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The Efficacy of Foliar Nutrition in Increasing Grain Yield of Beans (Phaseolus Vulgaris L.) Under Field Conditions in Semi Arid Areas of South Eastern Kenya

[1] Boniface Mwami, [2] Jacinta M, Kimiti, [3] Josephine Syanda

[1] Czech Univ Life Sci Prague, Fac of Trop AgriSci, Dept Crop Sci & Agroforestry, Kamycka, Praha - Suchdol, Czech Republic
[2] South Eastern Kenya University, Kitui-Kenya
[3] Kenya Agricultural and Livestock Research Organization, Machakos- Kenya
Email: [1] mwami@ftz.czu.cz/ bmwami@seku.ac.ke, [2] jkimiti@seku.ac.ke, [3] josephinesyanda@yahoo.com

***Abstract*---Food security has, tremendously, been imperiled globally by climate change and variability. Sundry efforts put by different organizations to address food insecurity has not, sufficiently, attenuated the problem. This is exacerbated by the rapidly growing population against the dwindling production resources. The problem is even worse in Arid and Semi-Arid Lands (ASALs) whose environmental conditions, for crop growth, are quite fragile. Dry beans (*Phaseolus vulgaris L.*) are a crucial food crop, commonly grown in these areas since they provide cheap source of proteins for poor households. However, beans production, in these fragile agro-ecologies, is impeded by sporadic rainfall, erratic rainfall, meagre soil nutrients, low moisture levels, nutrients fixation among other factors. A field-based study was undertaken at South Eastern Kenya University (SEKU), Kenya, and Kenya Agricultural and Livestock Research Organization (KALRO), Kenya, to determine the efficacy of foliar fertilizer nutrition on commonly grown bean varieties in semi-arid area of South Eastern Kenya. In the first season, the study was undertaken in Teaching and Research Farm of SEKU, while the second season was done in KALRO substation at Ithookwe. In both seasons, treatments were arranged in a Randomized Complete Block Design (CRBD) and were replicated three times. The efficacy of three concentrations of foliar nutrients, (0/L or control), (2.5mls/L) and (5mls/L), on grain yield of three bean varieties was evaluated. Data was collected on Leaf Area Index (LAI), number of pods, and grain yield. The results in both seasons exhibited that, Wairimu and Wairimu dwarf had the highest LAI of 0.08 and 0.09 respectively and were not significantly different from each other in both seasons; it was followed by Piriton (0.06) and KAT B9 (0.05) but were, also, not statistically different from each other. In terms of number of pods per plant, in season 1 and 2 respectively, Wairimu had the highest number (21.77, 26.83) followed by Wairimu dwarf (19.44, 27.66), Piriton 25.33) and KAT B9 13.32, 16.00) in that order. The grain yield, in both seasons (kg/ha), showed that Wairimu had the highest yield of (440.08, 439.60), followed by Wairimu dwarf (385.69, 388.71), Piriton (386.09, 382.13), and KAT B9 (381.45, 379.58) in that order**

In view of the above findings, the study recommends use of foliar nutrients/ fertilizers at the rate of 5.0 mls/L, as oppose to the conventional use of 2.5mls/L, in increasing the yields of the four aforementioned varieties, commonly grown in ASALs.

***Keywords*--- Food insecurity, efficacy, foliar nutrients, grain yields**

I. INTRODUCTION

Global population is increasing exponentially and the number of food insecure people is projected to increase as indicated in the study by [1]. A related study by [2] reports that one billion people globally are food insecure. Previous studies by [3], [4] indicate that Kenya, like other countries in sub Saharan Africa, is food insecure, with 89% of land mass being ASALs, according to previous study by [5]. Dry beans is one of the legumes, widely, used in Kenya to alleviate food insecurity according to Anon [6]. Studies by [7] indicates that, Kenya is ranked the seventh largest world producer of dry beans, which is the second most important staple food nationally, hence having a critical relevance in attenuating food and nutritional insecurity. Studies by [8], reveals that beans, principally, play a tremendous role in preventing hunger, malnutrition and food insecurity. Beans are versatile since they can be utilized as leaves, pods, green and dry seeds, and can be prepared in a wide range of recipes. Dry beans can be boiled and consumed, mashed with bananas or potatoes or mixed with other cereal grains like maize and consumed as “Githeri” as indicated in the previous study by [9] Production of beans, in ASALs has been dismal over the years due to decimated moisture levels, elevated evapotranspiration, low soil fertility, and pests and diseases menace according to a previous study by [10]. A previous study by [11] shows that draught is the most common peril of bean production. Micronutrient deficiencies, also, antagonize crop growth and performance hence reduce the crop yield potential. Foliar nutrients application, at the vegetative phase, has exhibited to antidote some of the deficiencies, which antagonize bean production, according to earlier study by [12]. Lack of sufficient moisture in ASALs limits the uptake of nutrients even after applying them to soil. Additionally, other nutrients may be leached, and others may be chemically fixed by soil components according to previous studies by [13], [14] . A study by [15] Showed that foliar fertilization may also be a good substitute to soil application to avoid the loss of fertilizers by leaching, and hence halt the ground water pollution. The objective of this study, therefore, was to determine the efficacy of foliar nutrients application on grain yields of selected bean varieties, commonly grown in ASALs, under field conditions

II. MATERIALS AND METHODS

Description of study sites

In the first season, the experiment was conducted at Teaching and Research Farm at SEKU main campus, Kitui county, Kenya which is located at, latitude 1 ° 8'58.19" S, longitude 37 ° 43'47.86" E and altitude 1105m above sea level. As a semi-arid region, geographically located in Kitui County, is among the most drought-susceptible regions in Kenya an average bimodal rainfall of 500 – 1050 mm annually and 40% reliability according to a previous study by [16]. An earlier study by [17] shows that the mean annual minimum temperatures range from 22 – 28ºC

In the second season, the experiment was carried out in KALRO sub-station at Kitui county located at 38 ° 02'E, 1 ° 37'S and altitude 1150 m above sea level. The mean rainfall is 1010 mm in bimodal pattern with long rains occurring from March to May and the short rains from October to December with peaks in April and November. According to [18] the mean temperatures are 22.5^0 C, dominant soil is chromic Luvisols and is of low in organic carbon, and highly deficient in N and P and generally has poor structure [19].

Experimental design and treatments

The experiment was laid out in randomized complete block design with four varieties (Wairimu dwarf, Wairimu, KAT B9 and Piriton) ,three replications and 3 foliar fertilizer concentrations namely 0mls/Litre of water, 2.5 mls/Litre of water, 5mls/Litres of water. The composition of the foliar fertilizer was NPK 12:0:0+12.8 CaO+2.6Mgo+ Micronutrients 12.8% Nitrogen,12.8% Calcium (CaO), 2.6 Magnesium (MgO), 750ppm Copper, 1500ppm Iron,750ppm zinc, 750ppm manganese, 105ppm molybdenum, 1500 ppm Boron

Soil physiochemical properties

In both sites, Soil samples were collected before establishing the experiment at depth of 0-15 cm using an augar for analysis. Plant litter on the soil surface was removed before collecting the samples. The samples were air dried, visible planr roots removed and samples gently crushed to pass through a 2-mm sieve. The fractions sample <2mm were used for subsequent chemical and physical analysis. Total available P, exchangeable K, Ca Mg, and K were estimated following standard methods as described by [18]. Cation ca^{2+}, Mg^{2+}, and K^+ were determined by atomic absorption spectrometry and soil P was measured following procedures as outlined by [7].

Procedure

Experimental plot was laid out in RCBD with three levels of treatments with plots measuring 1.5.by 1.5 meters. There were four rows per plot each with 16 seedlings. The treatments were 0mls/L, 25mls/L and 50 mls/L of foliar fertilizer application. The control (0 mls) was pure water without any foliar fertilizer. Soil field capacity was determined according to the procedure by [18] in the laboratory at SEKU before the experiment to guide on the amount of water required for watering [24]. Watering was done every day to maintain the moisture at field capacity. Two bean seeds were sown per hole with spacing of 20cm between seeds and 50 cm between the rows and thinned to one plant after two weeks after germination. The main plot was separated by one-meter foot path for easy access during management. Weeding was done, accordingly, manually fourteen days after seed germination and one week before flowering.

Harvesting the beans

Harvesting was done manually, in the two middle rows, leaving one plant from each end to take care of border effects, which could negatively affect the results, and was done by uprooting the plants with roots and dry leaves attached. Later threshing was done according to treatments.

III. RESULTS AND DISCUSSION

Table 4.1 Physiochemical properties of soils at the experimental sites (0-15cm depth)

Soil properties	SEKU	Kalro substation-Ithookwe
Ph	5.48	5.43
Organic carbon%	0.41	0.52
Total N%	0.08	0.83

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Available P ($mgkg^{-1}$)	12.85	13
Calcium (ppm)	1.7	1.9
Mg (ppm)	0.06	3.62
K (ppm)	0.23	0.25
CEC	13.2	14.8

Table 4.4.1 Effects of different concentrations of foliar fertilizer application on Leaf Area Index (LAI)

The increase in LAI in the treatments, compared to the control, could be attributed to increased efficiency in nutrient availability in the plant tissues due to synergistic effects of iron and nitrogen. This is corroborated by a study by [15] who reported an increase in LAI due to foliar fertilization. A similar study conducted by [8], reported an increase in LAI in the treatments, compared with the control, and attributed them to combined effect of iron and nitrogen. The current study, further, agrees with the findings of [19] who linked the increase of LAI with the increasing concentration nitrogen and trace elements such as Iron.

	Season 1				Season 2			
Bean variety	**Control**	**2.5mls/L**	**5mls/L**	**Means**	**control**	**2mls**	**5 mls**	**Means**
Wairimu	0.07Ca	0.08Ba	0.08Aa	0.08a	0.07Ab	0.08Bb	0.09Ca	0.08a
Wairimu dwarf	0.08Ca	0.09Ba	0.09Aa	0.09a	0.08Aa	0.09Ba	0.09Ca	0.09a
Piriton	0.05Cb	0.06Bc	0.06Ab	0.06b	0.06Ab	0.07Bb	0.07Cc	0.06b
KAT B9	0.04Cb	0.05Bc	0.06Ab	0.05b	0.04Ac	0.05Bc	0.06Cc	0.05b
Means	0.06C	0.07B	0.07A		0.06C	0.07Bb	0.08Aa	
LSD in columns= 0.01 in rows=0.004, C.V= 8.89					**LSD in columns= 0.01 in rows=0.004, C.V= 8.89**			

Means in the same row followed by different upper-case letters (A, B, C) or in the same column followed by the different lower-case letters (a, b, c) are significantly different at (P < 0.05)

Effects of different concentrations of foliar fertilizer on number of pods per plan

Differences in the number of pods, in control, in different varieties could be due to differences in their abilities to fix atmospheric nitrogen, which is dictated by their genetic make-up. This is supported by a study conducted by [20] who reported similar findings. On the other hand, the increase in the number of pods with the increase in foliar nutrients could be attributed to the beans' ability to fix a greater amount of nitrogen; due to synergistic effects of nitrogen and boron. This corroborates with studies by [21], [22] who reported increased number of pods and attributed this to greater ability of beans to fix higher amounts of nitrogen. A similar study by [23] attributed the increase in the number of pods to boron and nitrogen present in foliar fertilizers.

	Season 1				Season 2			
Bean genotype	**0 mls/L (control)**	**2.5mls/L**	**5mls/L**	**Means**	**0 mls/L (Control)**	**2.5mls/L**	**5mls/L**	**Means**
Wairimu	21.00Ca	24.00Ba	28.33Aa	21.77a	22.33Ca	27.66Ba	30.66Aa	26.83
Wairimu dwarf	16.00Cb	21.00Bb	25.33Ab	19.44b	18.66Cb	23.66Bb	27.66Ab	25.00
Piriton	12.00Cc	14.00Bc	21.66Ac	17.21c	12.66Cc	16.00Bc	25.33Ac	18.00
KAT B9	8.33Cd	12.66Bd	15.66Ad	13.32d	9.66Cd	14.33Bd	16.00Ad	13.66
Means	14.33C	17.75B	22.75A		16.16	21.33	24.92	20.80
C.V=6.05 LSD in columns=1.06; in rows=0.91					**C. V=6.05 LSD in columns=1.05; in rows=0.95**			

Means in the same row followed by different upper-case letters (A, B, C) or in the same column followed by the different lower-case letters (a, b, c, d) are significantly different at (P < 0.05)

Effect of different concentrations of foliar fertilizer on grain yield (kg/ha

Significant differences in grain yields of different varieties in control could be associated to differences in the ability to fix nitrogen which is, fundamentally, a genetical trait. This study is supported by earlier findings of [20] who found that beans fix different amounts of nitrogen depending on its genetical factors. The increase in grain yield, with the increasing foliar application rate, could be due to, synergistic effects of nitrogen, potassium and boron in plants' tissues thus enabling the plants to partition nutrients to both vegetative and reproductive parts. This corroborates with the study by [24] who reported increased number of pods and seeds after foliar nutrients application. This study is, further, supported by earlier studies by [25], [21] who reported an increase in grain yield with the increasing concentration of foliar fertilizer application.

	Season 1				Season 2			
Bean variety	**0 mls/L (Control)**	**2.5mls/L**	**5mls/L**	**Means**	**0 mls/L (Control)**	**2.5mls/L**	**5 mls/L**	**Means**
Wairimu	387.15 Ca	403.95Ba	529.15 Aa	440.08a	385.5Aa	405.05Ba	528.25Aa	439.60
Wairimu dwarf	361.25 Cb	390.96Bb	404.86 Ab	385.69b	364.1Ab	395.75Bb	406.25Ab	388.71
Piriton	364.15Cc	389.39Bc	404.75 Ac	386.09c	361.15Ac	384.00Bc	401.25Ac	382.13
KAT B9	361.00Cd	384.88Bd	398.48 Ad	381.45d	357.85Ad	382.15Bd	398.75Ad	379.58
Means	368.39C	392.30B	434.31A		367.16	391.74	433.63	
C.V= 0.55, LSD in columns=1.62; C. V= 0.55					**LSD in columns=1.62; in rows=1.4 in rows=1.40**			

Means in the same row followed by different upper-case letters (A, B, C) or in the same column followed by the different lower-case letters (a, b, c, d) are significantly different at (P < 0.05

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