Journal of Agricultural Science; Vol. 13, No. 9; 2021
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Productivity Responses of Buckwheat IPR 91 Baili to Different Doses of NPK in Brazil

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Received: July 5, 2021 Accepted: August 1, 2021 Online Published: August 15, 2021

doi:10.5539/jas.v13n9p97 URL: https://doi.org/10.5539/jas.v13n9p97

The research was financed by the Institutional Program for Scientific Initiation Scholarships PIBIC8, UniCesumar.

Abstract

Buckwheat (*Fagopyrum esculentum* Moench) is a prominent crop in today's agriculture. However, information about its behavior at different doses of NPK fertilization is scarce. The aim of this work was to determine the ideal fertilizer dose for the buckwheat cultivar IPR 91 Baili by establishing the dose-response curve. Two experiments were carried out (greenhouse and in the field). The treatments consisted of different doses of NPK (0, 100, 200, 300, 400 and 500 kg ha^{-1}). After the crop cycle, productivity was obtained. There was a statistical difference between the treatments and the control, in both experiments. The lowest yields were obtained in the controls, 2,301.156 and 2,262.500 kg ha^{-1}, and the highest 4,052.023 and 4,027.778 kg ha^{-1} at the dose of 500 kg ha^{-1}, in the greenhouse and in the field, respectively. There was no statistical difference between the NPK doses for the yield obtained. The rural producer must use the lowest dose (100 kg ha^{-1}). Future experiments are needed to evaluate the culture response to doses below 100 kg ha^{-1}.

Keywords: *Fagopyrum esculentum*, rational use of fertilizers, regional development.

1. Introduction

Buckwheat (*Fagopyrum esculentum* Moench) has its center of origin in China, from where it dispersed throughout Asia and other parts of the world (Kreft et al., 2006). Buckwheat or common buckwheat belonging to the Polygonaceae family, it is a dicotyledonous plant having no relations with common wheat (*Triticum aestivum* L.) (Ohnishi, 1998; Kreft et al., 2006).

However, due to the similarities to wheat's chemical composition and use of its grains, it is exceptionally considered as a cereal (Habtmarian, 2019). It has been used as food for hundreds of years, introduced in Brazil by Polish, Russian and German immigrants in the early 20th century, in the southern region (Anisimov et al., 2013).

Buckwheat is currently being rediscovered (Kreft et al., 2006; Habtmarian, 2019; Rauf et al., 2020). With the crop rediscovery and the increased demand for grain, further studies are needed for productivity to keep up with demand. Studies were conducted with the culture, related to yield (Görgen et al., 2016), adaptation (Alves et al., 2016), cultivation (Vazhov et al., 2013), nutritional properties (Zhu, 2016) and physical properties (Quequeto et al., 2018) and fertilization with phosphate in protected cultivation (Ribeiro et al., 2019). However, information on the recommendation and response of the crop to fertilization with NPK of this species is very vague, besides there are no studies on the dose-response curve.

Empirically, farmers in the region of Ponta Grossa, Paraná use the dose of 150 kg ha^{-1} of NPK (04-30-10), but may be using sub or super input dosage. The knowledge of the behavior in relation to their responses to fertilization, become an indispensable tool for the rural producer to plan and succeed in the cultivation of buckwheat and, consequently, to guarantee the financial return with the crop. The highest dose does not always give the best economic return (Lacerda et al., 2015; Guimarães et al., 2016; Gabardo et al., 2020; Macoski et al., 2021; Clock et al., 2021; De Araujo Avila et al., 2021).

Inadequate nutrient supply, whether lack or excess, can cause restrictions on plant growth and alter relationships between aerial and root biomass, as well as promote changes between vegetative and reproductive stages (Bovi et al., 2002; Neumann et al., 2019; Ascari et al., 2020). Thus, the objective of this work was to determine the ideal dose of fertilizer for the buckwheat cultivar IPR 91 Baili, through the establishment of the dose-response curve, in an experiment in greenhouse and field, in the region of the general fields, state of Paraná.

2. Material and Methods

The experiment was carried out in the experimental area of UniCesumar, Ponta Grossa Campus, located at 25°13′ latitude and 50°03′ longitude, and 900 m altitude. The climate of the site is subtropical humid, classified as CFb, according to Köppen. The average annual rainfall is approximately 1550 mm. Soil analysis was performed before the experiment implementation, obtaining: pH in water 5.8; P (Mehlich 1): 5.32 mg dm^{-3}, K: 60 mg dm^{-3}, S (monocalcium phosphate in acetic acid): 5.8 mg dm^{-3}, Ca: 2.9 cmolc dm^{-3}, Mg: 1.0 cmolc dm^{-3}, effective CTC (t): 5.5 cmolc dm^{-3}, M.O.: 1.8 dag kg^{-1}. The soil of the experimental area presents clayey texture is classified as dystrophic Red Latosol (Dos Santos et al., 2018). The cultivar used for the experiments was The IPR 91 Baili, with early cycle characteristic and high size. The seeds were given by the Institute of Rural Development of Paraná (IDR).

The design adopted for the experiment in the greenhouse was completely randomized, and in the experimental field in randomized blocks. In both experiments, six treatments and five replicates were used. The treatments consisted of different doses of NPK (04-30-10). Being: T1 (control), T2 (100 kg ha^{-1}), T3 (200 kg ha^{-1}), T4 (300 kg ha^{-1}), T5 (400 kg ha^{-1}) and T6 (500 kg ha^{-1}).

In the experiment in the greenhouse, pots with a capacity of 5 liters and diameter of 20 cm were used, previously filled with homogenized soil. Each pot was considered a repetition. Treatments (fertilizer doses) were added to each pot (previously identified). Sowing was performed on 09/25/2020, using 8 seeds per pot with a depth of 2 to 3 cm of sowing. After culture emergence, thoff was performed, remaining 6 plants per pot. Irrigation and other cultural treatments were performed according to the crop's need.

For the field experiment, sowing was performed manually on 10/03/2020, on oat straw, using spacing between rows of 0.20 m with 60 kg ha^{-1} of seeds. The plots had a dimension of 6 × 5 m, with 30 m^2 of total area and 4 m^2 of useful area. The crop emerged 6 days after sowing and its first flowers were observed 20 days after emergence in both experiments.

At the end of the crop cycle, approximately 70 days after emergence, the harvest was performed manually, when about 80% of the grains were ripe (15% moisture), both from the field and greenhouse experiments. Grain harvesting was performed with manual cutting of the entire plant without the use of desiccation. Next, manual threshing was performed using a canvas to avoid losses. Then the grains were cleaned by separating with sieves. After grain cleaning, moisture was measured with the universal meter and the weight converted to 13% humidity and estimated productivity.

The data were submitted to normality analysis (Shapiro-Wilk) and variance equality (Bartlett test), at the level of 5% significance. After that, the F test was applied in the variance analysis (ANOVA) with a "Tukey" media separation test, also at the level of 5% significance. The data were also represented graphically, with the elaboration of the dose-response curve equation adjusted to the polynomial model, due to obtaining the highest determination coefficient (r^2).

3. Results and Discussion

There was a statistical difference between the treatments (Table 1). The control differed from all doses of NPK (04-30-10) in both experiments. The lowest productivitieswere obtained in the controls, 2,301.156 and 2,262.500 kg ha^{-1}, and the highest 4,052.023 and 4,027.778 kg ha^{-1} at the dose of 500 kg ha^{-1}, in the pots and in the field, respectively. However, there was no statistical difference between the doses of NPK for the obtained productivity.

The productivities obtained in the greenhouse and field were similar (Table 1 and Figure 1). In the experiment in pots, there was an increase in relation to the control of 1,236.416; 1,288.439; 1,311.561; 1,571.676 and 1,750.867 kg ha^{-1} in productivity at doses of 100, 200, 300, 400 and 500 kg ha^{-1} NPK, respectively. In the field experiment, there was an increase of 1,359.895; 1,396.355; 1,581.250; 1,664.583 and 1,765.278 kg ha^{-1} in productivity in relation to the control, at doses of 100, 200, 300, 400 and 500 kg ha^{-1} NPK, respectively. The coefficients of variation obtained were adequate in both experiments.

Table 1. Productivity (Kg ha^{-1}) obtained in anexperiment in a greenhouse and in the field, according to different doses of NPK (04-30-10), in buckwheat, cultivar IPR 91 Baili. Ponta Grossa/PR, 2020

Treatments	Productivity kg ha^{-1} (greenhouse)	Productivity kg ha^{-1} (field)
T1: Control	2,301.156 b*	2,262.500 b
T2: 100 kg.ha^{-1}	3,537.572 a	3,622.395 a
T3: 200 kg.ha^{-1}	3,589.595 a	3,658.855 a
T4: 300 kg.ha^{-1}	3,612.717 a	3,843.750 a
T5: 400 kg.ha^{-1}	3,872.832 a	3,927.083 a
T6: 500 kg.ha^{-1}	4,052.023 a	4,027.778 a
C.V. (%)	8.38	9.15

Note. * Means followed by the same lowercase letter in the column do not differ by Tukey's test at 5% significance; Original data; C.V. = coefficient of variation.

There was a good adjustment of data in obtaining the dose-response curves. The coefficient of determination obtained was 0.84 and 0.87 in the greenhouse and field experiments, respectively (Figure 1). According to the dose-response curve, the rural producer should sow the crop using the lowest fertilizer dose (100 kg ha^{-1}). If twice the dose is used (200 kg ha^{-1}) productivity will increase on average 44,241 kg ha^{-1}, (52,023 in pot and 36,460 kg ha^{-1} in the field). In view of the volatility of the price of inputs today, spending on fertilizer would be higher to obtain an exponential yield in the field (Ribeiro et al., 2019).

Currently farmers in the region end up using the dose of 150 kg ha^{-1} of NPK (04-30-10). The present study concluded that 50 kg^{-1} of NPK more is unnecessary in sowing, with no return on productivity in the crop, in addition to preventing unnecessary doses from being used.

According to Göergen et al. (2016), the crop has great tolerance to acidity and ability to use phosphorus and potassium poorly soluble in the soil, this achieves good development in poor soils. The same authors report cases in which sowing occurs without the addition of fertilizers, up to dosages of 500 kg ha^{-1} NPK. However, the present work confirms that fertilization presents gains in the crop yield, however doses above 100 kg ha^{-1} NPK are unnecessary (Table 1 and Figure 1).

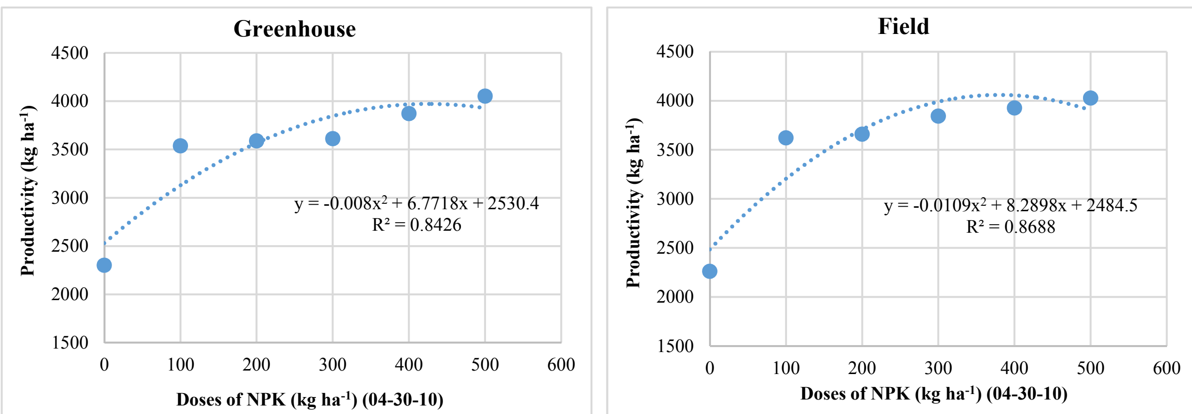

Figure 1. Productivity (Kg ha^{-1}) obtained as a function of different doses of NPK (04-30-10) in a greenhouse and field experiment, in buckwheat, cultivar IPR 91 Baili. Ponta Grossa/PR, 2020

Da Silva et al. (2002), evaluated different buckwheat genotypes in the Cerrado of Brazil, using the fertilizer formula similar to that of the present experiment (04-30-16), but with a standard dose of 400 kg ha^{-1} and obtained yield for the genotype Domingos 2, of 3,917 kg ha^{-1}, Uchimooko genotypes 2,230 kg ha^{-1} and Konan 2,177 kg ha^{-1}.

Popović et al. (2014), working at Servia, used the dose of 200 kg ha^{-1} of fertilizer, with the varieties of buckwheat: Novosadska, Godijevo, Bamby and Česka. The analysis of the average yield showed that the Novosadska variety produced a statistically significant higher yield (2,626 kg ha^{-1}) compared to the other tested varieties. The cultivar IPR 91 Baili presented higher yield potential than the varieties used in Popović's work (Table 1).

The average world crop yield in the period 2010-2012 was 913 kg $ha^{-1}$and has a tendency to increase with a rate of 17.12% per year due to research on genetic improvement and crop management. In 2011, there was an increase in yield of 144 kg ha^{-1}. About 68% of the buckwheat area is located in Russia and China (Popović et al., 2014; FAO, 2017).

The average crop productivity in America ranges from 1,237 kg ha^{-1} in South America to 1,042 kg ha^{-1} in North America. The lowest yield was produced in Africa of 848 kg $ha^{-1}$and Asia 890 kg ha^{-1}. The highest average yield in the world was produced in France (3,173 kg ha^{-1}), followed by Brazil (1,237 kg ha^{-1}), Poland (1,162 kg ha^{-1}), Slovenia (1,099 kg ha^{-1}) and the USA (1,042 kg ha^{-1}) (Popović et al., 2014; Mikami et al., 2018).

From the results obtained, we can conclude that the yield of buckwheat IPR 91 Baili in Brazil is significantly higher compared to the national and world average yield. It is concluded that this crop can be successfully produced in our cultivation conditions. Another relevant factor is the increased demand for gluten-free foods, such as buckwheat (Foschia et al., 2016; Christoph et al., 2018). According to Rodrigues et al. (2019) sales of gluten-free products have increased by around 30% per year since 2004. Representing expansion potential for crop production.

There were no visible problems related to pests, diseases and weeds in the experiments. Arduni & Mariotti (2018) state that among the advantages of culture is the low need for cultivation, chemical fertilizers and pesticides, therefore, it is suitable for both conventional and organic cultivation. These parameters can make buckwheat more attractive to Brazilian producers. Da Silva et al. (2002), argue that few studies were conducted with buckwheat in Brazil, restricted to the states of Rio de Janeiro (Duarte, 1948), Paraná (Baldanzi & Amaral, 1963) and Alagoas (Barros et al., 1982). Buckwheat is currently being rediscovered (Kreft et al., 2006; Habtmarian, 2019; Rauf et al., 2020).

It is a multi-purpose plant. Produced mainly for export, due to commercial interest of foreign companies, mainly Japanese companies that buy practically all Brazilian productivity (Ansanelli et al., 2020). The product is widely used in oriental cuisine. Yakisoba is a purely buckwheat dough, and is also used to produce vinegar and alcoholic beverages such as beer (Silva, 2002; Mikami et al., 2018; Buiatti et al., 2018; BRASIL et al., 2020).

Other beneficial characteristics of the crop for human consumption, besides not having gluten, are the high protein content, balanced amino acid profile, lipid balance containing unsaturated fats, and high rutin content (Kreft et al., 2006; Habtemarian, 2019). Rutin is an important therapeutic substance that favorably influences, among other aspects, the reduction of blood pressure and stimulates the body to use vitamin C (Pirzadah et al., 2020). Buckwheat protein is also of excellent quality and has a high content of lysine, an essential amino acid that is deficient in most common cereals (Sedej et al., 2011).

Mainly to its use as a gluten-free food, as a soil cover, in the feeding of animals (grains, hay and silage), in the exploitation of apiculture as a source of pollen for bees and in obtaining the best quality honey (Foschia et al., 2016; Christoph et al., 2018; Volsi et al., 2020). In rotation with the main summer crops, it adds a positive synergistic effect by reducing the nematode population, in addition to improving weed control (Bélair et al., 2002; Creamer et al., 1997) and increasing the concentration of organic matter in the acidic subsoil attributed to the exudates (Klug & Horst, 2010).

4. Conclusion

There was no statistical difference between the doses of NPK for the obtained productivity. Based on the dose-response curve, the rural producer should use the lowest dose (100 kg ha^{-1}).

Further experiments are needed to evaluate different buckwheat cultivars, as well as the response of the crop to doses lower than 100 kg ha^{-1}.

Acknowledgments

To UniCesumar, for the opportunity to carry out this work and for the granting of a scientific initiation scholarship, PIBIC 8.

To my advisor Professor Dra. Gislaine Gabardo, for the encouragement and dedication of her little time to my research project.

Professor Flavia Sayuri Arakawa and the coordinator of the Agronomy course Maicon Ramon Bueno, for their confidence in carrying out the work.

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