Biomass production and nitrogen accumulation of some dual-purpose legumes in Limpopo province, South Africa

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Abstract

Legumes have great potential for improving soil fertility. A field study was conducted at two different planting seasons at the University of Venda, School of Agriculture experimental farm on a deep, well-drained clay, Hutton form soil type. The objective of the study was to assess the biomass production and N content of some dual-purpose legumes and determine their potential role in smallholder farming systems in the province. Five legume species: *Mucuna pruriens*, *Lablab purpureus* (Cv Rongai), *Clitoria ternatea* (butterfly pea, Var. Milgara) and *Vigna unguiculata* (two varieties) were planted as treatments in a randomized complete block design. At 120 days after planting, plant samples were collected and biomass production, N concentration and N content determined. Lablab consistently produced more than 2.2 t ha^{-1} of biomass in both the growing seasons. Legume N concentration and accumulation ranged between 12 to 40 g kg^{-1} and 4 to 106 kg ha^{-1}, respectively, over the two growing seasons. Influence of growing season on growth performance of legume species was evident in this study. Lablab biomass production was consistent in both the growing seasons, indicating that it has the potential to be incorporated into cereal monoculture systems in the region when planted in summer or can be used as a green manure when planted in the winter and incorporated before the summer planting season.

Media summary

Assessment of the performance of some dual-purpose legumes indicate that Lablab has the potential to be integrated in the smallholder farming systems in Limpopo province, South Africa.

Key words

Temperature, Daylength, Rainfall, Altitude, Tropical environments, Performance.

Introduction

In Limpopo province of the Republic of South Africa, the rural economy is heavily reliant on agriculture, and 85% of the population in this area is involved in farming (White Paper on Agriculture 1995). With average farm sizes of 1.5 ha, agricultural production in the area is predominantly carried out by smallholder farmers at subsistence level. Productivity levels in these farms are still very low and the key factor which was identified by BASED (Broadening Agricultural Services and Extension Delivery) project was declining soil fertility (Ramaru et al. 2000). One of the causes of declining soil fertility is continuous cropping without the use of either organic manure or inorganic fertilizers. Majority of the farmers are resource poor and can therefore not afford to purchase fertilizers. For the few who can afford to purchase fertilizers, the rates of application are often below recommended rates. Legumes have great potential for improving soil fertility at a relatively low cost compared to chemical fertilizers. Legumes can also be used successfully and effectively as components in intercropping systems (Ayisi et al. 1997). The use of green manure legumes may be an option for improving soil fertility. Green manure adds nitrogen to the soil and organic matter which improves soil water holding capacity, nutrient content, nutrient balance, friability and pH. The objective of this study was to assess the biomass production and nitrogen accumulation of some dual-purpose tropical legume species in relation to time of planting and to determine their potential role in smallholder farming systems in Limpopo province.

Methods

Field studies were conducted during October 2002 to February 2003 and July toNovember 2003 at the University of Venda, School of Agriculture experimental farm on a deep well-drained clay, Hutton form soil type (Soil Classification Workgroup 1991). Some physical and chemical properties of the soils (0-20 cm depth) of the experimental site are shown in Table 1. The experimental design was a randomized complete block design (RCBD) with three replications. Four dual-purpose legume species: *Mucuna pruriens* (31000 plants ha^{-1}), *Lablab purpureus* (Cv. Rongai) (53000 plants ha^{-1}), *Vigna unguiculata* (Cv. IT93K2046-1) (66000 plants ha^{-1}), and *Clitoria ternatea* (butterfly pea, var. Milgara) (66000 plants ha^{-1}) were planted as treatments. During the July-November 2003 planting season, an additional cowpea variety (Var. Agrinawa) (66000 plants ha^{-1}) was included. Unit plot size was 6m x 4m. At 120 days after planting (DAP), whole plant samples were obtained from an area of $1m^2$. Plant samples were oven-dried at 70^oC to a constant weight and dry biomass was determined. The plant samples were then ground and analyzed for total N concentration. Nitrogen accumulation was calculated as a product of biomass and N concentration. Using the randomized complete block design (RCBD) model, analysis of variance was conducted using the general linear model (GLM) procedure of SAS (1996). Where significant differences among treatment means was observed at p=0.05, treatment means were compared using the least significant difference (LSD) procedure.

Table 1. Some physical and chemical properties of the soils (0-20 cm) of the experimental site.

Properties determined	Results
pH (Water)	5.53
EC (mS/m)	36
Particle size distribution (%)	
Sand	17.9
Silt	32.1
Clay	50.0
C (%)	1.97
N (%)	0.06
P (ppm)	3.93
Exchangeable cations ($cmol_c\ kg^{-1}$)	
Na	0.03

K	0.23
Ca	3.67
Mg	1.68
CEC ($cmol_c$ kg^{-1})	11.3

Results

Biomass production

The total dry biomass production was significantly different among the legume species in the first growing season (Table 2). Lablab consistently produced more than 2.2 t ha^{-1} of biomass in both the growing seasons. With the exception of butterfly pea, all legumes produced more than 2 t ha^{-1} of biomass in the 2003 season.

Table 2. Legume biomass production.

Legume species	Biomass yield (t ha^{-1})	
	2002/2003 season	2003 season
Mucuna	0.8	2.5
Lablab	2.3	2.5
Butterfly pea	1.6	0.1
Cowpea[1]	4.0	2.7
Cowpea[2]	NP	2.0
CV%	60.5	41.0
$LSD_{0.05}$	1.6	1.5

NP= Not Planted , [1]Cv. IT93K2046-1, [2]Var. Agrinawa.

Nitrogen concentration

Nitrogen concentration ranged between 12 to 24 g kg^{-1} in 2002/2003 growing season, and between 31 to 40 g kg^{-1} in 2003 season (Table 3). In 2003 season, lablab and the two cowpea varieties had significantly higher N concentration than mucuna and butterfly pea.

Table 3. Legume biomass N concentration.

Legume species	Nitrogen concentration ($g\ kg^{-1}$)	
	2002/2003 season	2003 season
Mucuna	15	31
Lablab	23	40
Butterfly pea	24	35
Cowpea[1]	12	39
Cowpea[2]	NP	39
CV%	10.9	4.1
$LSD_{0.05}$	4	2.8

NP= Not Planted, [1]Cv. IT93K2046-1, [2]Var. Agrinawa.

Nitrogen accumulation

Nitrogen accumulation followed a similar pattern to biomass production. Nitrogen accumulation ranged between 12 to 41 kg ha^{-1} in 2002/2003 growing season, and between 4 to 106 kg ha^{-1} in the 2003 growing season (Table 4)

Table 4. Nitrogen accumulation by different legume species.

Legume species	Nitrogen content ($kg\ ha^{-1}$)	
	2002/2003 season	2003 season
Mucuna	12	75
Lablab	53	97
Butterfly pea	37	4
Cowpea[1]	41	106

Cowpea[2]	NP	78
CV%	48.4	44.7
LSD $_{0.05}$	35	61

NP= Not Planted, [1]Cv. IT93K2046-1, [2]Var. Agrinawa.

Biomass production by individual species between the two growing seasons was different. The 2002/2003 growing season was during summer. The drought during that season may have lead to the low biomass production in mucuma. Consequently, this was also reflected in the N accumulated. The 2003 growing season was during winter/spring period. Butterfly pea seems to have been affected by the reduced daylength and low temperatures resulting in significantly lower biomass production than all the other legumes. Lablab performed well consistently in both growing seasons. Lablab is a legume well suited to most tropical environments, as it is adaptable to a wide range of rainfall, temperature and altitude. Several authors have reported that lablab grows well under warm and humid conditions at temperatures ranging from 18? to 30?C and is fairly tolerant to high temperatures (Hendricksen and Minson 1985; Kay 1979; Cameron 1988). Below 20?C, the plant reduces growth; leaves begin to drop at minus 2?C, but the plant can survive in frost for a limited period (Kay 1979; Mayer et al. 1986). The average daily maximum temperature during the two growing seasons ranged from 28? to 31?C and 24? to 29?C in the 2002/2003 and 2003 growing seasons, respectively. Average daily minimum temperatures ranged from 16? to 20?C and 10? to 18?C in the 2002/2003 and 2003 planting seasons, respectively. Hence, winter period in this region is fairly mild and this can allow for favourable growth of lablab. Average rainfall in this region is 600 mm. Lablab is drought hardy and has been grown in arid, semi-arid and humid regions with rainfalls between 200 and 2500 mm (Hendricksen and Minson 1985; Cameron 1988).

Conclusion

Influence of growing season on growth performance of legume species was evident in this study. Lablab biomass production was consistent in both growing seasons, indicating that it has the potential to be incorporated into cereal monoculture system in this region when planted in summer or it can be used as a green manure when planted during winter and incorporated before the summer crop is planted. In addition, with its deep taproot, lablab is able to bring minerals, otherwise not available for annual crops, from the depths to the topsoil.

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