

PERFORMANCE OF SOYBEAN CULTIVARS AT DIFFERENT DOSES OF BASE FERTILIZATION ON *Brachiaria decumbens* STRAW

DESEMPENHO DE CULTIVARES DE SOJA EM DIFERENTES DOSES DE ADUBAÇÃO DE BASE SOBRE PALHADA DE *Brachiaria decumbens*

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ABSTRACT: The deployment of soybean under no-tillage in degraded pasture has been a trivial practice, and the efficient and rational use of fertilizers is a decisive to its economic viability factor. The objective was to evaluate the agronomic performance of six cultivars subjected to doses of basic fertilization with NPK and straw grown on *Brachiaria decumbens*. The experiment was conducted in the experimental area of the State University of Mato Grosso do Sul, Unit Aquidauana. The experimental design was a randomized block design in split plot design with four replications. The plots consisted of six soybean cultivars (NA 5909 RR, M SOY 7908 RR, BMX Magna RR, BRS 245 RR, SYN 3358 RR, BMX Potência RR) and the subplots of five doses of NPK (0, 50, 100, 200 and 400 kg ha⁻¹). Were evaluated plant height, first pod height, number of ramifications per plant, mass of 1000 grains and grain yield. Increased doses of fertilizer caused a linear increase in all variables in all cultivars, being recommended for degraded pastures base fertilization with 400 kg ha⁻¹ of NPK. The varieties BMX Power RR 3358 and RR SYN showed higher mass of 1000 grains and consequently higher grain yield.

KEYWORDS: Crop-livestock integration. Degraded pasture. *Glycine max*. No-tillage.

INTRODUCTION

The main oilseed crop grown in Brazil and in the world is the soybean [*Glycine max* (L.) Merrill], being same source of raw material of great importance, especially to sectors of agribusiness and animal nutrition. The area planted with this oilseed in Brazil in 2013/14 was approximately 30 million hectares, with an increase of 8.6% compared to 2012/13. In relation to production just over 86.2 million tons of grains was obtained, an increase of 5.9% compared with 81.5 million tones produced in the harvest 2012/13 (CONAB, 2014).

The Brazilian average productivity in 2013/14 was 2,900 kg ha⁻¹, considered high in comparison to other countries (CONAB, 2014). The average increment of 38 kg ha⁻¹ year⁻¹ in yield grain between 1976/77 to 2013/14 is related to various causes, among which stands out the cultivation of highly productive cultivars (LUDWIG et al. 2011).

The high yield potential of the cultivars is the main objective of genetic breeding and the producer has the function of allowing this to express

yourself, provided with the proper environment. To define the type of base fertilizer to be adopted at the time of soybean implantation should be defined considering the inherent characteristics of each cultivar and environmental conditions, because they can interfere in the expected results, such as higher grains yield, plant height and pods insertion height appropriate for mechanized harvesting (REZENDE et al., 2004; CARVALHO et al., 2011).

The seeding density, plant population and fertilization to be performed in soybean are much discussed topics on which many studies already been published, however the interaction genotype versus environment directly affects the results, which makes it necessary new researches in order to improve the productive performance of this legume and exploit their productive potential (LUDWIG et al., 2011; RAMBO et al., 2003).

Soybean has been widely used in crop-livestock integration, which consists of a very efficient alternative to maintaining productivity and recovery of Brazilian pastures (MACHADO et al., 2011). In this system, crops are implanted to make

constant part of a system of grain production and animal production that interact and complement each other in several aspects such as management, fertility, physics and biology of the soil, thereby increasing farmer incomes and bringing social progress to the field (MACEDO, 2009).

One of the main factors that limit the productivity of a culture implanted on the integrated crop-livestock system is the nutrient management (CARVALHO et al., 2011), because usually the pastures are in some state of disrepair or in areas with degraded soils (PAULINO et al., 2012; GARCIA et al., 2014). However, there are little recommendations in the literature for the base fertilization of soybean in the crop-livestock system, justifying the present research.

Front of this context, this study aimed to evaluate the performance of six soybean cultivars at different doses of base fertilizer on straw *Brachiaria decumbens* Stapf. pasture degraded on Savanna/Pantanal ecotone region.

MATERIAL AND METHODS

The experiment was installed in the agricultural year 2011/2012, at experimental area of Universidade Estadual de Mato Grosso do Sul – University Unit of Aquidauana (UEMS/UUA), in Aquidauana (MS), located in the Savanna/Pantanal ecotone region, comprising the coordinates 20°27'S and 55°40'W with an average elevation of 170 m.

The soil was classified by Schiavo et al. (2011) as Ultisol sandy loam texture. Chemical analysis of the soil is showed in Table 1, and the results of granulometric analysis and soil density are showed in Table 2. The climate of the region according to classification described by Köppen-Geiger is Aw (Savanna Tropical). The data rainfall and the temperature average of the experimental period are disposed in the Figure 1.

Table 1. Results of soil chemical analysis in experimental area of layer 0-0.20 m. Aquidauana, MS, 2011.

pH	P	O.M	Ca	Mg	K	Al	H + Al	CEC	V
CaCl ₂	mg dm ⁻³	g dm ⁻³	cmol _c dm ⁻³						%
5.74	3.16	10.91	1.75	1.00	0.21	0.00	1.46	4.42	66.9

Phosphorus (P) – Mehlich; O.M: organic matter; CEC: cation exchange capacity.

Table 2. Results of granulometric analysis and soil density of the experimental area in the layers 0-0.10 m, 0.10-0.20 m and 0.20-0.40 m. Aquidauana, MS, 2011.

Depth (m)	Granulometric (%)			Soil density (g cm ⁻³)
	Sand	Silt	Clay	
0-0.10	68.31	16.63	15.06	1.57
0.10-0.20	69.07	15.18	15.75	1.67
0.20-0.40	69.28	15.15	15.57	1.70

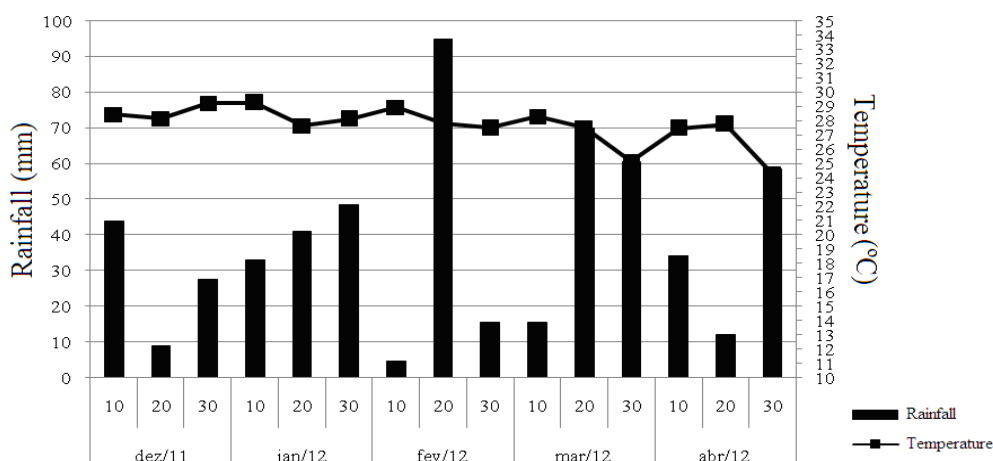


Figure 1. Rainfall (mm) and temperature (°C) average in the year 2011/2012.

The plots consisted of six soybean cultivars: NA 5909 RR, M SOY 7908 RR, BMX Magna RR, BRS 245 RR, SYN 3358 RR, BMX Potência RR (Table 3), and subplots for four levels of fertilization, plus the control (0, 50, 100, 200 e 400 kg ha⁻¹ commercial fertilizer formula 4-20-20). Each

plot had an area of 45 m² (9 x 5 m), and each subplot was constituted by four plant rows spaced 0.45 m between rows and 5 meters of length with an area of 9 m² (1.8 x 5 m). Table 3 show the cycle, growth habit and maturity group of the cultivars used in the experiment.

Table 3. Commercial name, cycle, growth habit and maturity group of the cultivars used in the experiment. Aquidauana, MS, 2011.

Commercial name	Cycle	Growth habit	Maturity group
NA 5909 RR	Premature	Indeterminate	5.9
M SOY 7908 RR	Premature	Determinate	7.9
BMX Magna RR	Premature	Indeterminate	6.2
SYN 3358 RR	Premature	Indeterminate	5.8
BRS 245 RR	Semi-premature	Determinate	7.3
BMX Potência RR	Semi-premature	Indeterminate	6.7

The pasture (*Brachiaria decumbens*, cultivar Basilisk) cultivated in the experimental area was desiccated with glyphosate active ingredient at dose of 3 L ha⁻¹, 14 days before of seeding as recommended Nunes et al. (2009). The sowing was done manually at 08/12/2011 with 20 seeds per meter, with germination rate of 80%, achieving an average density of 16 per meter, corresponding to a population of 355,555 plants ha⁻¹.

Seed treatment was performed with Thiram® 480 TS fungicide at dose 300 mL 100 kg⁻¹ seeds of the commercial product, Imidacloprido (Imidacloprido) insecticide at a dose 150 mL 100 kg⁻¹ seeds of the commercial product and at the moment of sowing the seeds were inoculated with peaty-based *Bradyrhizobium japonicum* inoculant at a dose of 240 grams per 100 kg seeds of the commercial product.

The control of *Pseudoplusia includens* Wal. and *Anticarsia gemmatilis* Hüb. was performed at 45 and 70 days after emergence (DAE) using the active ingredient Teflubenzuron at a dose of 50 mL ha⁻¹ of the commercial product. Fungicide application was not performed. The weeds were controlled by hand weeding. At 80 DAE was measured the descriptors plant height (PH) and first pod insertion height (PIH), the assessments were done on 10 plants per plot with the aid of a tape measure.

The harvest was done manually to 115 DAE, and at this time was evaluated the descriptors: number of ramifications per plant (NR), mass of 1000 grains (MTG) and grain yield (YIE). To

evaluation of number of pods and number of ramifications per plant were used 10 plants per plot, and for the evaluation of MTG and YIE, were collected plants from the two central rows of each plot using an analytical balance to determine the last two variables. The grain moisture was corrected to 13% and YIE was extrapolated for kg ha⁻¹.

The variables analyzed were initially submitted to Shapiro-Wilk's test to verify the normality of residuals and Bartlett's test for homogeneity of variances. Subsequently, the data were subjected to analysis of variance by applying the F-test. The qualitative factor (cultivars) underwent comparison of means by Tukey's test and the quantitative (doses of NPK) to polynomial regression. The best fitted equation is selected according to the coefficient of determination and significance of regression coefficients, the tested waste corrected based on analysis of variance t-test. All analyzes were performed with statistical software Sisvar (FERREIRA et al., 2011).

RESULTS AND DISCUSSION

Significant effect for doses of NPK (F), cultivars (C) and the interaction of between factors for all variables measured was observed, as shown on Table 4. The coefficient of variation (CV) was under 20% indicating good accuracy of evaluations.

Evaluating the AP for interaction F x C (Table 5) there was no statistical difference between cultivars for control (dose 0). In the dose of 50 kg ha⁻¹ of NPK, the cultivar BRS 245 RR was the one with the lowest average height, differing from the

others. For dose of 100 kg ha⁻¹ of NPK, the cultivars BMX Magna RR, SYN 3358 RR3 and BMX Potência RR were the ones that stood out and did not differ between them. As for the dose of 200 kg ha⁻¹ the cultivars that obtained better averages were

BMX Potência and SYN RR 3358 RR with no differences between them. The dose of 400 kg ha⁻¹ of NPK, the cultivar with larger average height was the BMX Potência RR, differing from the others.

Table 4. F values calculated from analysis of variance of plant height (PH), pod insertion height (PIH), number of ramifications (NR), mass of 1000 grains (MTG) and yield grain (YIE) of six soybean cultivars (C) cultivated in different doses of NPK (F). Aquidauana, MS, 2012.

FV	Variables					
	G.L.	PH	PIH	NR	MTG	YIE
F	4	1412.1**	257.20**	481.15**	3623.9**	622.3**
C	5	60.39**	145.83**	49.59**	251.96**	86.83**
F x C	20	20.33**	12.46**	5.64**	26.97**	3.34**
Error F (%)	72	46.69	7.6	8.95	106.57	1944.5
Error C (%)	18	3.43	3.42	4.32	1.05	7.83

** Significant at 1% probability; CV% = coefficient of variation in percentage; FV = Fonts of variation.

Table 5. Plant height (PH) and pod insertion height (PIH) of six soybean cultivars submitted at different doses of NPK. Aquidauana, MS, 2012.

Cultivars	Doses of NPK (kg ha ⁻¹)				
	PH (cm)				
	0	50	100	200	400
BMX Magna RR	34.48 a	37.68 a	47.66 a	54.33 c	57.88 d
MSOY 7908 RR	33.65 a	36.11 ab	41.60 c	46.67 d	55.42 d
SYN 3358 RR	32.74 a	35.63 ab	46.60 ab	60.80 ab	68.70 b
BMX Potência RR	34.08 a	38.07 a	45.31 ab	63.21 a	72.41 a
ND 5909 RR	34.14 a	37.64 a	44.28 bc	52.77 c	56.98 d
BRS 245 RR	33.57 a	34.01 b	43.69 bc	57.91 b	62.72 b
Cultivars	PIH (cm)				
	8.25 a	8.11 a	7.60 b	8.68 a	9.42 a
	5.51 c	6.57 b	6.56 c	7.44 c	7.54 c
	5.76 c	6.60 b	7.52 b	8.23 b	8.45 b
	6.54 b	6.21 b	7.54 b	7.61 c	9.00 a
	6.55 b	6.44 b	7.56 b	7.55 c	8.28 b
	6.75 b	8.16 a	8.88 a	9.15 a	9.52 a

Averages followed by the same letter in rows do not differ by Tukey's test at 5% probability.

Analyzing the PIH as function of the interaction of variables F x C, been found for control (dose 0) that the cultivar BMX Magna RR

showed higher average PIH, differing from the other cultivars, already in the dose of 50 kg ha⁻¹ of NPK the cultivars BMX Magna RR and BRS 245 RR

were the ones that stood out, differing significantly from the others. At a dose of 200 kg ha⁻¹ of NPK, the cultivars BMX Magna RR and BRS 245 RR showed the highest values of PIH, did not differing among them. At a dose of 400 kg ha⁻¹ of NPK, the cultivars BRS 245 RR, BMX Magna RR and BMX Potência RR were statistically different, highlighting from the others.

The effect of doses of NPK on PH was linear (Figure 2), where all cultivars reached taller plants with 400 kg ha⁻¹, showing efficiency of this base fertilization to areas of deployment of integrated crop-livestock system, resembling the results obtained by Carvalho et al. (2011).

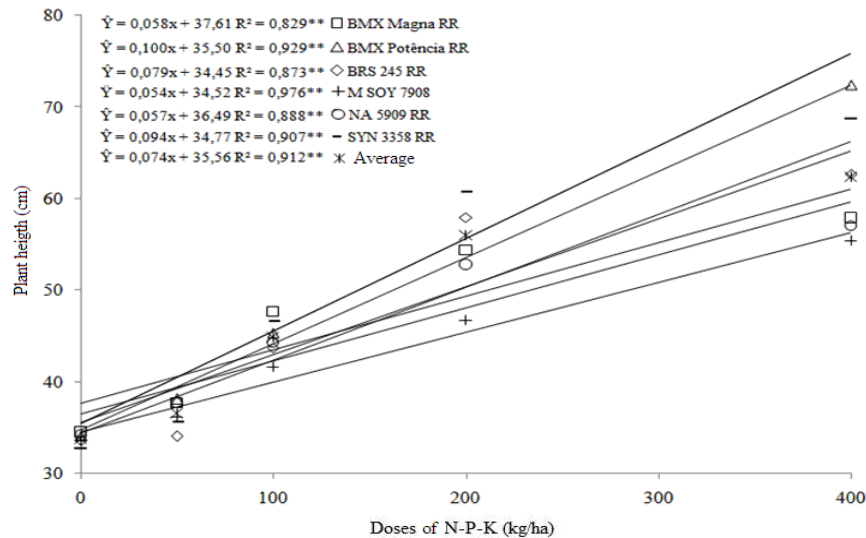


Figure 2. Plant height (PH) of six soybean cultivars as function of different doses of base NPK. Aquidauana, MS, 2012.

Larger plants can have more branching and armpits where the pods will develop, increasing YIE. On the other hand, there are more susceptible to lodging, which can result in losses at harvest. Mauad et al., (2010) recommended a minimum height of 60 cm to any reduction in grain losses in the harvesting operation. Based on this variable, it is recommended fertilization with 200 or 400 kg ha⁻¹

of NPK to cultivars BMX Potência RR and SYN 3358 RR and 400 kg ha⁻¹ of NPK to cultivar BRS 245 RR.

There was a linear increase in variable PIH relative to doses of NPK, reaching greater height with 400 kg ha⁻¹ in all cultivars, corroborating the results obtained by Carvalho et al. (2011) (Figure 3).

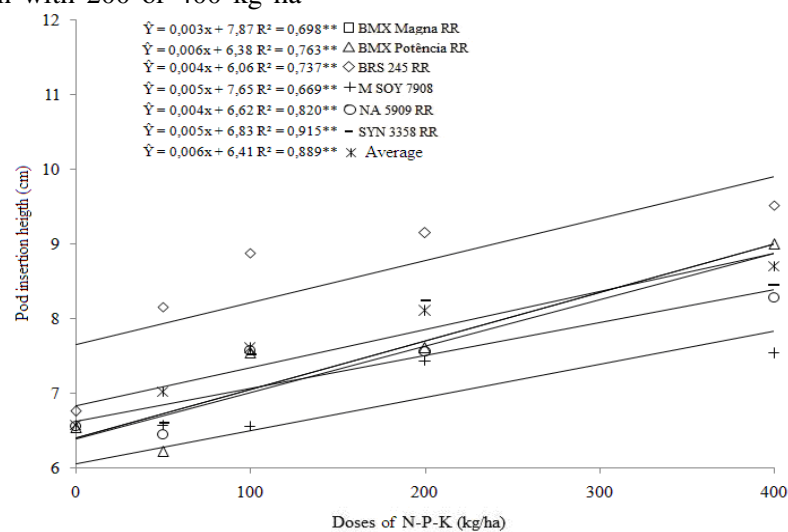


Figure 3. Pod insertion height (PIH) of six soybean cultivars as function of different doses of NPK. Aquidauana, MS, 2012.

According to Marcos Filho (1986), the PIH is an important feature, because as from 12 cm is possible to minimize the losses in the mechanical harvesting, what allows to infer that at no dose of NPK, any cultivar showed the height required for this type of harvest.

Araújo et al. (2005) argue that the variation in the dose of NPK did not influence the PIH variable in soybean, inherent characteristic to cultivar, contradicting the results of this work. The PIH were influenced by doses of NPK probably due to the amount of phosphorus present in the soil, relatively low for the soybean (TAIZ; ZEIGER, 2013).

Analyzing the NR of each cultivar in relation to F x C interaction was observed that for the control (dose 0), there was no statistical difference among cultivars (Table 6). For the dose of 50 kg ha⁻¹ the cultivars BMX Potência RR, BRS 245 RR and SYN 3358 RR have excelled, not differing among themselves, while the latter two did not differ statistically among others. For the dose of 100, 200 and 400 kg ha⁻¹ the cultivars BMX Potência RR, BRS 245 RR and SYN 3358 RR showed higher NR, having no difference among themselves, but differing significantly from the other cultivars.

Table 6. Number of ramifications per plant (NR) of six soybean cultivars submitted at different doses of NPK. Aquidauana, MS, 2012.

Cultivars	Doses of NPK (kg ha ⁻¹)				
	0	50	100	200	400
BMX Magna RR	7.00 a	7.12 b	7.92 b	9.37 b	10.57 b
M SOY 7908 RR	6.87 a	7.47 b	8.27 b	8.50 c	10.02 b
SYN 3358 RR	6.85 a	7.80 ab	9.40 a	10.62 a	12.17 a
BMX Potência RR	7.27 a	8.37 a	9.77 a	10.75 a	12.50 a
ND 5909 RR	6.87 a	7.57 b	8.57 b	9.65 b	10.57 b
BRS 245 RR	6.67 a	7.82 ab	9.80 a	10.62 a	11.77 a

Averages followed by the same letter in rows do not differ by Tukey's test at 5% probability.

The NR is determined during the late vegetative and reproductive stages initials. Proper plant nutrition is fundamental to the development of reproductive buds, storage photoassimilates,

decreased abortion of flowers and pods (TAIZ; ZEIGER, 2013). Therefore, it is recommended to base fertilization 400 kg ha⁻¹ of NPK for all cultivars (Figure 4).

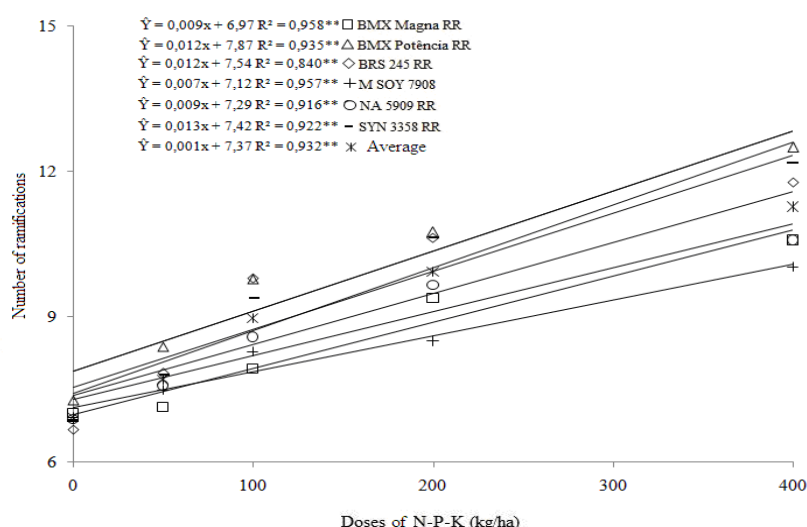


Figure 4. Number of ramifications (NR) of six soybean cultivars as function of different doses of NPK. Aquidauana, MS, 2012.

Independent of level of fertilization, the cultivars SYN 3358 RR and BMX Potência RR, that obtained higher NR, showed higher MTG and, consequently, higher YIE (Table 7). According to Taiz and Zeiger (2013) and Navarro Junior et al.

(2002) this occurred possibly because how much greater NR, greater will be the quantity of trifoliolate leaves, resulting in high photosynthetic area, that can result in greater YIE.

Table 7. Mass of thousand grains (MTG) and yield grains (YIE) of six soybean cultivars submitted at different doses of NPK. Aquidauana, MS, 2012.

Cultivars	Doses of NPK (kg ha ⁻¹)				
	MTG (g)				
	0	50	100	200	400
BMX Magna RR	87.27 bc	96.61 b	104.01 e	107.30 d	110.35 a
MSOY 7908 RR	87.18 bc	97.06 b	111.41 c	114.08 c	118.23 c
SYN 3358 RR	89.93 a	99.01 a	115.34 a	123.93 a	128.09 a
BMX Potência RR	88.59 a	99.35 a	114.77 a	122.99 a	127.21 a
ND 5909 RR	85.85 c	93.69 c	108.25 d	112.63 c	116.10 c
BRS 245 RR	89.28 ab	97.26 b	112.55 bc	119.09 b	121.77 b
Cultivars	YIE (kg ha ⁻¹)				
	0	50	100	200	400
BMX Magna RR	767 b	935 c	1.553 c	2.122 c	2.361 c
MSOY 7908 RR	916 b	1,373 b	2.025 b	2.398 bc	2.597 b
SYN 3358 RR	1,049 ab	1.611 ab	2.498 a	3.037 a	3.333 a
BMX Potência RR	1,311 a	1.789 a	2.430 a	2.953 a	3.273 a
ND 5909 RR	972 b	1.057 c	2.020 b	2.357 bc	2.410 c
BRS 245 RR	980 b	1.058 c	1.884 b	2.512 a	2.726 b

Averages followed by the same letter in rows do not differ by Tukey's test at 5% probability.

The effect of doses of NPK on MTG and YIE variables (Figure 5 and 6, respectively) was linear, reaching the highest values at 400 kg ha⁻¹ in all cultivars. Perini et al. (2012), Carvalho et al. (2011), Nava et al. (2011), Barbaro et al. (2009),

Broch et al. (2009), Ghosh et al. (2009), Bhattacharyya et al. (2008) and Navaro Junior et al. (2002) observed that increasing doses of NPK provided increments in YIE of soybean, agreeing with the results obtained in this research.

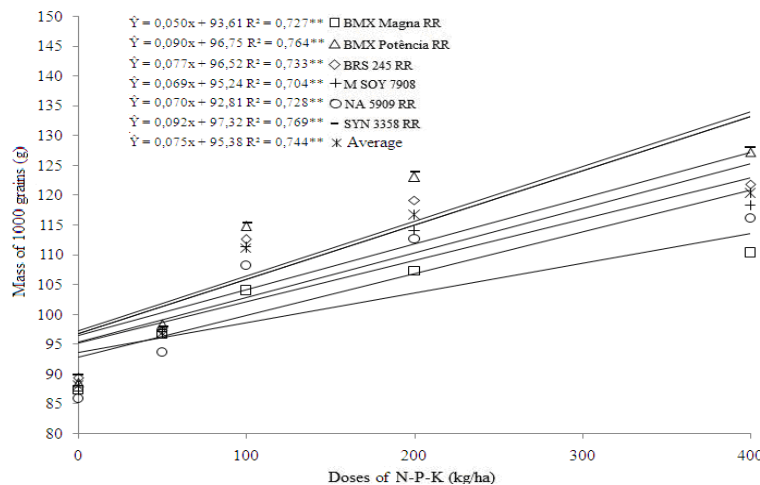


Figure 5. Mass of 1000 grains (MTG) of six soybean cultivars as function of different doses of NPK. Aquidauana, MS, 2012.

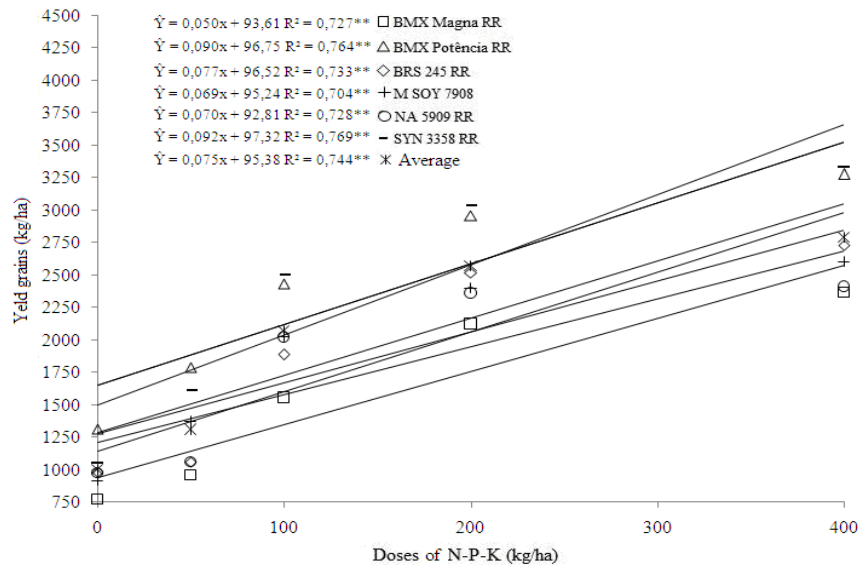


Figure 6. Grain yield (YIE) of six soybean cultivars as function of different doses of NPK. Aquidauana, MS, 2012.

Overall, the results obtained in this research indicate that application of high doses of NPK in soils with low and medium cation exchange capacity provided increase in the agronomic characters of soybean. It is noteworthy that the dose of 400 kg ha⁻¹ NPK provided the cultivars SYN 3358 RR and BMX Potência RR YG exceeding the national average, which is 2,900 kg ha⁻¹. It is important to note that the results obtained with this dose provided YG similar to other studies with soybean cultivars developed in this region (TEODORO et al., 2015; TORRES et al., 2015; TORRES et al., 2014). Based on these results, it is recommend the use of these cultivars and base fertilization for integrated crop-livestock in Brazil, especially in the Cerrado (Savanna) region.

CONCLUSIONS

Increased doses of base fertilizer with NPK caused a linear increase in all variables in all cultivars.

It is recommended base fertilization at the dose of 400 kg ha⁻¹ of NPK being recommended for cultivation on straw *Brachiaria decumbens* pasture degraded.

The cultivars BMX Potência and SYN RR 3358 RR showed higher weight of 1000 grains and, consequently, higher yield grain.

RESUMO: A implantação da cultura da soja sob plantio direto em pastagem degradada vem sendo uma prática trivial, e o uso eficiente e racional de fertilizantes é um fator decisivo para a sua viabilidade econômica. O objetivo foi avaliar o desempenho agrônomo de seis cultivares submetidas a doses adubação de base com NPK e cultivadas sobre palhada de *Brachiaria decumbens*. O experimento foi conduzido na área experimental da Universidade Estadual de Mato Grosso do Sul, Unidade de Aquidauana (UEMS/UUA). O delineamento experimental foi em blocos casualizados em esquema parcelas subdivididas, com quatro repetições. As parcelas foram constituídas de seis cultivares de soja (NA 5909 RR, M SOY 7908 RR, BMX Magna RR, BRS 245 RR, SYN 3358 RR, BMX Potência RR) e as subparcelas por cinco doses de NPK (0, 50, 100, 200 e 400 kg ha⁻¹). Foram avaliados a altura da planta, altura da primeira vagem, número de ramificações por planta, massa de 1000 grãos e produtividade de grãos. O aumento das doses de fertilizante causou um incremento linear em todas as variáveis avaliadas em todas cultivares avaliadas, sendo recomendada para pastagens degradadas à adubação de base com 400 kg ha⁻¹ de NPK. As variedades BMX Potencia RR e SYN 3358 RR apresentaram maior massa de 1000 grãos e, conseqüentemente, maior produtividade de grãos.

PALAVRAS-CHAVE: Integração lavoura-pecuária. Pastagem degradada. *Glycine Max*. Plantio direto.

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