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Research Article

Weed Management by Sowing Dates Optimization and Glyphosate Application: Impact on the Growth and the Yield of Common Bean Crop (*Phaseolus vulgaris* L.)

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Abstract

Background and Objective: An experiment was installed at Kasapa farm during the 2013-2014 cultural season in aim to assess the effects of sowing dates and glyphosate doses on the behavior of common bean. **Materials and Methods:** The essay was installed according to a split plot device, the main factor was constituted of planting dates and glyphosate doses secondary factor. The effects of three sowing dates (25th January, 5th February and 15th February) and four doses of glyphosate (1.5, 3, 4.5 and 6 L ha^{-1}) on common bean behavior were assessed. **Results:** The analysis of variance showed the lack of interaction between herbicides doses and sowing dates on all common bean growth and production parameters. However, Tukey HSD test revealed the effects of planting date on plant size. On first sowing date (25th January), the number of pods per plant was similar to plots sown on 5th and 15th February. Moreover, the highest grain yield (2.03 t ha^{-1}) was obtained in plots sown on 5th February. **Conclusion:** This study showed the influence of sowing dates on weed flora. The study also proved that four species of weeds, *Cyperus rotundus*, *Ageratum conyzoides*, *Ageratum houstonianum* and *Spilanthes acmella* were indifferent and resistant to two weed management modes (sowing date optimization and glyphosate application).

Key words: Weed flora, common bean, sowing dates, pre-sowing treatment

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Competing Interest: The authors have declared that no competing interest exists.

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

INTRODUCTION

Weeds are a major constraint to the cultivation of common bean whose sensitivity is spread throughout the growth cycle, but the most critical periods are at the stage of deployment of 3-5 sheets[1].

In many African countries, yield losses caused only by weeds easily reach over 50%[2,3]. According Dogan *et al.*[4] in most of them, the beginning of crop year is conditioned by rains, which for several decades there has been marked by climatic disturbances either by abundance or rain scarcity making it difficult to determine planting dates[5].

Studies by Toure *et al.*[6] and Da Costa *et al.*[7] showed that the sowing at the optimum time improves crop performance face several plagues and this taking into account the period for the emergence weeds must intervene after the phonological phase sensitivity of culture[8]. Since the constraint mentioned relative to the time of sowing and nuisance weed culture, it is necessary to use the IPM strategy combining cultural and chemical control for sustainable agriculture. Therefore, as weeds are as a major problem to be solved to increase common bean culture productivity. Generally, weeds in the case of a bad control lend themselves more to competition compared to cultivated plants in rivaling their space, light, humidity, nutrients and carbon dioxide resulting in losses of yields and difficulty of the harvesting operations even see the depreciation of the useful product. Moreover, common bean is relatively sensitive to the presence of weed mainly between 4-6 weeks after sowing.

The main objective of this study is to evaluate the effect of sowing date and glyphosate application on common bean behavior. Thus to achieve the objective, this study has set as hypothesis: (i) The crop yield would be influenced by sowing dates and/or herbicide doses applied before sowing and (ii) There is a sowing date and/or herbicide doses that influences weeds development.

MATERIALS AND METHODS

The experiment was conducted at Kasapa farm located in Lubumbashi at: 1243 m a.s.l., 11°39' South latitude and 27°28' East longitude[9]. The soil is ferralsol type with better physical properties, but poor chemically[10]. The results of chemical analysis before experiments showed: $pH_{(water)}$ 5.7, N: 0.69%, P: under trace form, C: 9% and K: 0.0026%. The flora was inventoried by the linear transect method on a 50 m line length and 5 m width[11]. This which moreover identified species: *Cynodon dactylon*, *Panicum maximum*, *Seteria pumila*, *Imperata cylindrica*, *Hyparrhenia* sp., *Tithonia diversifolia*, *Bidens oligoflora*, *Hephorbia hirta*, *Cyperus esculantus*, *Aspilia kocthii*, *Celosia trygina*, *Eleusine indica*, *Spermacoce pusila*, *Acanthospernum hispidum*, *Bidens pilosa*, *Ageratum houstonianum* and *Ageratum conyzoides*.

The climate has anciently fluctuated and has been marked by dry spells during the rainy season[12]. Although, subject to changes, the annual average temperature is 20°C and Koppen categorizes the type CW6 with a dry season covers many months unlike the rainy season[13].

Weather data from Luano station revealed for the 2013-2014 crop season: The peak rainfall marked the month of February against a decline in April, it is the same as for the number of rainy days and relative humidity.

However, the high temperatures values characterized the month of January, against the low values for April (Table 1). Prelon variety from the Institut National pour l'Etude et la Recherche Agronomiques (INERA) Kipopo station with features such as: Potential yield: 2-2.5 t ha^{-1}, 100 graines weight: 23 g, height at flowering: 35-45 cm served as biological material. However for the weed control herbicide glyphosate SL 480 g L^{-1} isopropyl amine salt equivalent to 380 g L^{-1}, non-selective post emergent broad spectrum[14].

After the first floristic inventory cited above, the opening of the land coupled with 20-25 cm deep tillage and harrowing manuals ensued. Pre-sowing spreading {glyphosate dose (1.5 L ha^{-1}), dose 2 (3 L ha^{-1}), dose 3 (4.5 L ha^{-1}) and dose 4 (6 L ha^{-1})}, because according to Sadegh *et al.*[15] pre-sowing treatment generally used to control weeds 4-6 weeks after sowing. Seedlings intervened to 3 dates spaced of 10 days: Date 1 (25th January), date 2 (5th February) and date 3 (February 15th) with 2 seeds per hole and spacing of 20×40 cm. The trial was installed according to the split-plot device with three repetitions with the main factor planting dates and high doses glyphosate, each sub plot measured

Table 1: Climate data of the experimental period from December, 2013 to April, 2014

Periods and climatic parameters	2013	2014			
	December	January	February	March	April
Precipitation					
Quantity (mm)	247.5	277.5	331.6	157.8	113.5
No. of rainy days	16	18	22	13	8
Temperature (°C)					
Maximum	31.5	32	29.8	30.5	29.1
Average	21.2	21.3	21.9	21.4	20.8
Minimum	16	15.6	14.8	16	14.8
Relative humidity (%)	84	87	88	85	81

Source: National Agency of Meteorology and Remote Sensing Satellite (METTELSAT)/Luano station

5×2.4 m. The general appearance of weed was assessed quantitatively according to Braun-blanquet. Two quadrats of 1 m^2 placed the middle of each plot in each subplot were used to inventory the species of weeds to flowering. Observation and data collection for the growth parameters including: Emergence rate and plant height and production: No. of pods per plant and No. of seeds per pod were made on 20 plants at 10 plants per centerline and subplot. Except for the yield determined at harvest.

The parameters of the culture were submitted to the analysis of variance (ANOVA) with the Ri386 2.15.0 software to test the effects of treatment and if possible their interaction on the observed parameters and will follow the separation medium by the Tukey HSD. However, the data on the weed density were subject to the Kruskal Wallis test saw the non-normality of the data.

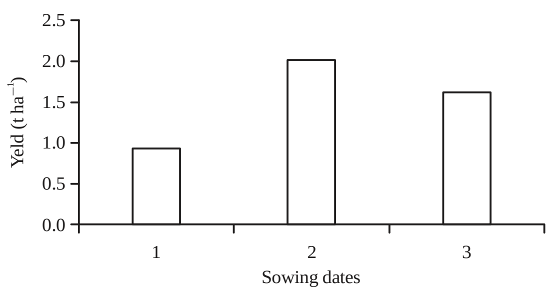

Fig. 1: Influence of sowing dates on common bean yield. Doses D1: 1.5 L ha^{-1}, D2: 3 L ha^{-1}, D3: 4.5 L ha^{-1} and D4: 6 L ha^{-1}, Sowing dates: 25 January, Date1: 25th January, Date 2: 5th February and Date 3: 15th February

RESULTS

Influence of sowing date, herbicides doses on the growth parameters and production of common bean: The emergence rate and the number of seeds per pod were not influenced by either sowing dates or by herbicide doses because $p>0.05$. In contrast, the sowing dates induced effects ($p<0.05$) on: The height of plants on 30th day after sowing, the number of pods per plant and grain yield of the crop.

Therefore, the comparison of the mean for each of these three parameters by the Tukey HSD emerged differences between the three sowing dates. Thus, it was observed that early sowing induces larger plants or (21.3 cm), against a small size simultaneously for the plots sown seedlings at the second date and last date. For the number of pods per plant, the largest number (10) was reported for the late sowing and the smallest number (4) for semi on the first date.

Seeding on the second date induced a high yield (2.03 t ha^{-1}), while in the first time there was a low yield (0.94 t ha^{-1}).

It should be noted that the combination seeding dates and herbicide doses were observed no influence parameter as $p>0.05$ (Table 2).

The examination of Fig. 1 indicates that common bean yield varies between 0.94 and 2.03 t ha^{-1}. The highest common bean grain yield is obtain at second date and the lowest at first date.

Effects of treatment on weed density: The alternative test to the variance analysis with the non-parametric Kruskal Wallis

Table 2: Influence of sowing dates, herbicide doses on the observed parameters

Sowing dates	Doses	Emergence rate	Plants height (cm)	No. of pod $plant^{-1}$	No. of seed pod^{-1}
Date 1: 25th January	D1	96.93±3.93	21.80±2.602	4±1.03	4±0.65
	D2	97.50±2.50	19.30±2.77	4±1.47	4±0.20
	D3	91.07±7.56	22.20±1.67	4±1.58	4±0.18
	D4	96.37±3.35	22.00±1.80	5±0.70	4±0.26
Date 1 average		95.46±4.85^a	21.30±2.29^a	4±1.17^b	4±0.37^a
Date 2: 5th February	D1	97.73±0.98	14.40±0.63	10±0.82	4±0.13
	D2	96.07±2.54	17.00±1.09	8±1.83	4±0.71
	D3	96.60±0.85	15.20±3.58	8±2.25	4±0.15
	D4	92.70±7.58	16.10±2.21	12±1.84	4±0.51
Date 2 average		95.79±3.96^a	15.73±2.12^b	9±2.36^a	4±0.39^a
Date 3: 15th February	D1	98.03±1.76	17.30±2.87	11±2.63	4±0.32
	D2	97.47±1.65	16.60±0.94	12±5.16	4±0.20
	D3	97.73±1.96	14.83±0.94	9±1.10	4±0.68
	D4	97.47±2.17	15.14±1.27	9±1.03	4±0.25
Date 3 average		197.67±0.637^a	15.90±1.812^b	10±2.87^a	4±0.39^a
Sowing date effect p = 0.05		0.318	0.000	0.000	0.592
Doses effects p = 0.05		0.477	0.974	0.393	0.715
Interaction p = 0.05		0.446	0.206	0.185	0.788

The different letters next averages indicate a significant difference after the Tukey HSD test ($p<0.05$). Doses D1: 1.5 L ha^{-1}, D2: 3 L ha^{-1}, D3: 4.5 L ha^{-1} and D4: 6 L ha^{-1}

showed no glyphosate dose has exerted influence on weed recoveries rates because ($p>0.05$). Nevertheless induction effects was observed by sowing dates ($p<0.05$). Only four species of *Cyperus rotundus*, *Ageratum conyzoides*, *Ageratum houstonianum* and *Spilanthes acmella* proved apparent indifference, but generally with the weed density varied among planting dates: Heavy infestation on the first date and low for the remaining two dates.

DISCUSSION

In this study, sowing date intervened indirectly on the emergence rate of seeds of the culture that depends heavily on intrinsic and extrinsic factors (Table 1). For this parameter, our results embrace those obtained by Raveneau[16] which circumscribes the average temperature of 20-25°C for legumes germination. This study reports that pre-sowing treatment, glyphosate regardless of the applied dose did not inhibit germination of common bean seeds. These results are similar to those obtained by Mick *et al.*[17] to the same culture and the same doses. This translates to a certain selectivity for seeds. In contrast, Kamble[18] reports that glyphosate led to a complete halt germination of Hibiscus cannabinus by cotyledon desiccation from 25000 ppm and this exhibition starting from 24 h. Further, the results of Pinto *et al.*[19] emphasize the negative after-effects of glyphosate (960 g a.i. ha^{-1}) on seedling vigor of seeds from the application in the field of common bean R9 is at the stage during the drying pods to accelerate dehydration seeds and improve the quality of commercial product and concerning[20] showing that reducing plant vigor after lifting result of the slowdown in the activity of gibberellic acid and/or indolacetic acid, during the germination process because after applying the product, part concentrated in the seeds and it is the latter which will weaken the embryo without destroying it, unlike paraquat dichloride 240 g a.i. ha^{-1} glufosinate ammonium 400 g a.i. ha^{-1} that do not accumulate the seeds pre-harvest treatment.

Planting dates reflect varietal unsuitability under different climatic conditions. However in the first planting date, the plant has not had to get a good distribution of rainfall, rainfall was low at the beginning of culture, then high during the flowering phase and pod development. Unlike the second date where climatic conditions were favorable compared to almost water needs and finally to late sowing, cultivation is not fully covered its water needs during the growing season as the number of rainy days was insignificant. Opinion supported by Green *et al.*[21] which highlighted the impact of ecological conditions as a factor limiting the productivity of crops that usually leads to lower productivity because the plant must first allocate resources for survival. As to the latter date, it has established a significant decrease in the amount of rainfall during the development phase, the results of the essay led by Mick *et al.*[22] emphasized the negative effect of water stress during the development phase of the common bean production parameters whose effects are characterized by a lower yield seeds.

Although, the bean and cowpea belong to the same botanical family, it should be noted that planting dates to maximize seed yield remain different. This being true basis of the study conducted under our climatic conditions by Yannick *et al.*[23] that showed increased seed yield at the optimum date (30th December), unlike the seedlings occurred at (15th December) and (15th January). This is justified by the significant term of cowpea growing season compared common bean culture.

Furthermore, in addition to sowing dates aspect[24] revealed the existence of certain common bean genotypes whose productivity is independent of sowing moments. Then completed by Ngueguim *et al.*[25] who showed that the effect of the date on the type of growth habit in the same genus and species to which early sowing suits to voluble varieties. This argument goes along the same lines as that emitted by Dutta[26] which is early sowing in the rainy season start is better suited to long vegetative cycle crops for maximum exposure time promoting into production timely: Case of *Helianthus annuus* L.

Indeed, the weed flora was affected by sowing dates not by active ingredient used for pre-sowing. Cultivated fields are much invaded by therophytes. This lets see from flora inventoried before opening the field. According Mick *et al.*[27] it has been observed in various biological types bean pure culture in varying proportions: The therophytes 66.66%, geophytic 12.5%, chamaephytes hemicryptophytes 8.33% and finally the nanophanérophytes 4.16%.

Therefore, it established a link between the arrival of the rains and the spontaneous emergence of seeds seed bank to explain the weed density for different planting dates. The results of the study conducted by Rasmussen[28] cultured winter wheat sowing reported that coinciding with the rains return facilitates the lifting of many seeds including seed bed was arranged by unintentionally tillage and further, they are depleted gradually as the rains fall as the synchronous lifting remains thus varying degrees of seed dormancy.

The results of this study are consistent with those obtained by Dimitrios *et al.*[29] noting that the weed density is generally high in case of heavy rainfall during a particular period and vice versa.

However in legumes, it is not preferable to observe a strong weed infestation before the development phase. This would explain to some extent the variability in yields caused by sowing dates because according Felton[30] the number of nodules culture is positively correlated with the density of weeds and it becomes much more complicated with weeds high power competitor facing the crop. For this study, the remarkable invasion of *Ageratum conyzoides*, *Ageratum houstonianum* and *Spilanthes acmella* could be explained above all by seed production of the previous season. This argument joined one issued for the cultivation of lens where it was emphasized a heavy infestation of culture by Asteraceae following the massive seed production associated with anemophilous dispersion mode and to some extent the potential allopathic of *Ageratum conyzoides* and *Ageratum houstonianum* whose effects are reflected in other habitat plants[31].

The removal of seeds from seed bank in the soil is characterized by a staggering as a species, there is a genotypic heterogeneity of seeds related to the period maturation and position on the mother plant[32]. In contrast the presence in the soil of the active bud *Cyperus rotundus* gives it the ability to quickly invade the field and that there are also conditions associated with heat and sunlight. Without eradication measures in a growing season a foot could produce 10-30 million tubers per hectare[33].

Glyphosate in pre-sowing treatment whatever the dose applied, failed to induce effects on the weed flora or influence the growth parameters and production culture this would be attributed to the soil type of the experimental site whose chemical characteristics being poor.

Previous studies have had to explain the ground after spraying herbicide relationship to understand the degradation processes which may result depending on the case either efficiency or inefficiency of the active ingredient. According to Andreu and Pico[34] and Sebiomo *et al*.[35] once arrived at the ground the herbicide will be adsorbed to the surface of soil colloids whose mobility depends on the organic content, type and quantity of clay because of poor soil organic matter glyphosate degrades rapidly, given its weak adsorption to soil colloids there could be a leaching and/or percolation[14,17]. The absence of glyphosate effects was observed in barley forage crop driving on a sandy-loam soil, argiustoll types: pH 5.7, 1.7% organic matter[36].

CONCLUSION

The results of this study show that the sowing date remains a determining factor in increasing the productivity of culture and weed infestation, but it should be noted that the variety used adapts better when intervening early on 5th February for which it was observed the highest grain yield and this would be favorable ecological conditions that prevailed during the different phenological phases of culture, unlike the other two dates.

However, application of glyphosate in pre-sowing on a strongly altered soil needs improvement prior chemical properties by the contribution of well-decomposed organic soil. This to improve its adsorption to soil colloids and may limit its rapid degradation. Although, weed was influenced only by planting dates and whose pressure increased with increased rains, it should be noted that four species: *Ageratum conyzoides*, *Ageratum houstonianum* and *Spilanthes acmella* proved resistant to both glyphosate doses and sowing dates.

SIGNIFICANT STATEMENT

A large literature exists on the fact that weeds are a major threat to crops. Various control methods exist despite their very high cost or their inefficiency. In this study it is to verify the effectiveness of good sowing date and the contribution of glyphosate in weed management.

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