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Research Article

Cowpea Stover Yield, Seed Mass and Soil pH under Different Management Practices and Environmental Conditions

Erick Sebetha

Food Security and Safety Niche Area, Faculty of Agriculture, Science and Technology, North-West University, Mafikeng Campus, Private Bag x 2046, Mmabatho 2735

Abstract

Background and Objective: Cowpea production is affected by crop rotation and this indicates the N contribution in cereal-legume rotation. The study was conducted to investigate the effect of cropping system, location, planting season and nitrogen fertilization on cowpea stover yield, seed mass and soil pH. **Materials and Methods:** The study comprised of three cropping systems (Maize-cowpea rotation, monocropping cowpea and intercropped cowpea), three locations (Potchefstroom, Taung and Rustenburg) and two rates of nitrogen fertilizers applied in kg ha^{-1} at each site (0 and 20 at Potchefstroom, 0 and 17 at Rustenburg, 0 and 23 at Taung). A factorial experiment randomized in complete block design with three replications was conducted during 2011/12 and 2012/13 planting seasons. The measured parameters were plant population at harvest, stover yield, seed mass and soil pH (KCl). **Results:** Cowpea harvested at Potchefstroom and Taung had significantly higher stover yield of 1319.4 and 1784.9 kg ha^{-1}, respectively than cowpea harvested at Rustenburg. Seeds harvested from intercropped system had significantly higher mass of 15.35 g than seeds harvested from mono-cropped and rotational systems. The interactions of location and planting season had significant effect on plant population and stover yield during harvesting. Soil collected at Taung had pH of 6.47 (slightly acidic) compared to soil collected at Potchefstroom and Rustenburg. **Conclusion:** Application of nitrogen fertilizer has no influence on the production of cowpea. Location with higher percentage of clay experienced reduction in soil pH.

Key words: Plant population, seed mass, soil pH, stover yield, maize-cowpea rotation, monocropping cowpea and intercropped cowpea)

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Corresponding Author: Erick Sebetha, Food Security and Safety Niche Area, Faculty of Agriculture, Science and Technology, North-West University, Mafikeng Campus, Private Bag x 2046, Mmabatho 2735 Tel: +27 18389 2787

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cowpea is a warm season legume grown by farmers in Africa, where its grain and stover are highly valued for food and forage[1]. Cowpea yield is always higher in rotation than intercrop because of low plant population in intercrop versus higher plants in rotation[2]. Cowpea yield significantly responds to crop rotation, indicating that factors other than N alone contributes to the yield increases in cereal-legume rotations[3].

Intercropping decreases stover yield in maize and legume at any intercrop arrangements, as compared to sole crops[4]. It was further indicated that in legume dry matter, the optimum response to nitrogen was at 50 kg ha^{-1} because legume depends more on the symbiotically fixed nitrogen than the applied nitrogen[4]. Dry biomass of intercropped cowpea was significantly affected by cropping system and application of nitrogen did not incur any significant difference[5].

The dry biomass of cowpea was significantly affected by interaction of main effects on cereal-cowpea intercropping[6]. It was also reported that, the increment in dry biomass production of sole cropped cowpea was attributed to absence of competition. The findings by Legwaila *et al.*[7] reported that sole cowpea crop produced significantly lower dry matter weight than intercropped. It was further reported that, sole cowpea plant lose some leaves before harvesting for dry matter weight analysis.

Planting location affected 1000 seed weight in a bean-maize based intercropping systems[8]. It was indicated that the addition of N-fertilizer to the bean crop planted at other locations of the study increased 1000 seed mass. The three way interaction of cropping system×location×nitrogen fertilizer in their study was significant on seed mass[8]. There were no significant differences in the weight of cowpea seeds between treatments in maize-cowpea intercropping study[7]. Chakma *et al.*[9] also observed no significant difference in weight of 1000 seed weight in a popcorn-mungbean/cowpea intercropping system.

Maize-soybean intercropping enhanced soil pH by 6.2% compared with corresponding monoculture[10]. It was further reported that, there were no significant difference in soil pH between intercrops and monocrops in the third year but soil pH was significantly lower in maize/faba bean and maize/turnip intercropping than in the monocrops in the 4th year of the experiment[10]. Tarfa *et al.*[11] reported the minimum reduction in soil pH in maize after soybean and cowpea plots compared to maize after maize and maize-cowpea intercrop due to the low N (20 kg ha^{-1}) applied to legume compared to maize (120 kg ha^{-1}).

The problem in this study, is the farmer's insufficient knowledge on the type of cropping system that produces high legume stover yield. The information on the influence of cropping system, location and nitrogen fertilization to soil pH is not sufficient. This study evaluated the effect of maize-cowpea rotation, intercropping and nitrogen fertilization on cowpea stover yield, plant population, seed mass and soil pH at harvest.

MATERIALS AND METHODS

Description of study area: The study was conducted at three dryland sites in South Africa, namely the Department of Agriculture Experimental Station in Taung situated at 27°30 S and 24°30 E, Agriculture Research Council-Grain Crops Institute (ARC-GCI) experimental station in Potchefstroom situated at 27°26 S and 27°26 E and the Agricultural Research Council-Institute for Industrial Crops (ARC-IIC) experimental station in Rustenburg[12] 25°43 S and 27°18 E. Taung experimental site is situated in grassland savannah with annual mean rainfall of 1061 mm that begins in October. The ARC-GCI experimental station (Potchefstroom) has clay percentage of 34 and receives annual mean rainfall of 622.2 mm with daily temperature range of 9.1-25.2°C during planting[13]. The ARC-IIC experimental station (Rustenburg) has clay percentage of 49.5 and receives an annual mean rainfall of 661 mm. Potchefstroom (ARC-GCI) has plinthic catena soil, eutrophic, red soil widespread[14]. The soil at Taung is described as Hutton, deep, fine sandy dominated red freely drained, eutrophic with parent material that originated from Aeolian deposits[15]. The soil at Rustenburg (ARC-IIC) has dark, olive grey and clay soil, bristle consistency, medium granular structure[16]. The weather data recorded at three sites during the course of the study was indicated[12] in Table 1. Soil physical properties of three locations of the study can be seen in Table 2.

Experimental design: The experiment was established in 2010/11 planting season and data considered for experiment was collected during 2011/12 and 2012/13 planting seasons[12]. The experimental design was factorial experiment laid out in random complete block design (RCBD) with three replicates. The statistical method was based on the previously published study by Blade *et al.*[17]. This technique allowed accurate randomisation and analysis of variance for a multivariate design.

The experiment consisted of three cropping systems (monocropping, rotational and intercropping), three locations (Potchefstroom, Taung and Rustenburg) and two levels of

Table 1: Mean temperature and rainfall data for Potchefstroom, Taung and Rustenburg for the duration of experimental period

Locations	Season	Climate data	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Potch	2011/12	Rainfall (mm)	35.6	66.3	75.9	19.1	33.8	66.3	4.3	0.0
		Max T (°C)	28.6	29.5	28.6	30.4	29.1	28.7	25.0	25.0
		Min T (°C)	11.2	13.8	15.8	16.2	16.3	13.6	8.1	5.2
	2012/13	Rainfall (mm)	21.8	13.5	42.4	45.7	28.7	43.9	47.5	8.1
		Max T (°C)	29.0	30.2	27.9	30.1	31.0	28.4	24.3	22.6
		Min T (°C)	12.4	14.6	15.4	16.8	15.5	14.6	9.1	3.9
Taung	2011/12	Rainfall (mm)	3.1	36.1	71.4	7.9	40.9	12.5	5.1	0.5
		Max T (°C)	31.1	33.3	32.8	36.1	32.9	32.9	28.0	27.7
		Min T (°C)	9.3	10.6	14.8	16.2	17.0	13.8	8.2	4.5
	2012/13	Rainfall (mm)	0.3	8.9	14.9	40.9	32.0	14.2	9.2	8.4
		Max T (°C)	32.5	34.9	32.9	36.3	31.5	31.8	27.3	26.8
		Min T (°C)	10.7	14.3	15.7	17.8	17.7	15.0	9.4	6.2
Rust	2011/12	Rainfall (mm)	23.4	49.8	47.2	19.3	6.4	27.9	6.6	0.3
		Max T (°C)	28.7	30.2	28.3	30.2	30.9	29.0	25.0	25.1
		Min T (°C)	11.7	14.9	17.0	15.3	17.2	14.4	9.3	6.6
	2012/13	Rainfall (mm)	21.1	25.9	48.0	37.3	20.6	10.9	46.5	0.0
		Max T (°C)	28.3	29.9	28.1	29.9	31.1	29.1	25.5	23.2
		Min T (°C)	12.8	14.8	16.1	17.4	16.3	14.7	10.2	4.7

Potch: Potchefstroom, Rust: Rustenburg, Max T (°C): Maximum temperature in degrees Celsius, Min T (°C): Minimum temperature in degrees celsius, mm: Millimetres

Table 2: Soil texture properties of the three experimental locations

		Soil depth (cm)	
Locations	Physical properties	0-15	15-30
Potchefstroom	Sand	58	58
	Silt	12	13
	Clay	30	29
Taung	Sand	91	91
	Silt	1	1
	Clay	8	8
Rustenburg	Sand	44	42
	Silt	7	8
	Clay	49	50

nitrogen fertilizer (urea) at each site, i.e., the amount of 0 and 20; 0 and 17; 0 and 23 kg N ha^{-1} applied on cowpea plots at Potchefstroom, Rustenburg and Taung, respectively[12]. The amount of 0 and 95; 0 and 92; 0 and 113.5 kg N ha^{-1} were applied on maize plots (Monocropping, rotational and intercropping) at Potchefstroom, Rustenburg and Taung, respectively. Maize cultivar (PAN 6479) and cowpea (Bechuana white) were used as test crop[12].

Data collection: Cowpea plant population and seed mass were recorded from an area of 12 m^2 within each plot of rotation and monocropping. The harvest area of cowpea in intercropping plots was 8 m^2.

The stover yield from each cowpea plot was calculated using the formula as described by Dobermann and Walters[18]:

$$\text{Stover yield} = \frac{\text{Dry subsample (kg ha}^{-1})}{\text{Fresh subsample (kg ha}^{-1})} \times \text{Field biomass yield (kg ha}^{-1})$$

Soil samples collected were sent to ARC-IIC for analysis of pH (KCl). Soil pH determination in KCl was done using a glass electrode pH meter.

Data analysis: Analysis of variance was performed using GenStat 14th edition (2012). Least significant difference (LSD) was used to separate means. A probability level of less than 0.05 was considered as significant statistically[19]. The type of ANOVA used in this study was a four way.

RESULTS

Effects of treatment factors on cowpea plant population (plants ha^{-1}) during harvest: According to analysis of variance results indicated that cropping system, nitrogen fertilizer, location and planting season had significant effect ($p<0.05$) on cowpea plant population during harvest. The average cowpea plant population can be seen in Table 3. Based on LSD cowpea planted under intercropping and rotational systems had significantly higher plant population of 45833.3 and 45115.7 plants ha^{-1}, respectively during harvest. Cowpea without nitrogen fertilizer application had significantly higher plant population of 45848.8 plants ha^{-1} during harvest than nitrogen fertilized cowpea. Cowpea planted at Potchefstroom had significantly higher plant population of 46944.4 plants ha^{-1} than cowpea planted at Taung and Rustenburg. Cowpea planted during 2012/13 planting season had significantly higher plant population of 45918.2 plants ha^{-1} than during 2011/12 planting season.

Table 3: Effects of cropping system, nitrogen fertilizer, location and planting season on cowpea plant population (plants ha^{-1}) at harvest

Cropping systems	Intercrop cowpea	Monocrop cowpea	Rotation cowpea
Means	45833.3	43611.1	45115.7
$LSD_{0.05}$	2168.43		
Nitrogen fertilizer	N-fertilizer	Zero-N	
Means	43858.0	45848.8	
$LSD_{0.05}$	1770.51		
Location	Potchefstroom	Rustenburg	Taung
Means	46944.4	44027.8	43588.0
$LSD_{0.05}$	2168.43		
Planting season	2011/12	2012/13	
Means	43788.6	45918.2	
$LSD_{0.05}$	1770.51		

Table 4: Interaction effects of location×planting season on cowpea plant population (plants ha^{-1}) at harvest

Locations	2011/12	2012/13
Potch	41504.60	52384.3
Rust	41574.10	46481.5
Taung	48287.00	38888.9
$LSD_{0.05}$	3066.62	

Potch: Potchefstroom, Rust: Rustenburg

Interaction effects of treatment factors on cowpea plant population during harvest: Results of analysis of variance in this study indicated that, the interaction of location×season had significant effect ($p<0.05$) on plant population during harvest. The interaction of treatment factors on cowpea plant population can be seen in Table 4. Based on LSD cowpea harvested at Potchefstroom and Rustenburg during 2012/13 planting season had significantly higher plant population of 52384.3 and 46481.5 plant ha^{-1}, respectively than other location during 2011/12 planting season. During 2011/12 planting season, cowpea harvested at Taung had significantly higher planting population of 48287.0 plant ha^{-1} than other locations during 2012/13 planting season.

Effects of treatment factors on cowpea stover yield (kg ha^{-1}): Results of analysis of variance indicated that cropping system and nitrogen fertilizer had no significant effect ($p>0.05$) on cowpea stover yield. Location and planting season had significant effect ($p<0.05$) on cowpea stover yield. The average cowpea stover yield can be seen in Table 5. Based on LSD cowpea harvested at Potchefstroom and Taung had significantly higher stover yield of 1319.4 and 1784.9 kg ha^{-1}, respectively than cowpea harvested at Rustenburg. Cowpea harvested during 2011/12 planting season had significantly higher stover yield of 1761.5 kg ha^{-1} than cowpea harvested during 2012/13 planting season.

Interaction effects of treatment factors on cowpea stover yield (kg ha^{-1}): Results of analysis of variance indicated that the interaction of location×planting season had significant effect ($p<0.05$) on cowpea stover yield. The interaction of treatment factors on cowpea stover yield can be seen in Table 6. The LSD indicated that cowpea harvested at Potchefstroom and Rustenburg during 2011/12 planting season had significantly higher stover yield of 2075.8 and 1294.9 kg ha^{-1} than during 2012/13 planting season.

Effects of treatment factors on cowpea hundred seed mass (g/100 seeds): According to analysis of variance results indicated that cropping system, location and planting season had significant effect ($p<0.05$) on cowpea hundred seed mass. Nitrogen fertilizer had no significant effect ($p>0.05$) on cowpea hundred seed mass. The average cowpea hundred seed mass can be seen in Table 7. Based on LSD seeds harvested from inter cropped system had significantly higher mass of 15.35 g than seeds harvested from mono cropped and rotational systems. Seeds harvested from Potchefstroom and Rustenburg had significantly higher seed mass of 15.46 and 15.19 g, respectively than seeds harvested from Taung. Seeds harvested during 2012/13 planting season had significantly higher mass of 15.98 g than seeds harvested during 2011/12 planting season.

Interaction effects of treatment factors on cowpea hundred seed mass (g plot^{-1}): Results of analysis of variance indicated that the interaction of cropping system×location×nitrogen fertilizer had significant effect ($p<0.05$) on cowpea hundred seed mass. The interaction of treatment factors on cowpea hundred seed mass can be seen in Table 8. Based on LSD cowpea planted under intercropping system with nitrogen fertilizer application at Potchefstroom and Rustenburg had significantly higher seed mass of 17.22 and 17.94 g plot^{-1}, respectively during 2012/13 planting season than 2011/12 planting season. Cowpea without nitrogen fertilizer under the intercropping system at Potchefstroom and Rustenburg had also significantly higher seed mass of 16.62 and 17.10 g plot^{-1} during 2012/13 planting season than during 2011/12 planting season.

Table 5: Effects of cropping system, nitrogen fertilizer, location and planting season on stover yield (kg ha^{-1})

Cropping systems	Intercrop cowpea	Monocrop cowpea	Rotation cowpea
Means	1258.9	1457.7	1386.9
$LSD_{0.05}$	314.60		
Nitrogen fertilizer	N-Fertilizer	Zero-N	
Means	1333.1	1402.5	
$LSD_{0.05}$	256.87		
Location	Potchefstroom	Rustenburg	Taung
Means	1319.4	999.1	1784.9
$LSD_{0.05}$	314.60		
Planting season	2011/12	2012/13	
Means	1761.5	974.1	
$LSD_{0.05}$			

Table 6: Interaction effects of location × planting season on cowpea stover yield (kg ha^{-1})

Locations	2011/12	2012/13
Potch	2075.80	563.0
Rust	1294.90	703.4
Taung	1914.00	1655.8
$LSD_{0.05}$	444.92	

Potch: Potchefstroom, Rust: Rustenburg

Cowpea planted under monocropping system with nitrogen fertilizer application at Potchefstroom and Rustenburg had significantly higher seed mass of 17.12 and 17.13 g plot^{-1}, respectively during 2012/13 planting season than 2011/12 planting season. Cowpea without nitrogen fertilizer under monocropping system at Potchefstroom and Rustenburg had also significantly higher seed mass of 16.62 and 15.51 g plot^{-1} during 2012/13 planting season than in 2011/12 planting season.

Cowpea planted under rotational system with nitrogen fertilizer application at Potchefstroom had significantly higher seed mass of 17.31 g plot^{-1} during 2012/13 planting season than 2011/12 planting season and other locations. Cowpea without nitrogen fertilizer application under rotational system at Potchefstroom and Rustenburg had significantly higher seed mass of 16.38 and 17.69 g plot^{-1} during 2012/13 planting season than in 2011/12 planting season.

Pre-planting soil pH (KCl): The analysis of pre-planting soil samples taken before planting at three locations can be seen in Table 9. At Potchefstroom, soil pH (KCl) values were 5.84 and 5.81 at 0-15 cm and 15-30 cm respectively indicating moderate acidic soil. At Taung, soil pH values were 6.51 at 0-15 cm and 6.63 at 15-30 cm, indicating slightly acidic at topsoil and neutral at subsoil. At Rustenburg, soil pH was 4.87 at 0-15 cm and 5.07 at 15-30 cm, indicating very strong acidic soil.

Effects of treatment factors on soil pH (KCl) during harvesting: According to analysis of variance results indicated that location, nitrogen fertilizer and planting season had significant effect ($p<0.05$) on soil pH (KCl) during harvest. The average soil pH can be seen in Table 10. Based on LSD soil collected at Taung had pH of 6.47 (slightly acidic) compared to soil collected at Potchefstroom and Rustenburg. Soil collected at Potchefstroom had pH of 5.82 (moderately acidic) compared to soil collected at Rustenburg. Soil collected under zero nitrogen fertilizer had pH of 5.80 (moderately acidic) compared to soil collected under nitrogen fertilizer application. Soil collected during 2012/13 planting season had pH of 5.80 (moderately acidic) as compared to soil collected during 2011/12 planting season.

Interaction effects of treatment factors on soil pH (KCl) during harvest: Results of analysis of variance in this study indicated that the interactions of location × nitrogen fertilizer × soil depth × planting season had significant effect ($p<0.05$) on soil pH. The interaction of treatment factors on soil soil pH can be seen in Table 11. According to LSD soil collected from the depth of 0-15 cm at Taung under nitrogen fertilizer had pH of 6.69 (neutral) during 2012/13 planting season as compared to 2011/12 planting season. Soil collected from the depth of 0-15 cm at Taung under zero nitrogen fertilizer had pH of 6.80 (neutral) during 2012/13 planting season compared to 2011/12 planting season. Soil collected from the depth of 15-30 cm at Taung under nitrogen fertilization had pH of 6.46 (slightly acidic) during 2012/13 planting season compared to 2011/12 planting season. Soil collected from the depth of 15-30 cm at Taung under zero nitrogen fertilizer had pH of 6.73 (neutral) during 2012/13 planting season compared to 2011/12 planting season.

DISCUSSION

The higher plant population and cowpea seed mass during harvest under intercropping system contradicted the findings by Jeranyama *et al.*[20], who reported that,

Table 7: Effects of cropping system, nitrogen fertilizer, location and planting season on cowpea seed mass (g $plot^{-1}$)

Cropping system	Intercrop cowpea	Monocrop cowpea	Rotation cowpea
Means	15.35	14.95	14.76
$LSD_{0.05}$	0.39		
Nitrogen fertilizer	N-Fertilizer	Zero-N	
Means	15.12	14.92	
$LSD_{0.05}$	0.32		
Location	Potchefstroom	Rustenburg	Taung
Means	15.46	15.19	14.41
$LSD_{0.05}$	0.39		
Planting season	2011/12	2012/13	
Means	14.06	15.98	
$LSD_{0.05}$	0.32		

Table 8: Interaction effect of cropping system × location × nitrogen fertilizer × planting season on cowpea seed mass (g $plot^{-1}$)

		N-fertilization		Zero-nitrogen	
Cropping system	Location	2011/12	2012/13	2011/12	2012/13
Inter-cowpea	Potch	14.53	17.22	13.51	16.62
	Rust	14.05	17.94	14.19	17.10
	Taung	14.65	14.78	14.91	14.67
Mono-cowpea	Potch	14.71	17.12	13.63	16.62
	Rust	13.79	17.13	13.27	15.51
	Taung	14.44	14.25	14.66	14.29
Rota-cowpea	Potch	13.92	17.31	13.89	16.38
	Rust	13.75	14.56	13.33	17.69
	Taung	13.70	14.32	14.09	14.17
$LSD_{0.05}$	1.35				

Inter-cowpea: Intercrop cowpea, Mono-cowpea: Monocrop cowpea, Rota-cowpea: Rotation cowpea, Potch: Potchefstroom, Rust: Rustenburg

Table 9: Soil pH (KCl) before planting at three locations

Locations	0-15 cm	15-30 cm
Potchefstroom	5.84	5.81
Taung	6.51	6.63
Rustenburg	4.87	5.07

maize-cowpea intercrop resulted in poor cowpea yields attributed to shading by the maize especially when cowpea was planted at the same time as the maize. The higher plant population, stover yield and seed mass during harvest at Potchefstroom may have been attributed to soil texture properties at the location as indicated in Table 2. Potchefstroom had average amount of clay percentage to hold soil nutrients. According to Eugene *et al.*[21], clay particles are believed to protect some of the easily decomposable organic compounds. The soil texture of both Potchefstroom and Rustenburg were able to maintain cowpea seed and this correlate with findings by Mtambanegwe *et al.*[22], who reported that, fine textured soil (clay) often contain higher amount of organic matter than sandy soil. According to Manna *et al.*[23], soil organic matter and its associated nutrient supply to soil has been cited as one major factor for yield production. Nitrogen fertilizer did not affect any cowpea parameters measured and this contradicted the findings by Rahman *et al.*[24], who reported legume crop biomass yield influenced significantly by N fertilizer application. The higher plant population and seed mass during harvest in 2012/13 planting season may have been attributed to good environmental factors (rainfall and temperature) during vegetative and reproductive stages of cowpea as indicated in Table 1. This corroborated the findings by Reichert *et al.*[25], who reported that weather conditions affects crop growth and development. According to Collares *et al.*[26] water deficited affects bean yield components especially during period of high temperature.

Soil pH from three locations at the end of the study was reduced as compared to pH before planting (Table 9 and 10). The lower pH at Potchefstroom and Rustenburg may have been attributed to soil texture and the amount of precipitation received in those areas. This corroborated the findings by McCauley *et al.*[27], who reported that high precipitation causes leaching of base forming cations and lowering of soil pH. Lower pH at locations with high percentages of clay (Potchefstroom and Rustenburg) contradicted the findings by McCauley *et al.*[27], who reported that soil with high proportion of clay have a large number of surface sites able to hold hydrogen ions and able to resist a decrease in soil pH. Little reduction of soil pH under nitrogen fertilizer corroborated the findings by Barak *et al.*[28], who reported that, urea N fertilizer had caused soil acidification. Implication of this study is that, production of cowpea by farmers should be based on the

Table 10: Effects of cropping system, location, nitrogen fertilizer, soil depth and planting season on soil pH (KCl)

Cropping system	Intercropping	Monocrop cowpea	Rotation cowpea
Means	5.75	5.69	5.74
$LSD_{0.05}$	0.08		
Location	Potchefstroom	Rustenburg	Taung
Means	5.82	4.94	6.47
$LSD_{0.05}$	0.06		
Nitrogen fertilizer	N-Fertilizer	Zero-N	
Means	5.69	5.80	
$LSD_{0.05}$	0.05		
Soil depth	0-15 cm	15-30 cm	
Means	5.76	5.72	
$LSD_{0.05}$	0.05		
Planting season	2011/12	2012/13	
Means	5.68	5.80	
$LSD_{0.05}$	0.05		

Table 11: Interaction of location×nitrogen fertilizer×soil depth×planting season on soil pH (KCl)

		0-15 cm		15-30 cm	
Locations	Nitrogen	2011/12	2012/13	2011/12	2012/13
Potch	N-fertilizer	5.80	5.71	5.86	5.74
	Zero-N	5.91	5.88	5.79	5.87
Rust	N-fertilizer	4.91	4.94	4.91	4.91
	Zero-N	4.96	5.00	4.99	4.91
Taung	N-fertilizer	6.07	6.69	6.25	6.46
	Zero-N	6.47	6.80	6.28	6.73
$LSD_{0.05}$	0.17				

factors such as soil type and environmental conditions of location. The production area with high percentage of sandy soil will differ in terms of cowpea production as compared to area with high percentage of clay soil. Cowpea farmers should focus on other fertilizers such as phosphorus instead of nitrogen fertilizer, since it does not have an influence on production of cowpea.

CONCLUSION

In this study, intercropping system played a role on cowpea seed mass and plant population during harvest. Location played a sole on production of cowpea. Potchefstroom due to its soil texture and climatic conditions is recommended for high production of cowpea. Application of nitrogen fertilizer has no influence on the production of cowpea. In this study, the interaction of location and planting season played a role on cowpea plant population and stover yield during harvest. Location with higher percentage of clay experienced reduction in soil pH. Nitrogen fertilizer has a role on the reduction of soil pH.

SIGNIFICANCE STATEMENT

The study discovered that, intercropping system played a significant role on the improvement of cowpea production in terms of plant population and seed mass during harvest. In this study, cowpea production differed across locations and Potchefstroom was regarded as better location for cowpea production. It was found that, application of nitrogen fertilizer had no influence on the production of cowpea. Soil pH in this study also differed across locations due to different soil types and environmental conditions.

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