# Evaluation of performances of a legume *Chamaecrista rotundifolia* to improve natural pastures in semi-arid ecosystems.

## Short title: Improvement of natural pastures

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## Abstract

This study aims to improve the natural pastures dominated by *Andropogon gayanus* by overseeding a legume, *Chamaecrista rotundifolia*. The experimental design is randomized complete blocks with three studied factors: sowing mod (weeding and unweeding the existing grasses), seeding density (control, 200 and 400 plants of forage legume/m²) and triple superphosphate application (0 and 100 kg/ha). Results showed that the numbers of plants of introduced fodder legume established in the stand was far less than expected '10 to 155 plants/m²). Phosphorus application doesn't affect this number but the sowing mod influenced this significantly. Weeded plots had higher number of legume plants/m² than un-weeded. Phosphorus application improved significantly biomass production on the ferralitic soil compared to the ferruginous soil. The percentage of *C. rotundifolia* in the total biomass ranged from 15 to 95% and 6 to 94% for ferralitic and ferruginous soil, respectively. In weeded plots, the average percentage of *C. rotundifolia* in the total biomass was better (75%) than in the non-weeded plots (15%). Similarly, the seeding density of *C. rotundifolia* at 400 plants/m² resulted in 57% part of *C. rotundifolia* compared to 47% in plots seeded at 200 plants/m² and 30% in the control plots. Seeding density of 200 plants/m² associated with phosphorus application could be recommended for natural pasture improvement by overseeding *C. rotundifolia* on ferralitic soil type.

**Key words:** Natural pasture improvement, overseeding, seeding density, *Chamaecrista rotundifolia*, Burkina Faso.

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# Amélioration des pâturages naturels par sursemis de légumineuses *Chamaecrista rotundifolia*

## Résumé

Cette étude vise à enrichir les pâturages naturels dominés par *Andropogon gayanus* en sursemant une légumineuse, *Chamaecrista rotundifolia***.** Le plan expérimental est un bloc complet randomisé avec trois facteurs étudiés sur des parcelles élémentaire de 20 $m^2$. Le mode opératoire a consisté à la préparation du sol (sarclage et non sarclage des herbes existantes), aux densités de semis (témoin, 200 et 400 plantes de légumineuses fourragères/m²) et à l'application de superphosphate triple (0 et 100 kg/ha). L'étude a été conduite sur deux années consécutives. Les résultats ont montré que le nombre de plants de la légumineuse fourragère introduite établis dans le peuplement était bien inférieur à ce qui était prévu (10 à 155 plantes/m²). L'application de phosphore n'a pas affecté ce nombre mais le mode de semis l'a influencé de manière significative. Les parcelles désherbées présentaient un nombre plus élevé de plantes de légumineuses/m² que les parcelles non désherbées. L'application de phosphore a amélioré de manière significative la production de biomasse sur le sol ferralitique par rapport au sol ferrugineux. Le pourcentage de *C. rotundifolia* dans la biomasse totale variait de 15 à 95% et de 6 à 94% respectivement pour les sols ferralitiques et ferrugineux. Dans les parcelles sarclées, le pourcentage moyen de *C. rotundifolia* dans la biomasse totale était meilleur (75%) que dans les parcelles non sarclées (15%). De même, la densité de semis de *C. rotundifolia* à 400 plantes/m² a donné une part de 57% de *C. rotundifolia* contre 47% dans les parcelles semées à 200 plantes/m² et 30% dans les parcelles témoins. La densité de semis de 200 plantes/m² associée à l'application de phosphore pourrait être recommandée pour l'amélioration des pâturages naturels par sur-semis de *C. rotundifolia* sur un type de sol ferralitique.

**Mots clés :** Amélioration des pâturages naturels, amélioration, sur-semis, densité de semis, *Chamaecrista rotundifolia*, Burkina Faso.

# Introduction

Livestock production in Burkina Faso is a major economic component in the country's attempt to achieve food self-sufficiency. It is the second source of income for the country after cotton (KABORRE, 2008) and represents about 26% of national exports and contributes to more than 12% of the Gross Domestic Product (GDP) (MRA, 2007). In recent years, the increase of livestock combined with the saturation of the space, pastoral practices have evolved to adapt to this new context (ZOUNGRANA, 1991; OUEDRAOGO *et al.*, 2019). Sudanian zone, which has now become an attraction pole for transhumants, is characterized by the traditional extensive system. All year round, ruminant feeding is based on the exploitation of natural pasture (KAGONE, 2000). However, the pastures in this zone fluctuate in quantity and quality with the seasons. The existing biomass is dominated by grasses (TOUTAIN *et al.*, 1994; OUEDRAOGO *et al*., 2023a; SANOU *et al.*, 2022) and legumes are very poorly represented (FOURNIER, 1991), although they constitute a more important source of nitrogenous matter and contribute to improving the nutritional value of the natural pastures (SANOU *et al.*, 2023). With a view to improving this grazing, research is being conducted at the Farako-Bâ station in Bobo-Dioulasso by incorporating fodder legumes. In cropping, these legumes provide soil cover and nutrient enrichment, and they supplement the ruminants' diet with a perspective of agriculture-livestock integration, which is the basis for the sustainability of agricultural production systems. Indeed, legumes have an essential property, that of capturing atmospheric nitrogen and fixing it on the roots, thanks to bacteria of the genus rhizobium (SANOU *et al.*, 2023). This property gives them three great qualities: they provide a protein-rich fodder, require little nitrogen fertilization and finally provide an improving effect on soil fertility in the short term. Their impact on agriculture is well appreciated and further investigations are needed to remove the constraints to their adoption by farmers for a good complementarity between agriculture and intensive livestock production in Burkina Faso. The present work aimed to contribute to a better knowledge of the legume *C. rotundifolia* in order to propose solutions for its valorization in pastoral areas. We tested the capacity of *C. rotundifolia* to improve natural grazing. Then, we evaluated the competitive abilities of *C. rotundifolia* in natural grassland with *A. gayanus*; we evaluated the contribution to the floristic composition and biomass of *C. rotundifolia* in grassland with *A. gayanus*. In addition, we evaluated the effect of *C. rotundifolia* on the quality of a pasture dominated by *A. gayanus*; we also evaluated the effect of P fertilization (TSP 100 kg/ha) on the persistence and contribution to biomass production of the target legume in native pasture. Finally, we evaluated the effect of soil type on the persistence of the target legume in native pasture.

## I. Materials and methods

### 1.1. Study site

The experiment was carried out at the Institute of Environment and Agricultural Research located at Farako-Bâ (11°06 N, 04°20 W, 405 m.a.s.l., Figure 1). Phytogeographically, the study site is situated in the southern soudanian zone of Burkina Faso with a mean annual precipitation varying between 900 mm and 1000 mm (FONTES and GUINKO, 1995) The site has a unimodal rainy season, which lasts for about 7 months each year from May to November. The mean annual rainfall for the last decades was 1272±124 mm, and the number of rainy days per annum was 71±6. Mean daily minimum and maximum temperatures ranged from 14°C to 32°C in January (the coldest month) and from 25°C to 41°C in April (the hottest month). Soil types are mostly the tropical ferruginous to ferralitic (DRIESSEN et al., 2001). The soils are characterized by a sandy-loan texture with, pH 5.2 to 5.4, average organic matter content of 0.95 to 1.03 % and low phosphorus content (41 to 85 mg/kg) (SEDOGO et al. 1991). The natural pastures are dominated by woody species such as *Danielia olivieri*, *Afzelia africana*, *Isoberlia doka*, *Pterocarpus erinaceus, Prosopis africana, Parkia biglobosa*, *Burkea africana et Albizzia chevalier* and some characteristic herbaceous species such as *Andropogon ascinodis, Andropogon gayanus, Aristida* *kerstingii, Ctenium newtonii, Loudetia togoensis, Monocymbium cereciforme, Pennisetum pedicellatum Schizachyrium sanguneum*, etc. (OUEDRAOGO *et al.*, 2023b) Legumes species are rare in the vegetation of the study site. However, the legume *Indigofera sp.*, which is mostly non palatable, occasionally has invaded some of these natural pastures. Aside from agriculture, which is the occupation of 80% of the area's active population, livestock breeding is the most next important activity for household income generation

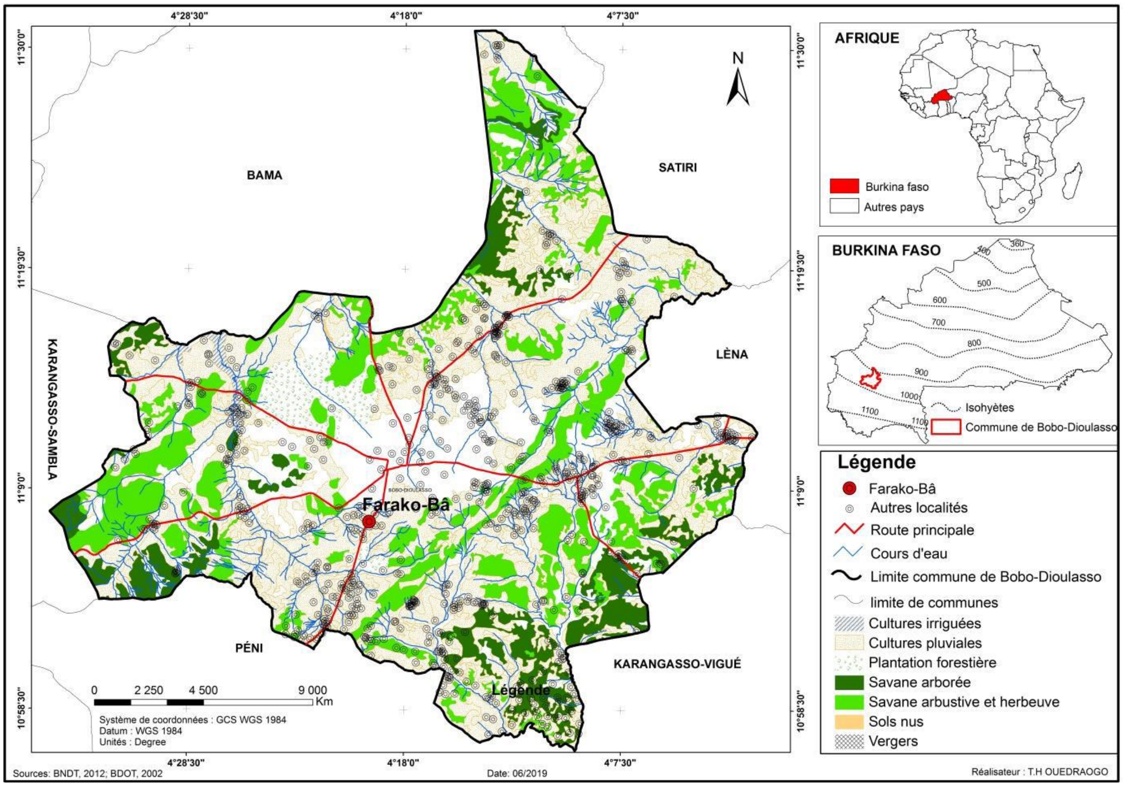



**Figure 1 : Location of the research site (Farako-Bâ research station)**

## 1.2. Materials

The plant material used consists of seeds of *Chamaecrista rotundifolia* (Pers.) Greene, a legume native to South America (Argentina, Bolivia, Brazil, Colombia, Paraguay, Uruguay and Venezuela), Central America (Costa Rica and Panama) and North America (Mexico) and is naturalized in countries such as the USA and in Africa, in addition to being studied and used as forage for more than 40 years in Australia. It is a weak perennial or self-regenerating annual (in areas with heavy frost or a long dry season) with prostrate growth when young; when older its floral branches tend to die.

The main stem is erect to about 1 m high (rarely to 2.5 m) and laterals are ascendant with stems of 0.45–1.1 m long (COOK et al. 2020). It has been introduced in Farako-Bâ research station with a collaborative research program with AusAID (CORAF/OID project 2102-2015). Seeds of *C. rotundifolia* were introduced in existing natural pasture composed of numerous herbaceous species and dominated by *Andropogon gayanus*.

### 1.3. Methods

The study was conducted in Farako-Bâ research station on two sites, the first on ferruginous soil and the second on ferralitic soil. The experimental set-up was a split-split split-plot with soil type as the main factor (Figure 2). In each of 4 replicates or blocks is composed of 10 elementary plots of 20 m² (5 m x 4 m). The elementary plots are separated from each other by 1m and the main row by 2 m. The experimental set-up includes four factors:

- Soil type with two levels: ferruginous soil and ferralitic soil;
- Fertilization: application of TSP (200 g in a single application after sowing for each elementary plots) and without TSP;
- Seeding density: two levels of seeding density (200 and 400 plants of *C. rotundifolia*/m² respectively CH200 and CH400 and control;
- Maintenance: weeded plots and non-weeded plots;

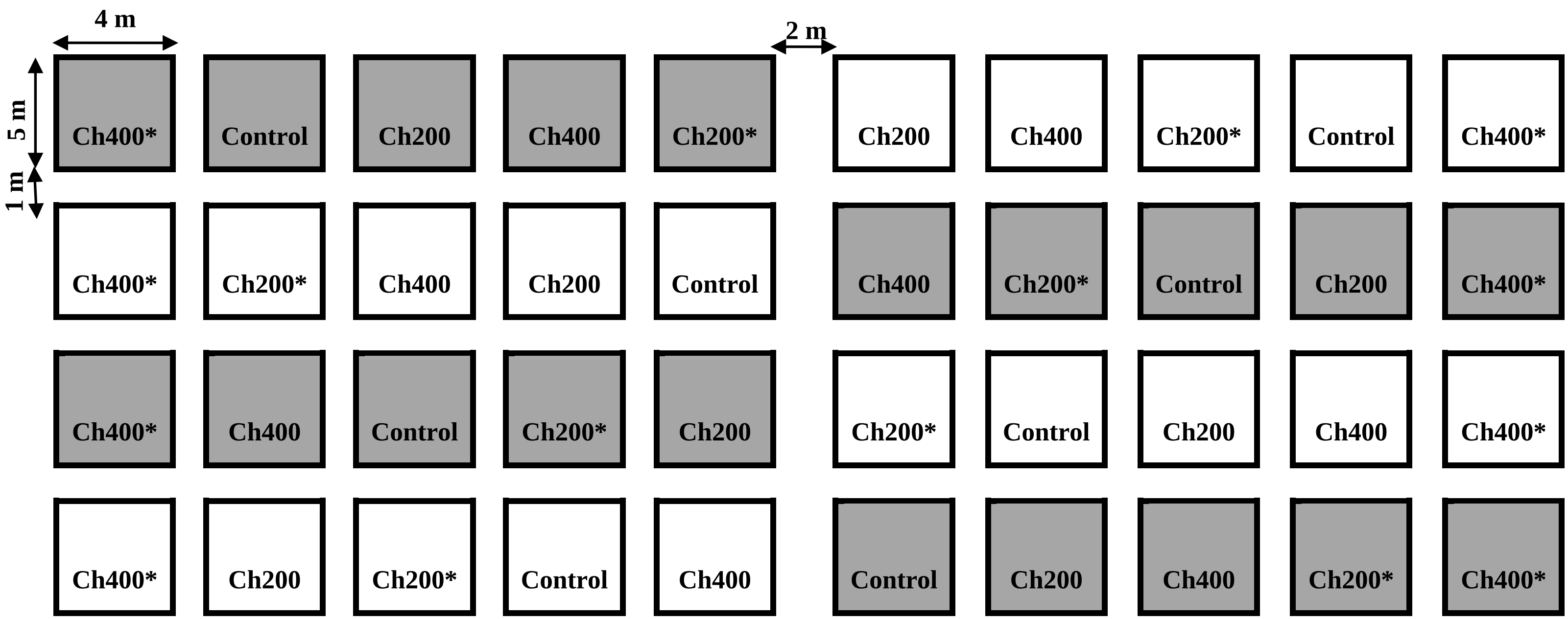
Sowing was done by broadcasting in order to have a uniform distribution of seeds on the plot. Figure 3 gives us an overall view of the adopted experimental design, implemented on ferralitic soil and ferruginous soil.

### 1.4. Data collection and analysis

The observations were made on two 1-meter square plots, permanently located on one of the diagonals of each elementary plot. A first count carried out from 01-02 June on both sites (ferruginous and ferralitic soil). It consisted of counting, considering three groups of plants (the introduced legume *Chamaecrista rotundifolia*, the dominant local plants *Andropogon gayanus* and others). A second count followed by biomass cuts was conducted from 03 August with two 1 $m^2$ plots on both sites also to assess the biomass production of *C. rotundifolia*, *A. gayanus*, and others. On each of the elementary plots, two square plots were located diagonally and harvested. All the harvested biomass was weighed per plot individually using an electric balance. All biomass of the same treatment from the four replicates were then pooled and carefully mixed. Two 100 g samples for dry matter determination were taken and exposed to sunlight before being oven dried at 105°C for 24 hours. From the dry weight (DW) of these samples the percentage of dry matter (%MS) to fresh weight (FW) is determined. Another 500 g sample was taken and air dried for analysis.

All data collected were performed with using the stats package in R statistical software. The calculated parameters were first analyzed with ANOVA considering the block as a random factor and the treatments applied as a fixed factor for each site. The models were fitted using the function ‘aov’ from the ‘stats’ package in R software. When a significant difference was detected, a pair-wise comparison was made using Tukey's test at the 5% level of significance.

Prior to analysis, data exploration was performed following the protocol described by ZUUR et al. (2010).




= Application de TSP

= Without TSP

Ch200× = Weeded plot

Ch400× = Weeded plot

Ch200 = Un-weeded plot

Ch400 = Un-weeded plot

**Figure 2. Experimental design set-up in ferralitic soil and ferruginous soil**

## II. Results

### 2.1. Evolution of the structure of the pasture

The structure of the pasture is represented by the number of plants of the different species recorded per m². This structure is variable depending on the evaluation period (early in the rainy season and later in the rainy season corresponding to maximum of biomass), soil, TSP application, weed control and C. rotundifolia seeding.

*Andropogon gayanus* that is the most dominant species in the Farako-Bâ pastures, is represented by a number of clumps per $m^2$ ranging from 4 to 12 on ferralitic soils and 8 to 32 on ferruginous soils. This species is more dominant on the pastures of ferruginous soils compared to ferralitic soils. On the other hand, in the category of other species, their number is much higher on ferralitic soil (67 to 169 plants/m²) than on ferruginous soil (26 to 54 plants/m²) (Table I).

The number of plants of *C. rotundifolia* varied between 15 to 22 and 18 to 34 plants/m² on ferralitic soil under direct seeding condition in the natural pasture without weeding with and without TSP application respectively in August. On ferruginous soil, this number varied between 16-25 and 10 -18 plants/m² for the same treatments.

### 2.2. Evolution over time of the number of plants introduced as a function of the seeding density by counting

The evolution of the number of plants of leguminous plants/m² reflects the aptitude of the introduced forage legume to sustain itself in the natural pasture. Between June and August, the different densities *C. rotundifolia* (16-25 and 10 -18 plants/m²) depending on the type of soil generally increased for plots weeded at planting time except for the case of ferruginous soil with TSP application and Ch400 planting where it decreased by more than half between these two dates.

However, on the ferralitic soil, the evolution of Ch200 and Ch400 on the weeded plots increases at the first count as well as at the second count with no TSP (Table II). With TSP, the number of plants increased at the first count and Ch200 decreased at the second count. On the ferruginous soil, the evolution of the number of leguminous plants/m² at the first count as well as at the second count with the seeding density of Ch200 and Ch400, the application of TSP strongly improved the evolution of the number of plants at the second count, 144 for Ch200 and 155 for Ch400 on the plots weeded at the time of the installation of C. rotundifolia. The density of seedlings on the non-weeded plots always shows a superiority of the number of *Chamaecrista* plants in Ch200 and Ch400 while in the Control there are no *Chamaecrista* plants. On the ferruginous soil, we notice an improvement in the number of *Chameacrista* plants /m² in Ch200 and Ch400 but in large numbers with the addition of TSP. The presence of

*Chamaecrista* in the control plots was also noted, indicating a colonization of these plots even if the number decreased between the two counts. Under weed control conditions at the installation of *C. rotundifolia*, the addition of TSP improves its representativeness (number of plants/m²) on ferruginous soil compared to ferralitic soil.

**Table I. Evolution of the structure of improved pastures depending on the treatments (number of plants/m²)**

| Sol | TSP (kg/ha) | Weeding | Year 2 (early in the rainy season) | | | | | Year 2 (at the maximum of biomass) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Treatment | Chamaecrista | Andropogon | Stylosanthes | Others | Chamaecrista | Andropogon | Stylosanthes | Others |
| Ferralitic soil | 0 | Weeded | Ch200 | 26 | 0 | 0 | 72 | 72 | 2 | 0 | 55 |
| | | | Ch400 | 57 | 1 | 0 | 43 | 65 | 1 | 0 | 43 |
| | | Non weeded | Ch200 | 7 | 2 | 0 | 107 | 15 | 6 | 0 | 83 |
| | | | Ch400 | 12 | 4 | 0 | 94 | 22 | 10 | 0 | 71 |
| | | | Control | 0 | 12 | 0 | 78 | 0 | 12 | 0 | 54 |
| | 100 kg | Weeded | Ch200 | 69 | 1 | 0 | 117 | 51 | 5 | 0 | 49 |
| | | | Ch400 | 84 | 0 | 0 | 29 | 90 | 0 | 0 | 22 |
| | | Non weeded | Ch200 | 10 | 3 | 0 | 169 | 18 | 9 | 0 | 56 |
| | | | Ch400 | 12 | 2 | 0 | 156 | 34 | 6 | 0 | 106 |
| | | | Control | 0 | 4 | 0 | 67 | 0 | 11 | 0 | 34 |
| Ferruginous | 0 | Weeded | Ch200 | 46 | 4 | 0,1 | 30 | 81 | 2 | 0 | 89 |
| | | | Ch400 | 83 | 2 | 0 | 30 | 92 | 2 | 0 | 39 |
| | | Non weeded | Ch200 | 5 | 10 | 0 | 44 | 16 | 11 | 0 | 63 |
| | | | Ch400 | 69 | 6 | 0 | 42 | 25 | 19 | 0 | 42 |
| | | | Control | 18 | 5 | 0 | 34 | 5 | 18 | 0 | 100 |
| | 100 kg | Weeded | Ch200 | 53 | 4 | 0,3 | 39 | 144 | 2 | 6,5 | 74 |
| | | | Ch400 | 57 | 4 | 0,4 | 27 | 155 | 1 | 0 | 42 |
| | | Non weeded | Ch200 | 4 | 8 | 0,1 | 44 | 10 | 21 | 0 | 66 |
| | | | Ch400 | 8 | 9 | 0 | 26 | 18 | 25 | 0 | 59 |
| | | | Control | 46 | 8 | 0,4 | 54 | 2 | 32 | 0 | 83 |

**Table II. Evolution of the number of plants/m² of C. rotundifolia according to the treatments**

| Weeding | Sol | Seeding density | Sans TSP | | | TSP | | |
|---|---|---|---|---|---|---|---|---|
| | | | Year 1 | Year 2' | Year 2" | Year 1 | Year 2' | Year 2'' |
| Weeded | Ferralitic | Ch200 | 14 | 26 | 72 | 18 | 69 | 51 |
| | | Ch400 | 57 | 57 | 65 | 52 | 84 | 90 |
| | Ferruginous | Ch200 | 35 | 46 | 81 | 34 | 53 | 144 |
| | | Ch400 | 68 | 83 | 92 | 110 | 57 | 155 |
| Un-weeded | Ferralitic | Ch200 | 20 | 7 | 15 | 16 | 10 | 18 |
| | | Ch400 | 40 | 12 | 22 | 37 | 12 | 34 |
| | | Control | 0 | 0 | 0 | 0 | 0 | 0 |
| | Ferruginous | Ch200 | 18 | 5 | 16 | 20 | 4 | 10 |
| | | Ch400 | 39 | 69 | 25 | 33 | 8 | 18 |
| | | Control | 0 | 18 | 5 | 0 | 46 | 3 |

NB: Year 1 and Year 2' = early in the rainy season Year 2" =at the maximum biomass

### 2.3. Evolution of biomass production according to soil types

The evaluation of biomass production early in the rainy season and at the maximum biomass of year 2 showed an evolution of this biomass according to the different treatments studied (Table III). In the month of June, TSP application resulted in an approximate 50 to 100% increase in biomass for all treatments on ferralitic soil (1.9 to 2.3 with fertilization and 2.1 to 3.5 t DM/ha without fertilization). However, on ferruginous soil, the effect of this phosphorus fertilization was not very high (1.9 to 2.3 and 1.7 to 2.9 t DM/ha). In August, this trend remained the same except that the increase in biomass production was very significant between June and August, reaching 8 t DM/ha in the case of the TSP application on ferruginous soil. This increase in biomass is very remarkable for the species *C. rotundifolia* where it is double in most cases. Especially in the weeded plots, it was observed that *C. rotundifolia* recorded a high biomass production with TSP application on ferralitic soil and without TSP application on ferruginous soil.

On the un-weeded plots, the biomass of Ch400 progressively decreases in the treatment without TSP application while it increases in the treatment Ch200 and the Control. On the weeded plots the biomass evolves clearly with Ch200 and Ch400 (Figure 3).

On ferruginous soil without TSP, biomass evaluated was higher on weeded and un-weeded plots (Figure 4). Seeding density at 400 plants/m² (Ch400) doubled the biomass production of C. rotundifolia (2200 to 5200 kg DM/ha) a significant increase in biomass. With the addition of TSP, there was no significant effect on biomass production of C. rotundifolia on all plots. However, at the seeding density of 200 plants/m², a higher biomass production was observed.

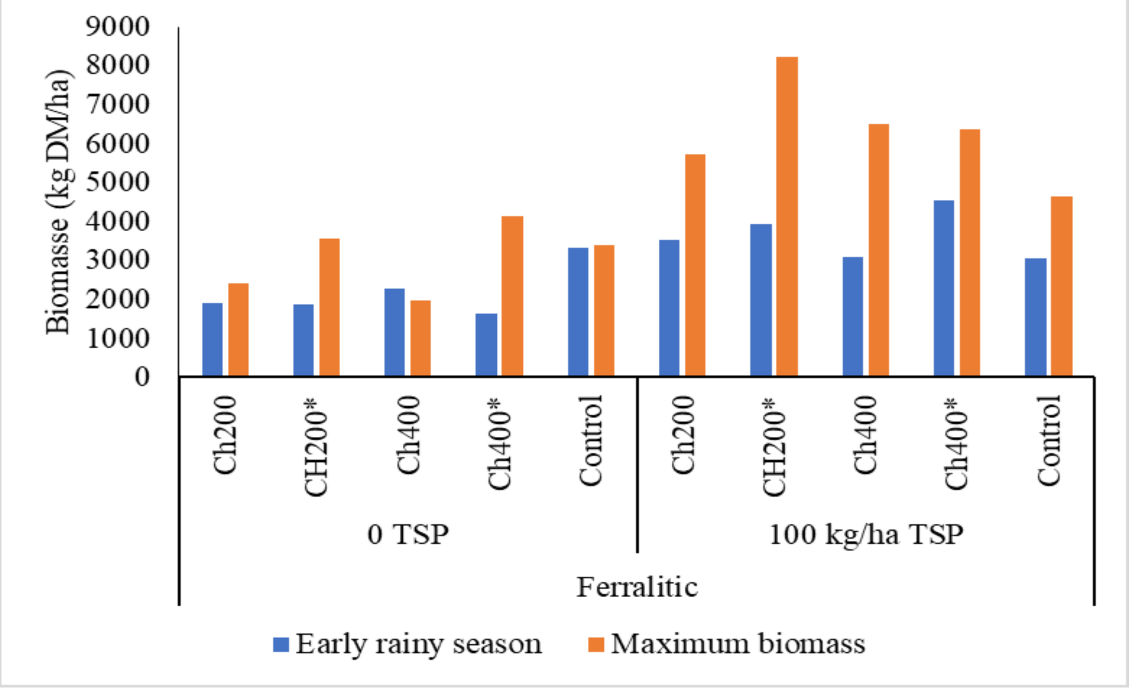



**Figure 3. Total biomass of overseeded pasture with C. rotundifolia on ferralitic soil**

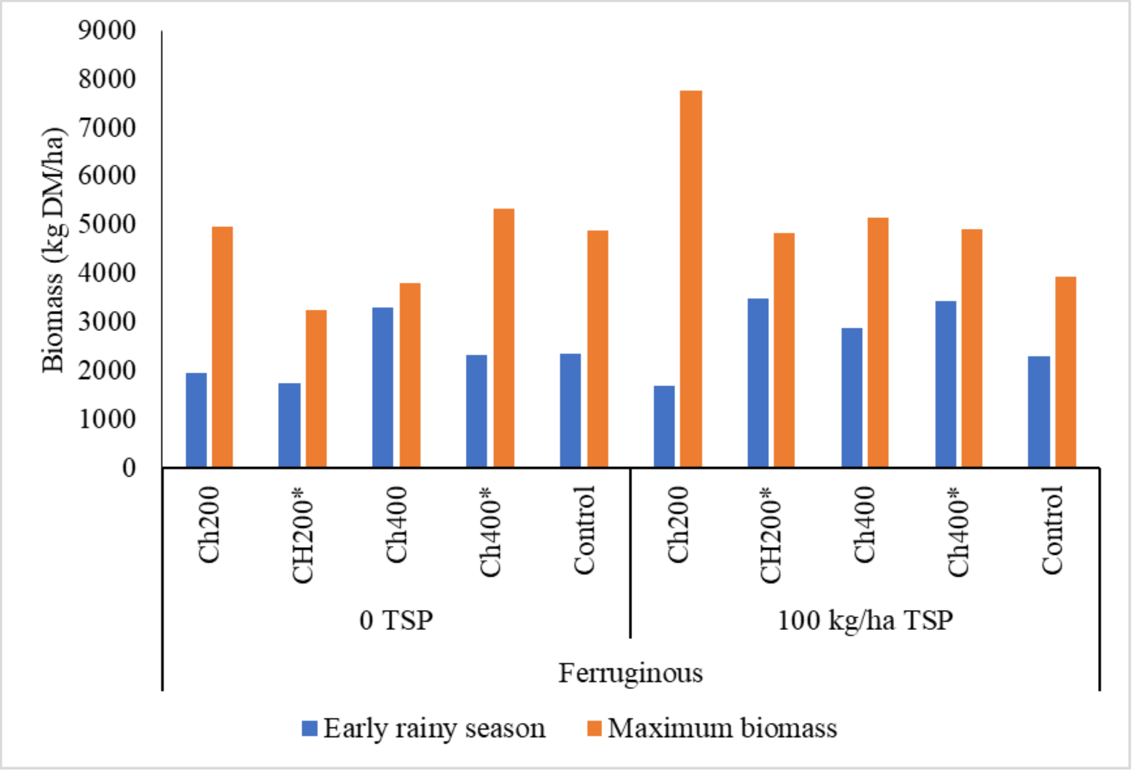



**Figure 4. Total biomass of overseeded pasture with C. rotundifolia in kg DM/ha on ferruginous**

**Table III. Evolution of biomass production by treatment (in kg DM/ha) in year 2**

| Soil | TSP application | Weeding | Seeding density | Year 2 (early in the rainy season) | | | | Year 2 (at the maximum of biomass) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Chamaecrista* | *Andropogon* | Others | Total | *Chamaecrista* | *Andropogon* | Others | Total |
| Ferralitic | Without TSP | Weeded | CH200 | 1 376 | 293 | 197 | 1 866 | 3 217 | 56 | 285 | 3 557 |
| | | | Ch400 | 1 252 | 65 | 313 | 1 630 | 3 656 | 307 | 160 | 4 123 |
| | | Un-weeded | Ch200 | 182 | 1 628 | 80 | 1 890 | 758 | 1 152 | 507 | 2 417 |
| | | | Ch400 | 274 | 1 505 | 497 | 2 276 | 396 | 1 275 | 302 | 1 973 |
| | | | Control | - | 3 107 | 218 | 3 325 | - | 2 450 | 947 | 3 397 |
| | TSP | Weeded | CH200 | 2 553 | 913 | 484 | 3 950 | 6 572 | 202 | 1 460 | 8 234 |
| | | | Ch400 | 4 412 | - | 140 | 4 552 | 6 026 | - | 348 | 6 374 |
| | | Un-weeded | Ch200 | 328 | 2 947 | 260 | 3 535 | 1 180 | 3 699 | 853 | 5 731 |
| | | | Ch400 | 1 191 | 1 385 | 511 | 3 087 | 4 426 | 1 734 | 339 | 6 499 |
| | | | Control | - | 1 995 | 1 062 | 3 057 | - | 4 546 | 83 | 4 629 |
| Ferruginous | Sans TSP | Weeded | CH200 | 1 266 | 218 | 265 | 1 749 | 2 247 | 502 | 486 | 3 236 |
| | | | Ch400 | 2 268 | - | 66 | 2 334 | 5 182 | - | 153 | 5 335 |
| | | Un-weeded | Ch200 | 68 | 1 696 | 184 | 1 948 | 240 | 3 969 | 743 | 4 953 |
| | | | Ch400 | 177 | 2 924 | 205 | 3 307 | 505 | 2 884 | 421 | 3 811 |
| | | | Control | 19 | 1 935 | 390 | 2 343 | - | 4 724 | 161 | 4 885 |
| | TSP | Weeded | CH200 | 2 724 | 214 | 534 | 3 472 | 3 402 | 626 | 797 | 4 825 |
| | | | Ch400 | 2 979 | 217 | 248 | 3 443 | 3 533 | 796 | 581 | 4 910 |
| | | Un-weeded | Ch200 | 75 | 1 495 | 113 | 1 684 | 776 | 6 743 | 246 | 7 766 |
| | | | Ch400 | 296 | 2 334 | 238 | 2 868 | 766 | 4 107 | 264 | 5 138 |
| | | | Control | - | 2 065 | 229 | 2 294 | - | 3 455 | 488 | 3 943 |

### 2.4. Evolution of the contribution of *Chamaecrista* to the total biomass

The evolution of the percentage of C. rotundifolia in the total biomass of grasslands according to treatments shows an improvement between the months of June and August (Table IV). On ferralitic soil, the percentage of *C. rotundifolia* in biomass ranged from 15 to 95% in June and 19 to 95% in August. The high proportions of *C. rotundifolia* are observed in treatments where plots were weeded at *C. rotundifolia* establishment with or without TSP application. In the un-weeded plots, values ranged from 19 to 60%, values that are within the proportions expected by the study. On ferruginous soils, the percentage of *C. rotundifolia* in the grass biomass ranged from 6 to 94% depending on the treatment. Weed control at seeding of *C. rotundifolia* favored the dominance of this species with or without TSP application. The percentage of this specie in the grass biomass was lower in the un-weeded plots (5 to 18%). However, the percentage of this species in the biomass was higher in plots with TSP (9-18%) compared to plots without TSP (5-11%). The effect of seeding density is not very evident on either soil type.

**Table IV. Evolution of total biomass production and percentage of Chamaecrista according to treatments**

| Soil type | TSP application (kg/ha) | Weeding | Seeding density | Total biomass (kg DM/ha) | | Percentage of *Chamaecrista* (%) | |
|---|---|---|---|---|---|---|---|
| | | | | Year 2’ | Year 2” | Year 2’ | Year 2” |
| Ferralitic | 0 kg | Weeded | Ch200 | 1 866 | 3 557 | 70 | 87 |
| | | | Ch400 | 1 630 | 4 123 | 79 | 88 |
| | | Un-weeded | Ch200 | 1 890 | 2 417 | 15 | 31 |
| | | | Ch400 | 2 276 | 1 973 | 15 | 19 |
| | | | Control | 3 325 | 3 397 | 0 | 0 |
| | 100 kg | Weeded | Ch200 | 3 950 | 8 234 | 64 | 78 |
| | | | Ch400 | 4 552 | 6 374 | 95 | 95 |
| | | Un-weeded | Ch200 | 3 535 | 5 731 | 16 | 23 |
| | | | Ch400 | 3 087 | 6 499 | 33 | 60 |
| | | | Control | 3 057 | 4 629 | 0 | 0 |
| Ferru-ginous | 0 kg | Weeded | Ch200 | 1 749 | 3 236 | 65 | 75 |
| | | | Ch400 | 2 334 | 5 335 | 94 | 91 |
| | | Un-weeded | Ch200 | 1 948 | 4 953 | 5 | 5 |
| | | | Ch400 | 3 307 | 3 811 | 6 | 11 |
| | | | Control | 2 343 | 4 885 | 1 | 0 |
| | 100 kg | Weeded | Ch200 | 3 472 | 4 825 | 79 | 71 |
| | | | Ch400 | 3 443 | 4 910 | 88 | 73 |
| | | Un-weeded | Ch200 | 1 684 | 7 766 | 6 | 9 |
| | | | Ch400 | 2 868 | 5 138 | 13 | 18 |
| | | | Control | 2 294 | 3 943 | 0 | 0 |

NB: Year 2’ = early in the rainy season Year 2” =at the maximum biomass

### 2.5. Effect of the studied factors

Only TSP supply, weed control and TSP*Weed control interaction had a significant effect on the biomass production of *C. rotundifolia*. In contrast, only weed control and seeding density had a significant effect on the proportion of C. rotundifolia in the total biomass of the studied treatments. In August, the effect of weed control on *C. rotundifolia* biomass production was highly significant as was its percentage of total pasture biomass. On the other hand, the effect of TSP input as well as the TSP*Weed control interaction were no longer significant on this biomass. However, C. rotundifolia seeding density, TSP*seeding density, TSP*weeding and Soil*TSP*seeding density interactions showed a significant effect on the percentage of C. rotundifolia in the biomass of the studied pastures. Separation of means by Fisher's test revealed that in the weeded plots, the average percentage of *C. rotundifolia* in the total biomass was better (75%) than in the non-weeded plots (15%). Similarly, the seeding density of *C. rotundifolia* at 400 plants/m² resulted in 57% part of *C. rotundifolia* compared to 47% in plots seeded at 200 plants/m² and 30% in the control plots. Plots weeded with and without TSP had better contributions of C. rotundifolia to total biomass (82% and 68% respectively) compared to un-weeded plots with or without TSP (18% and 11% respectively). Regarding the TSP*Density interaction, the Ch400 + TSP and D400 without TSP treatments as well as Ch200 without TSP recorded higher biomass percentages than the other treatments with 62%, 52% and 50% respectively. As for the triple interaction Soil *TSP*Density, the ferralitic soil with TSP addition at seeding density 400 recorded the highest share of C. rotundifolia in the pasture biomass (77%).

## III. Discussion

Legume forages are a low-cost form of nitrogen introduction to pastures, improving soil fertility and animal development (GOMEZ *et al.*, 2021; SANOU *et al.*, 2023). Recommended sowing rates for pure forage crops of *Chamaecrista rotundifolia* refer to 2 kg/ha or 50 plants/m² (OMN, 2001). In our study, the number of plants of *C. rotundifolia* counted in the over-sown pasture varied between 15 to 22 and 18 to 34 plants/m² on ferralitic. This increasing could be explained by new germinations while the decrease could be explained by the mortality of plants of some species due to the competition between plants for light and nutrients. However, the greater representativeness of *C. rotundifolia* on the un-weeded plots of pastures on ferralitic soil compared to those on ferruginous soil is explained by the greater dominance of *A. gayanus* on the latter compared to the former. The low representativity of plants of *C. rotudifolia* either on ferruginous soil and ferralitic soil in the un-weeded plots is questioning for the aptitude of this legume to compete with tall gramineous plants in natural pasturelands. On this subject, DU et al. (2022) stated that the distribution range of plants is usually related to their competitiveness and the competitive ability between common widespread, which are generally considered to be invasive, and common endemic species, is still not very clear. Thus, observations need to be continued for long time as *C. rotundifolia* is sown into native pastures to augment feed quality or improved grasses in Brazil and Australia (KA et al., 2020).

Overall, the biomass production values observed in our study are better than the potential given for the species (7 t DM/Ha). In fact, in our case and on ferralitic soil, we observed in August, a production of *C. rotundifolia* of 8 t DM/ha on a plot weeded with TSP. According to the same source, the biomass of the species contains 21% crude protein. In Nigeria, OLANITE *et al.* (2014) obtained similarly low biomass productions compared to ours (7 t DM/ha maximum) in associations of *C. rotundifolia* with P. maximum. Our results are also better than those of Achard et al, (SD) who estimate biomass production of *C. rotundifolia* at 5 t/MS in Martinique. Although in our case, we are not yet at the maximum biomass of natural pastures, the contribution of *C. rotundifolia* to the biomass of observed grasslands is satisfactory. The observed values are comparable to the values of 19 to 48% observed by (CLEMENTS *et al.,* 1996) under similar conditions in Australia (1100 mm rainfall/year) in mixed pastures with Panicum maximum and *C. rotundifolia* producing between 4 and 9 t DM/ha. These authors also found a 3-22% biomass contribution of this legume in the ingesta of heifers grazing these improved pastures depending on the year.

On weeded plots at the time of *C. rotundifolia* establishment, the biomass of this species is particularly high and is favored by the addition of TSP on both ferralitic and ferruginous soils. However, this raises the question of the economic feasibility of this method of introduction with respect to the community character of natural pastures. Also, given the extensive nature of livestock farming, farmers are not predisposed to make significant investments in the rehabilitation of natural pastures. Even if the results of direct introduction are less interesting, it is preferable because of its low cost. On the same line, MAPIYE et al. (2006) stated that communally managed pastures have low excludability and therefor, no judicious farmer will be willing to invest in them, as the return on that investment will be shared with others.

Nutritive value of fodder of *C. rotundifolia* is variable according to the literature. Abreu et al. (2020) reported crude protein (CP) concentration variable from 8.6 to 10.3 % for leaves and 5.6 to 6.5 % for stems in Brazil, which are low values for a leguminous plant. These values are lower than those found by CRUZ *et al*. (1999) of 16.0 and 18.6 % for leaves and 5.5 and 9.1 % for stems in the dry and rainy seasons, respectively. All those values are less than 25,1% reported by in south Benin (DIMON et al., 2018).

The study was conducted in a research station, a well protected area. The exposure to open conditions with grazing could influence the reality. Therefore, according to COOK *et al.* (2020) this specie is reasonably drought-tolerant with plants forming rosettes under heavier grazing, but leaves often turn red and drop, if plants are left un-grazed and tall during dry conditions. Furthermore, reported that C. rotundifolia is recommended for rangeland legume reinforcement as it is persistent under heavy grazing and exhibit a higher degree of compatibility with grasses such *Cynodon nlemfuensis* (stargrass) and *Paspalum* spp (MAPIYE *et al.*, 2006).

## Conclusion

This study aimed to improve natural pastures by introducing the legume *C. rotundifolia*. The analysis of the representativeness and the contribution to the total herbaceous biomass showed that the legume is well adapted to the pedoclimatic conditions of western region of Burkina Faso. *C. rotondufolia* even proved to be a colonizing species in other surrounding areas with high pod production. Sowing the legume *C. rotundifolia* in natural pasture at rates of 200 and 400 plants/m² showed actual densities in the second year that were much lower than the targeted sowing densities. On ferralitic soils, the low representativeness of *A. gayanus* favored the installation of the introduced legume and consequently induced a significant contribution to the total herbaceous biomass. The addition of phosphorus increased the competition of *A. gayanus* to the detriment of *C. rotundifolia*, hence the superiority of *C. rotundifolia* biomass in plots without TSP addition compared to plots with TSP addition. On the other hand, on ferruginous soils, the representativeness of *C. rotundifolia* as well as its contribution to the biomass are favored by the addition of TSP. Further studies on the capacity of this species to colonize natural pastures will allow for a better understanding of its use in improving pasture and soil fertility. However, this colonization must be controlled to prevent it from becoming invasive. It is also important that important assessments be made of root biomass, nitrogen fixation and soil biological activity under these forage crops to determine their impact on soil fertility.

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