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The Efficacy ofBasagran Post-Emergence Herbicide on Weeds in Common Beans Variety (Chelalang')

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Abstract: Common bean (*Phaseolus vulgaris L.*) is the most important pulse and second to maize as food crop (GOK, 2011). Beans are the main source of protein and vitamins. The most important effect of weeds on crop plants is competition for growth resources such as nutrient elements, moisture, sunlight and space. Weeds management in beans has posed a challenge especially on medium to large scale production due to its (beans) closer spacing and manual labour inavailability. Basagran® is a post-emergence selective herbicide used for the control of many small actively growing broadleaf and grass weeds on maize, beans, peas, soybeans and Irish potatoes among others. This research is aimed at determining the efficacy of Basagran 480 SC post-emergence herbicide on weeds in Common Beans under different rates and stage of weed growth in small to large scale farms. The experiment comprised three levels of the herbicide namely: 1.5 l/ha; 2.0 l/ha; 3.0 l/ha and three stages of weeds growth namely (i) 1 week after germination of both crop and weeds (ii) 2 weeks after germination of both crop and weeds and (ii) 3 weeks after germination of both crop and weeds. The experimental design used was Randomized Complete Block Design (RCBD) with 3 replications. Data obtained were subjected to analysis of variance, SPSS and subjected to mean separation using LSD Test where applicable There was a significant difference in the yield of grains when the herbicide levels and stages of growth were varied. The efficacy of Basagran® herbicide washighest at an application rate of 3.0 litres per ha applied at about two weeks after germination of the weeds and the crop. The study recommends the use of Basagran® herbicide at the right application rates of about 3.0 litres per ha on bean fields for the control of most broad-leafed and grass weeds in order to boost grain yield.

1. Introduction

Common bean (Phaseolus vulgaris L.) belongs to the legume family (Leguminosae). The crop is widely cultivated and forms one of the largest food components in Latin America and Africa and it is of great value in these countries for its high content of dietary protein and micronutrients such as iron and folic acid. It is one of the most economically important crops in Latin America and acts as a source of income for small farmers (Pachico, 1989).

In Kenya, common bean (*Phaseolus vulgaris L.*) is the most important crop and second to maize as food crop but leading among the pulses grown in the country (MOA, 2011). The national annual demand for common bean has been estimated at 500,000 metric tonnes, but the actual annual production is only about 125,000 metric tonnes (Muasya, 2001). The total area under bean cultivation in Kenya is estimated at 500,000 ha (MOA, 2011) leading to actual bean yield of 250 kg per ha partly under mixed cropping. When planted in a pure stand, the bean yields of 700 Kg per ha has been reported (Songa, Ronno, and Dannial,1995; Muasya, 2001). This production is low compared to the potential yield of up to 5000 Kg per ha. Such high yields have been achieved in other countries, such as Mexico under field conditions (Muasya, 2001).

Beans are the major grain legume consumed worldwide as edible seeds and pods and as a main source of protein and vitamins i.e. rich in acids lysine tryptophane, methiomine, vitamin B, nicotine acid, Ca and iron. This makes it act as a source of balanced diet for rural poor who cannot afford animal protein. It is being used in a variety of form to complement carbohydrate diets e.g. immature pods, mature seeds or dry beans. N-fixation through root nodules of beans improves soil fertility status and reduces amount of N used in cultivation of beans and other bean /intercrops (cereals). It has high value in intercropping with cereals and also as catch crop in perennial crops which helps to increase food security and provide balanced diet.

In Kenya beans grow best in altitude above 600 m a.s.l because below this, high temperatures cause flower and pod abscission causing poor fruit set and hence reduced yield. There are also high incidences of diseases like; bean rust, and bean anthracnose below this altitude. Altitude between 900-2100 m a.s.l is most suitable but can be grown up to 2700 m.a.s.l. as in case of maize. Beyond this altitude there is the problem of frost damage because it's not resistant. Temperatures range from 17-26^{o}C.

Research institutions in the whole world are striving to develop crop cultivars with high yield potential. In this effort, Kenya Agricultural & Livestock Research Organization (KALRO), Kenya Seeds Company and Egerton University have developed common bean cultivars with grain yield potential of as high as 3 tonnes per ha. Full exploitation of such grain yield potential would mean the area currently under beans would yield enough grain for local consumption. This is only possible with suitable cropping practices and proper management strategies which include weed management and control of other pest problems.

The most important effect of weeds on crop plants is competition for growth resources such as nutrient elements, moisture, sunlight and space. When the crop plants are deprived of these essential resources by weeds they fail to realize their full genetic yield potential (Robert Zimdahl, 2007). Weeds can also affect the quality of the crop and spread of pests and diseases.

Herbicides are the emerging method of weed management in beans in Kenya, especially with development of selective herbicides on beans. This is essential with the increasing acreage under beans, mechanization and inadequate manual labour. But the herbicides are manufactured by agro-chemical firms in foreign countries and evaluated for efficacy in agro-ecological zones that may be dissimilar to situations prevailing in beans growing areas in Kenya. Before the herbicides are introduced for commercial use in the country they are normally evaluated for their efficacy for control of the various target weeds. Verification of the safety of the herbicide on the target crop is also undertaken. These are statuary requirements by Pest Control Products Board whose compliance is mandatory.

2. Materials and Methods

The experiment to evaluate the effect of different levels (rates) of Basagran herbicide and stage of weeds on weeds control hence yield of Beans (*Phaseolus vulgaris L.*) will be performed at Gachika and Ndiwa farms in Londiani. The sites lie at an altitude of 2230 m and 2250 m above sea level respectively. The temperatures in the field are in the range of 14-22^{0}C.There is two major agro-climatic zones in the Sub County: Upper Highland UH_1 and UH_2. The mean annual rainfall is 1800 mm. The Sub County is characterized by reliable rainfall which is bimodal and can reach 130mm/month in the months of April and September. Soils are well drained dark clay loam top soil with reddish briown subsoils. The soil reaction (pH) is medium acid (5.79 and 5.21) satisfactory for maize/Beans growth. Soil organic matter content is sufficient

2.2 Experimental Procedures

Plant Materials

Common bean variety (Chelalang')

Inputs

DAP fertilizers

2.3 Experimental Design and Treatments

Randomized Complete Block Design (RCBD)
The experiment was replicated thrice

i) Treatments

The experiment comprises three levels of Basagran 480 SC herbicide namely: 1.5 l/ha; 2.0 l/ha; 3.0 l/ha and three stages of weeds growth namely (i) one weeks after germination of both crop and weeds (ii) two weeks after germination of both crop and weeds and (ii) three weeks after germination of both crop and weeds.
All other inputs were applied uniformly.

ii) Treatment combinations

Rates of Basagran 480 SC herbicide

H_1 – 1.5 lha^{-1}
H_2 – 2.0 lha^{-1}
H_3 – 3.0 lha^{-1}

Stage of Weeds growth

S_1 – One week after germination of both crop and weeds
S_2 – Two weeks after germination of both crop and weeds
S_3 – Three weeks after germination of both crop and weeds

Table 2.1 Treatment combinations

	H_1	**H_2**	**H_3**
S_1	S_1H_1	S_1H_2	S_1H_3
S_2	S_2H_1	S_2H_2	S_2H_3
S_3	S_3H_1	S_2H_2	S_3H_3

2.4 Plot Layout in the Field

The illustration below is the layout of the plots in the field

Table 2.2 Plots Layout in the Field

	H_1			**H_2**			**H_3**		
R_1	S_1	S_2	S_3	S_2	S_3	S_1	S_3	S_1	S_2
	H_3			**H_1**			**H_2**		
R_2	S_3	S_1	S_2	S_1	S_2	S_3	S_2	S_3	S_1
	H_2			**H_3**			**H_1**		
R_3	S_2	S_3	S_1	S_3	S_1	S_2	S_1	S_2	S_3

Key:

H – Basagran herbicide levels
S – Stage of Weeds growth
R – Replicates

2.5 Data Collection

i) Plant height was measured one week after germination and continued weekly till maturity.
ii) Type and number of weeds (before and after weed control)
iii) Days taken to maturity per plot
iv) Number of pods per plant at maturity will be counted and recorded.
v) Pod length per plot
vi) Number of grains per pod per plot
vii) Weight of grains per plant at maturity will be measured and recorded.
viii) Yields per plot will be recorded upon maturity

2.6 Data Analysis

Data collected was summarized using MS Excel spread sheet and analyzed using SPSS version 23.0

Analysis of Variance (ANOVA) was conducted to determine if there was significant difference between the treatments means at 95% level of confidence (P = 0.05) and where significant difference was noted, post hoc test was performed. Separation of means was done using LSD Test.

3. Results and Discussion

The height of the crop was measured 7 days after germination and continued every week until physiological maturity attained 9 weeks after germination. Physiological maturity was noticeable when about 50% of the foliage was browning, changes in crop height ceased (Figure 3.1). The bean variety grown; *Chelalang*, appears to attain physiological maturity at 10 weeks after germination.

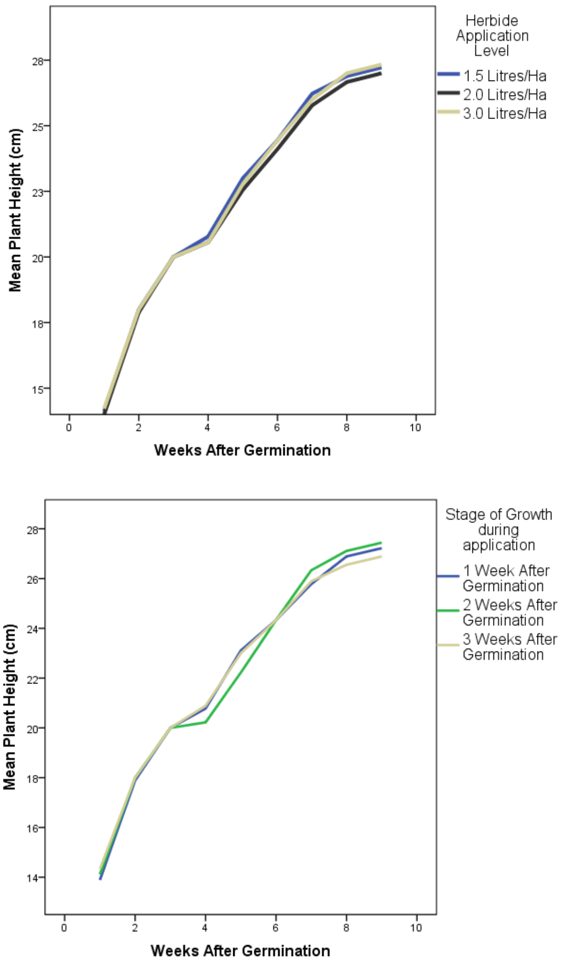

Figure 3.1: Plant Height

The data collected on plant height was subjected to analysis of variance (ANOVA) at 5% level of significance, the analysis did not show any significant differences in plant height due to the herbicide levels. The 1.5, 2.0 and 3.0 litres of Basagran per ha did not show any significant differences (P> 0.05) on its effect on the crop height. This finding suggest Basagran did not affect crop height at the concentrations applied, this is consistent with the manufacturers assertion that beans are tolerant to Basagran as long as it is applied after the first two trifoliate leaves have expanded fully (BASF, 2001). Basagran at different concentrations appears not to have had any significant effect on plant height.A similar analysis of variance carried out to analyse for differences in mean plant height due to different stages of application of the herbicide did not show any significant differences (P> 0.05).

3.2 Number of Pods per Plant

The number of pods per plant was counted at physiological maturity and recorded as per the treatment combinations. Analysis of variance was carried out to establish if there were any differences among the treatment means (Appendix 2). The ANOVA revealed that there was a significant difference on the number of pods per plant due to varying herbicide levels at 5% significance level. Further, separation of means using Least Significant Difference (LSD) showed that there was no difference in the number of pods per plant between the 1.5 litres/ha herbicide level with the 2.0 litres/ha, but there was a significant difference between the 1.5 litres/ha and the 3.0 litres/ha of herbicide (Table 3.1). This finding suggests that a higher concentration of Basagran herbicide, at 3.0 litres/ha application rate, may have suppressed weed growth as to cause a significant effect on podding thus encouraging pod formation in the *Chelalang* bean variety.

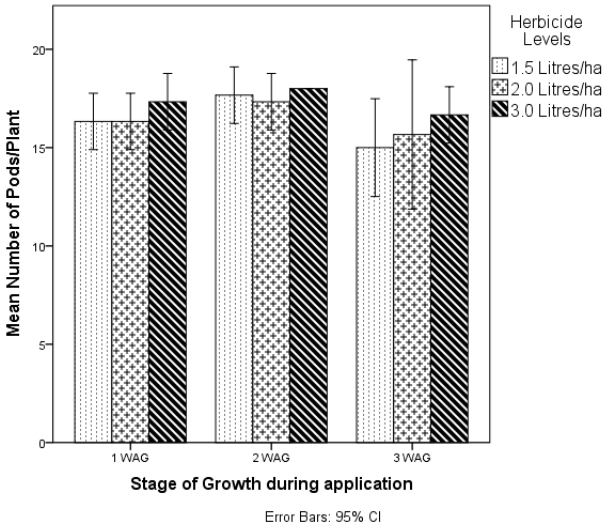

Figure 3.2: Number of Pods per Plant

Table 3.1: Effect of herbicide levels on pods per plant

	1.5	2.0	3.0
1.5	X	-0.11ns	-1.00*
2.0	0.11ns	X	-0.89*
3.0	1.00*	0.89*	X

Means separated by LSD at 0.05 alpha level
* Significant at(P< 0.05)

The stage at which the herbicide was applied had a significant effect on the number of pods per plant (P<0.05) according to the analysis of variance, an indication that weed suppression varied depending on the stage of weed growth at which Basagran was applied to control the weeds. The number of pods per plant was significantly higher when the herbicide was applied two weeks post-emergent (Table 3.2) suggesting that the weeds were better-controlled at this stage. This finding indicates that three weeks after germination of the weeds is not sufficiently controlled to allow for bean growth and development.

Table 3.2: Effect of application stage on pods per plant

	1	2	3
1	X	-1.00*	-0.89*
2	1.00*	X	1.89*
3	-0.89*	-1.89*	X

Means separated by LSD at 0.05 alpha level
* Significant at (P< 0.05)

3.3 Pod Length

The length of the pods was measured at physiological maturity. The data collected was subjected to analysis of variance which indicated that there was no significant difference on pod length (P>0.05) due to application of the herbicides at different concentrations.

The application of the herbicide at different stages of weed growth had a significant effect (P<0.05) on the length of the pods as illustrated in figure 3.2.

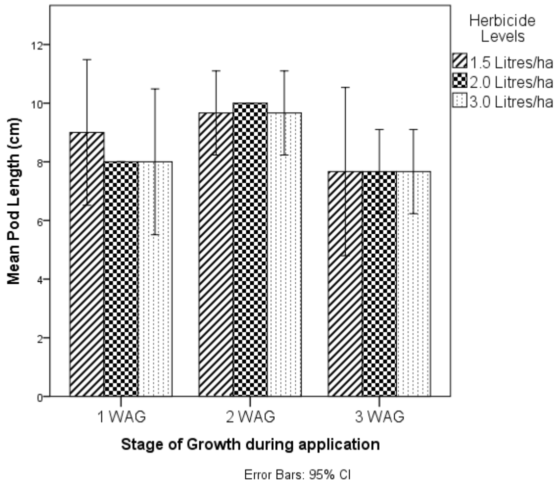

Figure 3.3: Pod Length at different stages of application and herbicide levels

Table 3.3: Effect of Herbicide application stage on pod length

	1	2	3
1	X	-1.44*	0.67*
2	1.44*	X	2.11*
3	- 0.67*	-2.11*	X

Means separated by LSD at 0.05 alpha level
* Significant at 0.05

Separation of the means using LSD indicated a significant difference between all the levels; the longest pods were recorded in the 3 litres /ha herbicide concentration (Table 3.3). This seems to suggest greater suppression of weeds at the higher levels of herbicide application; at 3 litres/ha.

3.4 Number of Grains per Pod

The number of grains per pod was estimated by counting the number of pods from the sample plants during harvest. The data was subjected to analysis of variance (ANOVA) at 5% alpha level. The herbicide application levels did not show a significant effect on number of grains per pod (P>0.05). The stage at which the herbicide was applied, however, had a significant effect on grains per pod (P<0.05) as shown in table 3.3 suggesting that it affected grain development in the beans. This finding may be attributed to differences in suppression of weed competition by the different stages of herbicide application.

The number of grains per pod was significantly higher for the population drawn from plots sprayed two weeks after germination of the weeds & the crop compared to that of one week and three weeks (Table 3.3). These findings may indicate that the application of Basagran two weeks after germination of the weeds was effective in suppressing weed competition in the crop field.

Table 3.4: Effect of application stage on number of grains per pod

	1	2	3
1	X	-0.78*	0.22
2	0.78*	X	1.00*
3	- 0.22	-1.00*	X

Means separated by LSD at 0.05 alpha level

* Significant at 0.05

3.5 Grain Yield

The yields obtained from the experimental plots were measured using a digital weighing scale at harvest. The mean yields were subjected to analysis of variance which revealed a significant effect (P<0.05) due to the herbicide levels. The higher levels of herbicide application at 3.0 litres/ha had a significantly higher influence on grain yield (Figure 3.3). This seems to indicate that the higher concentration may have eliminated the adverse effect of weeds on grain yield.

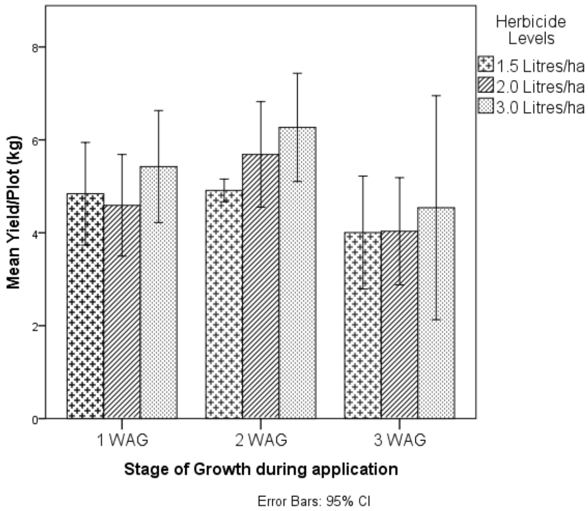

Figure 3.4: Grain yields

The stage of application of the herbicide also gave significantly different grain yields (P<0.05) as shown in figure 3.3. Basagran application two weeks after germination of the crop & weeds gave a significantly higher yield compared to the first and third week (Table 3.5). This appears to indicate that weeds were better controlled two weeks after germination rather than too early at 1 week and too late at three weeks. The plots controlled at one week tended to allow more weeds to grow since not all the weed seeds had germinated within that period.

On the other hand, controlling the weeds three weeks after their germination meant the weeds had grown tougher tissues and were more resistant to the effect of the herbicides which works on its photosynthetic pathway.

Table 3.5: Effect of Herbicide levels (Litres/ha) on grain yield per plot

	1.5	2.0	3.0
1.5	X	-0.18	- 0.83*
2.0	0.18	X	- 0.64*
3.0	0.83*	0.64*	X

Means separated by LSD at 0.05 alpha level
* Significant at 0.05

Table 3.6: Effect of application stage on grain yield per plot

	1	2	3
1	X	-0.67*	0.76*
2	0.67*	X	1.43*
3	- 0.76*	-1.43*	X

Means separated by LSD at 0.05 alpha level
* Significant at 0.05

Delay in the control of weeds in the bean field appears to significantly reduce grain yields as demonstrated by the low yields in the plots that were sprayed three weeks after germination of the weeds (Table 3.6).

Similar results on the effect of weeds on Bean grain yields were reported by Esmaeilzadeh and Aminpanah (2015) who found a significant effect from weeds on pod yield in an experiment conducted in Northern Iran. Pod length was reduced significantly due to what the authors' referred to as weed interference and consequently resulted in lower grain yields in beans. da Costa, Barbosa and de Sa (2013) also found similar results and suggested that coexistence between weeds and crops reduced seed vigour resulting in lower grain yields. These observations suggest that the effect of weeds on grain yields may be due the competition for nutrients, water and photo-synthetically active radiation between the weeds and the crop resulting in suppressed crop yields.

3.6 Efficacy of Basagran(R)

The efficacy of the herbicide in the control of weeds in the bean field was measured by counting the various weed species that were actively growing one month after application of the herbicide. The total weed count per plot was tabulated and differences due to herbicide levels and stage of application were analysed using analysis of variance. Since the entire plots had been sprayed with the herbicides the weed population that was observed one month later was attributed either to newly germinated weed seeds or weed plants that resisted control by the herbicide.

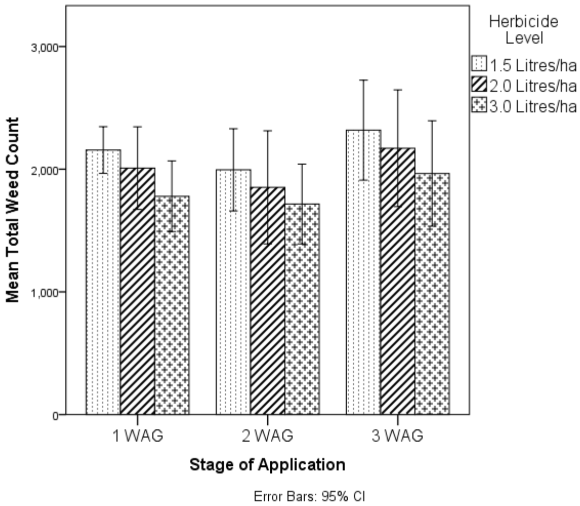

Figure 3.5: Effect of stage of application and herbicide levels on weed count

The mean total weed count differed significantly (P<0.05) due to the herbicide concentration (levels) as illustrated in figure 4.4. The highest weed population was observed in the lower herbicide level plots (1.5 litres/ha) and a higher concentration of 3.0 litres/ha Basagran gave the lowest weed population (Table 3.7), an indication that the herbicide was more effective at the higher concentration of 3 litres of herbicide per ha.

Table 3.7: Effect of Herbicide levels (Litres/ha) on weed count per plot

	1.5	2.0	3.0
1.5	X	151.11*	346.67*
2.0	-151.11*	X	195.56*
3.0	-346.67*	-195.56*	X

Means separated by LSD at 0.05 alpha level
* Significant at 0.05

The stage at which the herbicide was applied also gave a significant difference (P<0.05) on weed population as illustrated in figure 3.4. Application of herbicides two weeks after germination gave a significantly lower weed count compared to one week and three-week stage (Table 3.8).

3.8: Effect of application stage on weed count per plot

	1	2	3
1	X	127.22*	-169.89*
2	-127.22*	X	-297.11*
3	169.89*	297.11*	X

Means separated by LSD at 0.05 alpha level,
* Significant at 0.05

4. Conclusionsand Recommendations

4.1 Conclusions

The objective of the study was firstly to determine the effect of varying herbicide levels on the growth and yields of dry beans, variety Chelalang' in the study area and secondly to establish the effective period (stage of weeds) for the control of weeds by the test product and its effect on growth and yields of beans. There was a significant difference in the yield of grains when the herbicide levels were varied. The yield differences may be attributed to better control of weeds at the appropriate application levels. The rate of 3 litres per ha was the most effective in the control of diverse species of weeds in the experimental field.

The efficacy of Basagran® herbicide was highest at an application rate of 3.0 litres per ha applied at about two weeks after germination of the weeds and the crop.

4.2 Recommendations

The study recommends the use of Basagran® herbicide at the right application rates of about 3.0 litres per ha at about two weeks after germination of the weeds on bean fields for the control of most broad-leafed and grass weeds in order to boost grain yields

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