, 2004).

Plant density significantly affected seed yield of *A. histrix*. At The widest spacing (80 cm), seed yields were significantly lower ($P<0.05$) than at the 20 and 40 cm spacings. Over three years, plant spacing of 40 cm produced the highest seed yield (389.2 $kg.ha^{-1}$), while the lowest seed yield was related to plant spacing from 80 cm (205.1 $kg.ha^{-1}$) (Table 4).Seed yield in *A. histrix* from a given area is a product of seeds per unit area and weight of seed produced (Rincker *et al.*, 1988). Plants in 80 cm spacing produced littler seeds than plants in 20, 40, 60 cm rows. Caravetta *et al.* (1990) show that this was caused by more area between plants within a rows leads to reduce light reception by leaves per unit area.

During the three years of *A. histrix* growth, seed quality was improved as fertilizer level increased. Several work have reported that seed weight of other legumes were significantly enhanced by phosphorus application (Houndjo *et al.*, 2018b; Amodu *et al.*, 2004; Reddy *et al.*, 2000). The weight of 1000 seed appeared to be an important yield component at different fertilizer level also it is used as standard procedure to estimate the viability and vigor of seeds (Omokanye, 2001). The low average of 1000 pods weight and 1000 seeds weight of seeds from plots of 0 $t.ha^{-1}$ of cattle manure could have resulted from environmental conditions during cell division which can further reflected in seed weight and total seed yield (Yemane and Skjelvag 2003; Omokanye, 2001). For seed production in forage legume the results in this study support numerous reports in the literature (Agishi *et al.*, 1983; Akinola 1978; Akinola *et al.*, 1989; Ariba *et al.*, 1988), and these indicate that P-fertilization should take precedence over N-fertilization.

5. Conclusion

A. histrix can enhance soil fertility and improve the productivity of ruminant livestock. Our study aimed to evaluate the effect of row spacing and fertilizer on growth and seed production of *A. histrix*. The results on seed yields showed that an increase in cattle manure rates significantly increased *A. histrix* seed yields. We also observed that sowing in closer rows (20 cm or 40 cm) significantly improved forage yields compare with plots with wider row spacing. It has been observed that under careful management, it is very profitable to increase yield and quality of seed by adding cattle manure at 12 $t.ha^{-1}$ in conjunction with 40 cm of row spacing.

References

[1] Abayomi YA, Fadayomi O, Babatola JO, Tian G (2001). Evaluation of selected legume cover crops for biomass production dry season survival and soil fertility improvement in a moist savanna location in Nigeria. *African Crop Science Journal*, 9**(**4): 615-627.

[2] Aboh AB, Ehouinsou M, Olaafa M (2005). *Aeschynomene histrix*, une légumineuse fourragère pour contrôler *Imperata cylindrica* au Sud-Bénin. *Bulletin de la Recherche Agronomique du Bénin*, N° 47-Mars.

[3] Ademiluyi BO, Omotoso SO (2008). Comparative evaluation of *Tithonia diversifolia* and NPK fertilizer for soil improvement in maize (*Zea mays*) production in Ado- Ekiti, South Western Nigeria. *Research Journal of Agronomy*, 2(1): 8-11.

[4] Adjolohoun S (2008). *Yield, nutritive value and effects on soil fertility of forage grasses and legumes cultivated as ley pastures in the Borgou region of Benin.* Thèse pour l'obtention du Diplôme de Doctorat en Sciences agronomiques et Ingénierie biologique. Faculté Universitaire des Sciences Agronomiques de Gembloux. Belgique. 101 p.

[5] Adjolohoun S, Bindelle J, Adandédjan C, Toléba SS, Houinato M, Kindomihou V, WRV Nonfon WRV, Sinsin B (2013). Influence de l'écartement et de la fertilisation azotée sur le rendement et la qualité des semences de *Brachiaria ruziziensis* en climat tropical sub-humide. *Fourrage*, 216, 339-345.

[6] Agishi EC, Asare EO 1980. Pasture establishment and seed production in the savannas of Nigeria. *Proceedings of Livestock and Veterinary Conference.* Ahmadu Bello University, Zaria, Nigeria, 15–17 April 1980. AERLS and NAPRI. pp. 282–301.

[7] Akinola JO, Agishi EC (1989). Seed production and forage performance of Centro (*Centrosema pubescens*) and Sirato (*Macroptilum artropropurium*) as influenced by staking and type of pod harvest. *Trop. Grass.*, 23: 225-231.

[8] Akinola JO, Iji PA, Onifade OS (2010). Effects of seeding rate, row spacing and nitrogen and phosphorus fertiliser on forage yield and quality of *Stylosanthes scabra* cvv. Seca and Fitzroy in south-western Nigeria. *Trop. Grass.*, 44: 282-288.

[9] Amodu JT, Adeyinka IA, Lakpini CAM (2004). Response of lablab varieties to farmyard manure in the northern Guinea Savanna of Nigeria. *Trop. Grass.*, 38: 186-191.

[10] Ariba OO, Agishi EC, Kera BS, Olorunju SAS (1988). Agronomic studies of *lablab purpureus*: a. The effect of different levels of P fertilizer and time of planting on seed yield. *NAPRI Annual report*.

[11] Boonman JG (1972). Experimental studies on seed production of tropical grasses in Kenya. 3. The effect of nitrogen and row width on seed crops of *Setaria*

sphacelata cv. Nandi II. *Netherlands Journal of Agricultural Science*, 20: 22-34.

[12] Caravetta GJ, Cherney JH, Johnson KD (1990). Within-row spacing influences on diverse sorghum genotypes: I. Morphology. *Agron. J.*, 82:206-210.

[13] César J et Gouro A (2004). Les légumineuses fourragères herbacées. Productions fourragères en zone tropicale. Production animale en Afrique de l'ouest, fiche n°7.

[14] Chloupek O, Simon U (1997) Seed production of lucerne. Proceedings of the XIIth Eucarpia Meeting of the Group Medicago. Brno, Czech Republic: Academia Publishing House.

[15] Chocarro C, Lloveras J (2015).The effect of row spacing on alfalfa seed and forage production under irrigated Mediterranean agricultural conditions. *Grass and Forage Science*, 70, 651-660.

[16] Cook BG, Pengelly BC, Brown SD, Donnelly JL, Eagles DA, Franco MA, Hanson J, Mullen BF, Partridge IJ, Peters M, Schultze-Kraft R (2005). *The Production of Tropical Forages : An alternative selection tool.* Available <http://www.tropicalforages.info> accessed on [07/02/19]

[17] de Andrate (1990). Location of Seed Crops: Legumes *in* Loch D.S., Ferguson J.E. (eds), *Forage seed production. Volume 2: tropical and subtropical species*, CAB Int., 129-140.

[18] Dembélé K (2006). Contribution à l'étude de l'amélioration des pâturages naturels par introduction de légumineuses fourragères. Mémoire de fin d'étude, UPBI IDRI, 113 p + annexes.

[19] Duncan AJ, Tarawali SA, Thorne PJ, Valbuena D, Descheemaeker K, Homann-Kee Tui S (2013). Integrated crop-livestock systems − a key to sustainable intensification in Africa *Tropical Grasslands – Forrajes Tropicales Volume 1, 202−206.*

[20] FAO. (2000). Fertilizers and their uses, 26-29.

[21] Ferguson JE, English H Loch DS (1990). Crop Management: Legumes. In Loch DS and Ferguson JE Forage Seed Production. Volume 2, Tropical and Subtropical species. CABI Publishing, CAB International, Wallingford, UK.

[22] Gbenou B, Adjolohoun S, Houndjo DBM, Saïdou A, Houinato M, Ahoton L, Sinsin BA (2018). Animal dung availability and their fertilizer values in a context of low soil fertility conditions for forage seed and crops production in Benin (West Africa). *Agri. Sci. Res. Jour.*, 8(5): 117-125.

[23] Hare MD, Gruben IE, Tatsapong P, Lunpha A, Saengkham M, Wongpichet K (2004). Inter-row planting of legumes to improve the crude protein concentration in *Paspalum atratum* cv. Ubon pastures in north-east Thailand. *Trop. Grass.*, 38, 167 –177.

[24] Houndjo DBM, Adjolohoun S, Gbenou B, Saïdou A, Ahoton L, Houinato M, Seibou Toleba S, Sinsin BA (2018a). Benin: socio-demographic and economic characteristics, crop-livestock production systems and issues for rearing improvement. *A review*. *Int. J. Biol. Chem. Sci*.,12(1): 519-541.

[25] Houndjo DBM, Adjolohoun S, Gbenou B, Saïdou A, Ahoton L, Houinato M, Sinsin BA (2018b). Cattle dung, phosphorus fertilizer and row planting on *Centrosema pubescens* (Benth) grow and seed component attributes in ferralitic soils of Benin (West Africa). *Agri. Sci. Res. Jour.*, 8(5): 108-116.

[26] Kouelo Félix A, Houngnandan Pascal, Gerd Dercon (2013). Contribution of seven legumes residues incorporated into soil and NP fertilizer to maize yield, nitrogen use efficiency and harvest index in degraded soil in the center of Benin. *Int. J. Biol. Chem. Sci.*, 7(6): 2468-2489.

[27] Koura B (2015). *Improvement of animal productivity by using crop residues in integrated crop-livestock systems in Benin*. PhD thesis. University of Abomey-Calavi. Abomey-Calavi. 186 p.

[28] Kretschmer AE, Bullock RC 1980. Aeschynomene spp.: Distribution and potential use. *Proceedings of the Soil and Crop Science Society of Florida* 39: 145-152.

[29] Lesse DPAA (2016). *Gestion et modélisation de la dynamique des parcours de transhumance dans un contexte de variabilités climatiques au nord-est du Bénin.* Thèse de Doctorat. Université d'Abomey-Calavi. Abomey-Calavi. 305 p.

[30] Maliki R, Sinsin B, Floquet A, Parrot L (2011). Contingent constraints of soil conservation innovations: case of yam-based systems with herbaceous legumes in the Guinea-Sudan transition zone of Benin. *Glo. Jour. Env. Res.*, 5(3): 118-128.

[31] Maliki Raphiou, Sinsin Brice, Floquet Anne (2012). Evaluating Yam-Based Cropping Systems Using Herbaceous Leguminous Plants in the Savannah Transitional Agroecological Zone of Benin. *Jour. Sust. Agri.*, 36:4, 440-460.

[32] Merkel U, Peters M, Tarawali SA, Schultze-Kraft, Berner DK (2000). Characterisation of a collection of *Aeschynomene histrix* in subhumid Nigeria. *Jour. Agr. Sci., Camb.*, 134: 293-304.

[33] Mkhabela TS, Materechera SA (2003). Factors influencing the utilization of cattle and chicken manure for soil fertility management by emergent farmers in the moist midlands of KwaZulu-Natal province, South Africa. *Nutr. Cyc. Agro.*, 65: 151-162.

[34] Muzafer AS., Pinky D., Dwivedi HS. (2015). Impact of Chemical Fertilizer and Organic Manure on the Germination and Growth of Soybean (*Glycine max* L.). *Adv. Life Science. Tech*.

[35] Ogedegbe SA, Ogunlela VB, Olufajo OO, Odion EC (2012). Seed yield attributes of Lablab (*Lablab purpureus* L. Sweet) as influenced by phosphorus application, cutting height and age of cutting in a semi –arid environment. *Asian Jour. Crop sci.*, 4(1): 12-22.

[36] Omokanye AT (2001). Seed production, herbage residue and crude protein content of centro (*Centrosema pubescens*) in the year of establishment at Shika, Nigeria. *Tropicultura*, 19(4): 176-179.

[37] Peters M, Tarawali SA, Alkanper J (1994). Evaluation of tropical pasture legumes for fodder banks in subhumid Nigeria. 2. Accessions of *Aeschynomene histrix, Centrosema acutifolium, C. pascuorum, Stylosanthes guianensis* and *S. hamata. Trop. Grass.*, 28: 74-79.

[38] Rayar AJ (1986). Response of groundnut (*Arachis hypogea* L.) to application of farm yard manure and N and P on light sandy loam soil of Northern Nigeria. *Inter. Jour. Trop. Agri.*, IV 46-54.

[39] Reddy DD, Rao AS, Rupa, TR (2000). Effects of continuous use of cattle manure and fertiliser

phosphorus on crop yields and soil organic phosphorus on a vertisol. *Bior. Tech.* 75:114 - 118.

[40] Rincker CM, Marble VL, Brown DE, Johansen CA (1988). Seed production practices. In: Hanson C.H. (ed.) *Alfalfa Science and Technology*, Agronomy 29, pp. 985–1012. Madison, WI, USA: ASA, CSSA and SSSA Publishers.

[41] Samia OY, Salam KA, Salam A, Mohammed MH, Moaid AH (2015). Effects of organic and mineral fertilizers on growth and yield of soybean (*Glycine max* L. Merril). *International Jour . Agro. Agri. Res.*, 7(1), 45-52.

[42] Sanfo A (2008). *Caractérisation des légumineuses fourragères et leur mode d'utilisation pour l'amélioration des pâturages soudaniens : cas de la zone ouest du Burkina Faso*. Mémoire de fin de cycle pour l'obtention du diplôme d'ingénieur du développement rural.

[43] Shuan L, Jun-Quan Z (1989). Effect of level and source of nitrogen fertilizer on the pure seed yield of Setaria sphalcelata cv. Narok in Yunnan province, southern China. In: XVI *International Grassland Congress, Nice, France*, pages 679-680.

[44] Tarawali G, Mohamed Saleem MA, Von Kaufmann R (1988). Legume-based cropping: A possible remedy to land tenure constraint to ruminant production in the subhumid zone of central Nigeria. In: *Dzowela, B.H (ed.)* African Forage plant Genetic Resources, Evaluation of forage Germplasm and extensive Livestock Production Systems. Pp. 417-429. ILCA, Addis Ababa, Ethiopia.

[45] Udoh DJ, Ndoh BA, Asuquo PE, Ndaeyo NU (2005). Crop Production Techniques for the tropics. *Concept Publication. Lagos Nigeria*. P. 446.

[46] Van Reewijk LP (1992). *Procedure for Soil Analysis. Technical Paper*. No 9. 3rd Edn. (International Soil Reference and Information Centre: Wageningen, the Netherlands).

[47] Yemane A, Skjelvag AO (2003). Effects of Fertilizer Phosphorus on Yield Traits of Dekoko (Pisum sativum var. abyssinicum) Under Field Conditions. *J. Agr. Crop Sci.* 189, 14-20.

[48] Zampaligré N (2007). *Caractérisation des semences de légumineuses et analyse de la végétation de la strate herbacée des pâturages soudaniens améliorés par semis direct de légumineuses*. Mémoire de fin d'étde, 72 p + annexes.

Table 1: Average monthly rainfall and mean temperature during the growing seasons of 2016–2018

Months	Temperature (°C)			Rainfall (mm)		
	2016	2017	2018	2016	2017	2018
January	28	26	27	0	0	23
February	28	27	26	0	0	0
March	28	29	27	11	3	51
April	27	27	28	121	117	151
May	28	28	27	133	135	149
April	27	27	27	276	257	199
Jun	27	26	26	217	140	215
July	26	26	25	110	120	114
August	26	25	26	101	72	51
September	27	27	27	167	106	108
October	26	26	27	99	57	117
November	25	26	26	0	0	19
December	28	26	28	3	0	0
Total	-	-	-	**1238**	**1107**	**1197**

Table 2: Chemical properties of the soil at the experimental site

Soil properties	Value
C (%)	0.4
N (%)	0.05
O.M. (%)	1.17
pH $_{(2/5\ water)}$	6.2
K (mg/100g)	20
Ca (mg/100g)	60
Mg (mg/100g)	10
P (mg/100g)	0.2

Source: (Houndjo et al., 2018b)

Table 3: Development attributes (days after sowing) of *Aeschynomene histrix* as influenced by growing year

Year	Flowering onset	50% flowering	Podding onset	Pod filling	Pod repining onset
2016	135 b	147 b	136 c	150 c	204 c
2017	110 c	122 c	111 b	127 b	181 b
2018	166 a	174 a	167 a	177 a	230 a
Mean	**137**	**148**	**138**	**151**	**205**

Table 4: Growth parameters of *Aeschynomene histrix* as influenced by plant row spacing during three growing years (2016-2018) [WAS = number of weeks after sowing]

Year	Plant height (cm) WAS		Soil cover (%) WAS		Plant branching (unit) WAS	
	(8)	(16)	(8)	(16)	(8)	(16)
20 cm × 20 cm	15 a	71 a	7 a	95 a	2 a	47 a
40 cm × 40 cm	14 a	77 a	4 b	75 b	2 a	49 a
60 cm × 60 cm	15 a	69 a	2 c	58 c	1 a	51 a
80 cm × 80 cm	14 a	70 a	1 d	37 d	1 a	59 a
Mean	**15**	**72**	**4**	**66**	**2**	**52**

Table 5: Effect of plant density, cattle manure and phosphore fertilizer application, on seed yield (kg.ha^{-1}) of *Aeschynomene histrix* on ferralitic soils of Benin

Fertilizer	Row spacing				Mean
	20 cm	40 cm	60 cm	80 cm	
2016					
FTSP:	357bBβ	414.4 cbAβ	299.8cCβ	203.9bcDβ	**318.8**
F0	233.4eBα	206.7 eAβ	211eAα	144.5eCβ	**198.9**
F4	300.7dBβ	361.1 dAβ	274.9dCα	170.3dDβ	**276.7**
F8	343.8 cBβ	404.4 cAβ	298.1cCβ	195.7cDβ	**310.5**
F12	375.5aBα	455.9 aAα	353.8aCα	231.9aDα	**354.3**
F6	365.8 aBβ	426.6 bAγ	314.8bCγ	213.2bDβ	**330.1**
Mean	**329.3**	**378.2**	**292.1**	**193.2**	**298.2**
2017					
FTSP:	372cBα	429.4cAα	314.8cCα	218.9cDα	**333.8**
F0	229.0eAα	235.3fAα	204.0eBα	180.6dCα	**212.2**
F4	310.7dBαβ	373.6eAαβ	284.9dCα	185.3dBα	**288.6**
F8	362.5cBα	419.4dAα	313.1cCα	210.7cDα	**326.4**
F12	404.3aBα	480.9aAβ	383.8aCα	256.9aDα	**381.5**
F16	382bBα	446.6bAα	334.8bCβ	233.2bDα	**349.1**
Mean	**343.4**	**397.5**	**305.9**	**214.3**	**315.27**
2018					
FTSP:	365.5cBα	422.9bAαβ	308.3cCαβ	212.4cDβα	**327.3**
F0	222.5eAα	228.8eAα	197.5eBα	174.1dCα	**205.7**
F4	304.2dBβ	367.1dAβ	278.4dCα	178.8dDαβ	**282.1**
F8	356.0cBα	412.9cAβα	306.6cCαβ	204.2cDαβ	**319.9**
F12	397.8aBα	494.4aAα	377.3aCα	250.4aDα	**380**
F16	375.5bBα	425.1bAβ	328.3bCβ	226.7bDβ	**338.9**

Mean	**336.9**	**391.8**	**299.4**	**207.8**	**308.98**
3-year mean	***336.6***	***389.2***	***299.1***	***205.1***	***307.48***

*For the same column and for the same year, means followed by different lower case letters (a, b and c) are significantly different at $p < 0.05$; For the same row, means followed by different upper case letters (A, B and C) are significantly different at $p < 0.05$; For the same year and for the same level of fertilizer, means followed by different alpha numeric letters (α, β, and γ) are significantly different at $p < 0.05$. FTSP: 37.8 kg P_2O_5 .ha^{-1}; F0: dry cattle manure rates of 0 tons.ha^{-1}; F5: dry cattle manure rates of 5 tons.ha^{-1}; F10: dry cattle manure rates of 10 tons.ha^{-1} ; F15: dry cattle manure rates of 15 tons.ha^{-1} and F20: dry cattle manure rates of 20 tons.ha^{-1}

Table 6: Effect of cattle manure applied at the equivalent rate of 16.5 kg P ha^{-1} (15 t.ha^{-1}) and mineral fertiliser (P_2O_5) applied at 37.8 kg ha^{-1} on *A. histrix* seeds during three growing seasons (2014-2016) in southern Benin

Parameters	Seed yield (kg.ha^{-1})	1000 Seed weight (g)	Seed yield (% increase over control)	1000 seed weight (% increase over control)
Control	205.6	1.17	-	-
Manure at 17 kg P. ha^{-1} equivalent (12 t.ha^{-1})	363.8	1.36	76.94%	16.23%
Fertilizer at 17 kg P .ha^{-1} (40 kg P_2O_5 .ha^{-1})	326.6	1.34	58.85%	14.52%

Table 7: *Aeschynomene histrix* pod and seed characteristics as influenced by fertilizer levels in southern Benin during three growing seasons (2014-2016)

Fertilizer	1000 pods weight (g)	1000 seeds weight (g)	1000 shells weight (g)	Ratio seed/shell
0 (control)	1.65e*	1.17c	0.48d	2.46a
4 tons/ha	1.72d	1.17c	0.55c	2.14a
8 tons/ha	1.80c	1.24b	0.56c	2.21a
12 tons/ha	1.99a	1.36a	0.63a	2.15a
16 tons/ha	1.95ab	1.34a	0.60b	2.23a
40 kg/ha P_2O_5	1.92b	1.33a	0.59b	2.28a
Mean	1.84	1.27	0.56	2.24

*For the same column means followed by different lower case letters (a, b and c) are significantly different at $p < 0.05$.

Table 8: Effect of plant density, cattle manure application, on Dry matter yield (kg.ha^{-1}) of *Aeschynomene histrix* during three growing seasons (2014-2016), in southern Benin.

Fertilizer	Row spacing				Mean
	20 cm	40 cm	60 cm	80 cm	
FTSP:	4.81cA	4.88cA	4.75cA	4.39cB	**4.71**
F0	3.67fA	3.42fB	3.01fC	2.55fD	**3.16**
F5	3.76eA	3.64eB	3.55eC	3.33eD	**3.57**
F10	4.26dA	4.14dB	4.04dC	3.85dD	**4.07**
F15	5.25bA	5.23bA	5.05bB	4.64bC	**5.04**
F20	5.99aA	5.85aB	5.39aC	4.83aD	**5.51**
Mean	**4.62**	**4.53**	**4.30**	**3.93**	**4.34**

*For the same column, means followed by different lower case letters (a, b and c) are significantly different at $p < 0.05$; For the same row, means followed by different upper case letters (A, B and C) are significantly different at $p < 0.05$. FTSP: 37.8 kg P_2O_5 .ha^{-1} ; F0: dry cattle manure rates of 0 tons.ha^{-1}; F5: dry cattle manure rates of 5 tons.ha^{-1}; F10: dry cattle manure rates of 10 tons.ha^{-1} ; F15: dry cattle manure rates of 15 tons.ha^{-1} and F20: dry cattle manure rates of 20 tons.ha^{-1}