

Full Length Research Paper

Response of common beans (*Phaseolus vulgaris* L.) to seed treatment in Central Kenya

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Seed treatment presents an opportunity to boost bean productivity; however, the technology has not been widely tested in Kenya and the sub Saharan Africa region. An experiment was carried out at Kandara, Central Kenya to compare the effects of seed treatment applications on bean performance. The split-plot design experiment with three replicates included four seed treatment products: Apron Star, Seed Plus, Gro Plus and TriCoat applied at recommended and half recommended rates with two bean varieties as test crop. Split-plot ANOVA was implemented using Genstat and *agricolae* R procedures to compare the effects of seed treatment applications on aphid pest severity and bean performance parameters. Varietal performance differences to the seed treatment were observed with *Nyota* variety performing better than KATB1. Generally, Apron Star at recommended rates reported lowest pest incidences and consistent bean performance over the two cropping seasons. Consistent treatment effects were observed for recommended rates compared to half rate applications. Under favorable environmental conditions, use of the seed treatment products alone produced yields comparable to the fertilizer treatment. The benefits observed from use of seed treatment technology makes it a potentially sustainable strategy for improving productivity for cash strapped small-scale producers in the region.

Key words: Common beans, Kenya, pests, productivity, seed-borne diseases, seed treatment.

INTRODUCTION

Common beans (*Phaseolus vulgaris* L.) is the most important food legume globally (Parsa et al., 2018), and a

major multi-functional grain legume in smallholder farming systems of sub-Saharan Africa (SSA). It is grown

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on more than four million hectares annually in Africa, providing dietary protein for more than 100 million people (Buruchara et al., 2011). Beans is a highly traded crop in the East African region, earning farmers income. They are a major cover and rotation crop in cereal cropping systems and contribute to sustainability of the farming system by improving soil fertility through biological nitrogen fixation (Vanlauwe et al., 2019). Despite this importance, bean production is seriously constrained by seed-borne and early-season diseases, pests and nematodes (Bradley, 2008). Common beans in particular are prone to diverse fungal infections, mainly root rots, and diseases which can be transmitted by seeds or soils at planting (Abate and Ampfo, 1996). The damage caused by the insect pests on legumes is estimated at about 70% yield loss in East Africa (Edema and Adipala, 1996; Mwanauta et al., 2015). Some of the major pests at early stages of bean establishment include cutworms, aphids, beanfly, white fly and nematodes. For example, stem maggot (*Ophiomyia phaseoli*), ootheca (*Ootheca bennigseni*) and aphids (*Aphis fabae*) cause yield losses of about 37 to 100% (Ochilo and Nyamasyo, 2011), 18 to 31% (Karel and Rweyemamu, 1984) and 37% (Munyasa, 2013), respectively.

Seeds are exposed to adverse environmental conditions during germination, emergence, and seedling development, which impacts on the overall crop performance and productivity. Some of the factors that limit optimal seed establishment include limited or excess soil moisture, soil compaction and crusting, poor seed/soil contact, excessively high or low temperatures, seed-borne or soil-borne pathogens (Bennett et al., 1992). Seed-borne pathogenic fungi can prevent germination, kill seedlings, or reduce plant growth by damaging the roots and vascular system, which prevents the transport of water and nutrients (Mancini et al., 2016).

Early germination pest and disease attack on beans reduce overall plant stand and vigour thus affecting productivity. On the other hand, continued cultivation of land without crop rotation has led to a decline in soil fertility (Juo et al., 1995), reduction in healthy soil life, and a buildup of diseases in the soil system. Research shows that the ability of a crop plant to resist or tolerate insect pests and diseases is tied to optimal physical, chemical, and biological properties of soils (Altieri and Nicholls, 2003). Incidences of plant pests and diseases have also increased due to the changing climatic conditions (IPPC Secretariat, 2021). All these factors combined with poor crop management have led to low and declining crop productivity, way below the potential of the released varieties.

A study by McGuire and Sperling (2016), covering 9,660 observations across six countries and 40 crops including Kenya, Malawi, DR Congo, Haiti, South Sudan, and Zimbabwe showed that farmers access 90.2% of their seed from informal seed systems. For beans, the supply of formal sector seed generally represents less

than 2% of the total bean seed sown (Rubyogo et al., 2010). Thus, a huge percentage of farmers use their own saved seed or seed obtained from other farmers in their communities or from the grain market, which is usually not treated. If the seed is infected, then it would affect crop performance and the potential yield.

Various approaches including seed cleaning, seed grading, and seed dressing can help improve seed quality leading to increased productivity. Seed treatment is emerging as a cost-effective approach to improving crop production. Seed treatment shows promise of addressing some of the agronomic challenges leading to the improvement of crop stand establishment. Seed dressing or treatments consist of the application of biological, physical, and chemical agents and techniques to seed to provide protection and improve the establishment of healthy crops (White and Hoppin, 2004). These agents can be applied in various ways including dust, slurry, or film coating. Different seed treatments are used alone or in combination to prevent several pest types, diseases, nutrient deficiencies and to enhance plant growth. These include fungicides, insecticides, inoculants, plant growth regulators, fertilizers, and fertilizer enhancers. Seed treatments can be used to control fungal pathogens that are seed surface-borne, internally seed-borne, and fungal pathogens or pre-emergence and post-emergence soilborne pathogens that attack germinating seeds and seedlings (Lamichhane et al., 2020). Other benefits of seed dressing include increased germination, uniform seedling emergence, and breaking dormancy (Umesha et al., 2018).

With increased concern about the need for environmental, human, and food safety, seed treatment is considered an environmentally smart technology since only small quantities of the chemicals are used on an area basis. According to Lamichhane et al. (2020), the amount required for chemical seed treatment is relatively low in the range of 5 to 10% compared to that applied in furrow or foliar sprays. The conventional chemical control methods by soil and foliar applications have several challenges including cost, selectivity, the emergence of pest resistance, pest resurgence, health hazards, and environmental pollution (Rahman et al., 2008). With the reduction in the amount of chemicals used, effective seed priming technologies can be cost-effective and ecologically sustainable especially to the resource-poor farmers (Otim et al., 2016; Nderitu et al., 2008).

Whereas use of pre-sowing fungicidal treatment of field crops is a routine practice in the United States, Australia and France (White and Hoppin, 2004; Lamichhane et al., 2020; You et al., 2020), the same practice is limited in Africa and Kenya in particular. Data for the few studies remains in grey literature contributing to lack of scientific knowledge to inform decision-making and strategic promotion of seed treatment technologies with farmers. Nawaz et al. (2021) pointed out the lack of studies on bio-priming relating to mungbean, while Calzada et al. (2017)

has noted that no investigations have been carried out in tropical conditions to assess growth-promoting agents on bean crop productivity. Further, the many products on the market have not been sufficiently evaluated and promoted. As a result of the aforementioned limitations, the adoption of seed dressing technologies remains very low. There is a need to evaluate the effectiveness of the seed dressing products on different crops and crop varieties under diverse soil and climatic conditions followed by wide demonstrations and promotion of the technologies among the target farming communities.

To this end, a study was carried out at a field station in Kandara, Central Kenya to evaluate the effect of selected commercially available seed dressing products on bean performance, specifically yield. Ultimately, the study helps to refine the use of seed dressing technologies for farmer adoption and provides lessons for the private sector as they promote the products.

MATERIALS AND METHODS

Study area

This study was carried out at on-station sites at the Kenya Agricultural and Livestock Research Organization (KALRO), Horticultural Research Center, Kandara near Thika in Central Kenya. The trial was conducted over two cropping seasons: Long Rains 2019 (LR2019) between April 2019 and August 2019 and Short Rains 2019 (SR2019) between October 2019 and January 2020. The experiment evaluated the performance of two bean varieties: *Nyota* and *Katamani* Bean 1 (KATB1) following seed treatments with chemical seed dressers, nutrient priming, and biological products.

KALRO Kandara is located in Muranga County, near Thika and 40 km from Nairobi, Kenya. The site is located on coordinates 00° 59' South and 37° 04' East, with an altitude of around 1,548 m. It experiences a bimodal pattern of rainfall with an annual mean of 1,000 mm distributed over two seasons. Long rains occur between March and May, while short rains occur between October and December. The mean annual maximum and minimum temperatures are 25.1 and 13.7°C, respectively (Ndegwa et al., 2009). Soils are well-drained, extremely deep, dusky red to dark reddish-brown, *Nitisols* (Jaetzold et al., 2006). The soil results from bulk composite samples for the experimental site are summarized in Table 1. This is a moderately fertile soil characteristic of lands in the central highlands of Kenya.

Experimental design

The experiment evaluated the performance of two bean varieties following seed treatment with four commercial products (Table 2). Two of the products (Apron Star 42WS and Seed Plus 30WS) are chemical seed dressers, Gro Plus™ is a nutrient priming product and TriCoat is a biological product. The choice of these products was aimed to compare both chemical, organic, and fertilizer priming products to inform scaling out of low-cost sustainable bean technologies especially for smallholder farmers using own-saved seed that is not treated. The products were selected from those readily sold and promoted by agro-dealers.

Apron Star 42WS is a seed treatment fungicide-insecticide mixture formulated to manage downy mildew, damping-off diseases as well as protect seeds and seedlings against early-season insect

pests and soil-borne diseases in legumes, cereals, cotton, and vegetables. Seed-Plus 30WS includes two fungicides formulated to control diseases within the seed as well as those in the soil environment. The fungicide mixture increases the level of disease control and extends the range of disease control. Gro Plus is a starter nitrogen-free fertilizer that is useful to treat all crop seeds; including local farm-saved local seeds and hybrid seed types. The product formulation includes phosphate (P₂O₅) and potash (K₂O) which supports faster seed germination and improves performance and vigor by promoting root growth and establishment. TriCoat is a seed coating product formulated with *Trichoderma asperellum* which is a ubiquitous beneficial soil fungi. The fungus quickly colonizes plant roots, offering germinating seed protection against common soil-borne pathogens.

The seed dressing products were applied on the seed at the commercially recommended rate (RR) as well as half recommended rate (HRR) by recalculating the application rates of the product or the amount of seed used. The seed treatment was constituted in separate buckets to avoid cross-contamination. Apron Star 42WS and Seed-Plus 30WS were applied as a slurry mixed with seed. For Gro Plus, the seed was put in a bucket and a few drops of water added to moisten the seed. Gro Plus was sprinkled on the seed and shaken continuously until the seeds were fully coated. TriCoat in aqueous form was sprinkled on the seed and agitated in a closed bucket to ensure complete coverage. The seeds were then dried out on a polythene sheet under shade for the products to stick, and then seed planted the same day. The Untreated Control involved no application of the seed treatment products.

The test crops for the experiment were two common bean varieties including *Nyota* (KAD 02), a red mottled bean and *Katamani* Bean 1 (KATB1) a yellow-green bean market class. The two bean varieties are considered drought tolerant and maturing in 70 days. The experiment was laid out as a split-plot design with ten (10) treatments replicated three times (Table 3). The main plot (6 m by 6 m) was the seed treatment and the sub-plots (3 m by 3 m) were the crops and application rates of the products. The common beans were planted at an inter-row spacing of 50 cm and intra-row by 10 cm with one seed per planting hill. Weeding was done using a hand hoe. No other pesticide application was applied during the bean growth cycle. This was to enable the assessment of the full effect of seed dressing on crop performance.

Data collection

The bean crop performance was monitored throughout the cropping season and records were kept for key growth parameters such as germination, and general growth vigour. Plant height was assessed at peak flowering stage by measuring using a meter rule and averaging 5 randomly selected plants in the net plot area. The beans were assessed for flowering and podding dates, pests and diseases incidences. Incidences of pests and diseases were monitored biweekly on 5 tagged plants all through the cropping period. Pests were monitored by recording the severity of 5 randomly selected plants in the net plot area at vegetative, podding and maturity stages. Aphid infestation and severity was assessed by scoring the number of colonies on the plant parts. A pest severity scale of 0-5 was applied as below: 0- No infestation; 1: Light infestation consisting of several small, separate colonies; 2: Medium infestation and galling with some colonies starting to coalesce; 3: Many colonies coalescing and up to shoots completely infested and galled; 4: Heavy infestation and galling on 2- 5 shoots, and 5: Heavy infestation and galling on more than shoots.

Assessment of nodulation was done at peak flowering stage of the common beans by destructive sampling of 5 plants, counting the nodules and their location. This was aimed to determine the impact of the seed dressers on the beneficial soil microorganisms

Table 1. Soil characterization results from bulk samples from KALRO Kandara trial site in March 2019.

Parameter	Analysis results (mean)*
Soil pH	6.1
EC (Salts) (uS/cm)	101.3
Phosphorus (ppm)	66.8
Potassium (ppm)	889.9
Calcium (ppm)	1,545.9
Magnesium (ppm)	371.6
Manganese (ppm)	492.3
Sulphur (ppm)	20.3
Copper (ppm)	2.3
Boron (ppm)	0.9
Zinc (ppm)	7.2
Sodium (ppm)	38.2
Iron (ppm)	96.8
C.E.C (meq/100 g)	16.6

*Bulk composite samples.

Table 2. Selected seed treatment products.

Product	Active ingredients	Nature of product
Apron Star 42WS	Thiamethoxam, Metalaxyl-M and Difenconazole	Fungicide-insecticide mixture
Seed Plus 30WS	Imidacloprid, Carbedazim	Fungicide-insecticide mixture
Gro Plus	Phosphate (P ₂ O ₅) and Potash (K ₂ O)	Fertilizer P and K priming
TriCoat	<i>Trichoderma sp.</i>	Biocontrol/Biofertilizer

Table 3. Seed treatments for the bean legume experiment in KALRO Kandara, Murang'a

Treatment number	Description	Product application dose
1	Untreated Control	Untreated
2	DAP fertilizer- RR	25 kg P ₂ O ₅ /ha
3	Apron Star- RR	10 g/4 kg seed
4	Seed Plus- RR	10 g/2 kg seed
5	TriCoat- RR	250 ml/ha (60kg seed)
6	Gro Plus- RR	50 g/2 kg seed
7	Apron Star- HRR	5 g/4 kg seed
8	Seed Plus- HRR	5 g/2 kg seed
9	TriCoat- HRR	125 ml/ha (60kg seed)
10	Gro Plus- HRR	25 g/2 kg seed

RR: Recommended rate; HRR: Half recommended rate.

as well as on biological nitrogen fixation.

Finally, the grain and biomass yield were measured at crop maturity. This involved threshing the grain by hand, determining wet and dry weight of the whole plot and sub samples, counting the number of pods per plant, and weighing the grain after hand threshing. All measurements were done on the net plot of 6.25 m². These plant growth parameters enabled comparison of the effect of

the different seed dressers on key crop growth components.

Data analysis

Data analysis was initiated by performing the classical two-way nested Analysis of Variance (ANOVA) on the sampled plots and

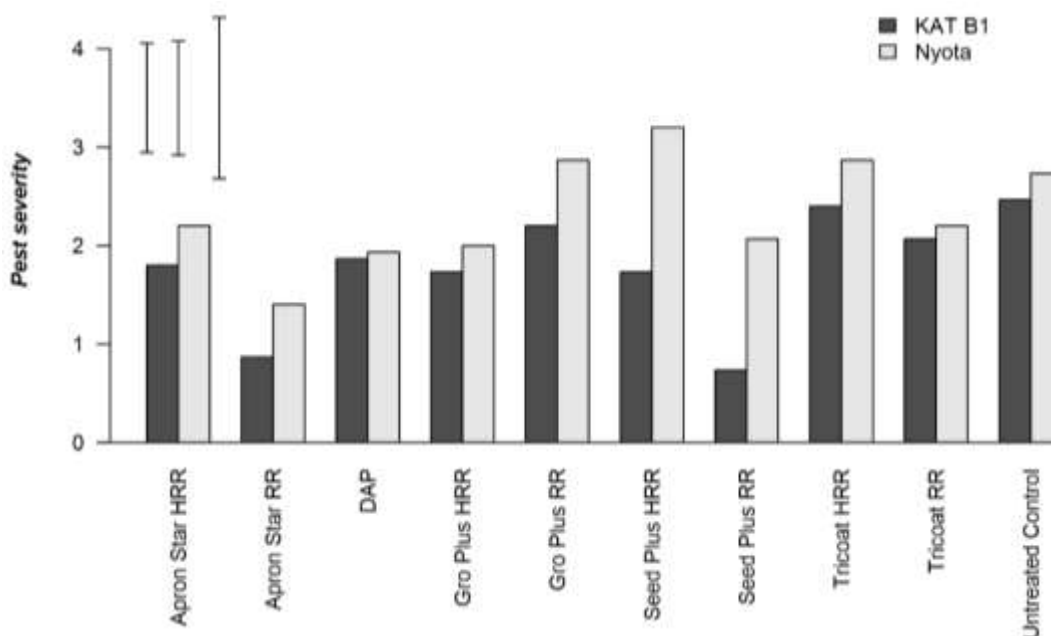


Figure 1. Effect of seed treatment on pest severity during LR 2019 (Long Rains, 2019): HRR = Half Recommended Rate, RR = Recommended Rate; LSD (0.05) for variety (first error bar), seed treatment (second error bar), and the interaction (third error bar).

bean crops to examine the effect of treatment, season, variety, plot number, and season on the final common bean yield. The analysis was extended to capture the interaction terms that reflected the simple main effects, that is, the mean difference in yields between treatments at each season, for each common bean variety, as well as mean yield for each season for each common bean variety. In cases where there is no statistically significant interaction, we report the main effects instead.

RESULTS AND DISCUSSION

Aphid pest severity

The aphid pest severity results did not show significant differences between seed treatments and the interaction; however, significant differences were detected by variety (Figure 1). The highest pest severity was recorded in the Control treatment in KAT B1 variety, while the lowest pest severity was observed in the Seed Plus recommended rate. In regards to the *Nyota* variety, the pest severity was highest in Seed Plus-HRR and lowest in Apron Star-RR applications.

Generally, application of the seed dressing products at recommended rates tended to lower aphid infestation across the varieties and seasons relative to the Control. This can be attributed to the protective/repulsive nature of the products or the improved health of plants that results in improved immunity from attack by insects. Mixed results for half-rate applications could be attributed to non-optimal protection of the products.

The Apron Star RR, Seed Plus RR and the TriCoat RR treatment reduced pest incidence relative to their half-rate applications by 52, 58 and 14%, respectively in the KAT B1 variety, while this corresponded to 36, 35 and 23% in the *Nyota* variety, respectively. The study, therefore, indicates that there were varietal differences in pest resistances and responses to seed treatments, which should be subjected to further investigations.

Plant height

There were significant differences in plant height, for the variety factor in the long rain season (Figure 2A). The highest plant height for KAT B1 bean variety during the long rains was recorded in the Apron Star-RR, followed by Gro Plus-RR, the control, DAP fertilizer, TriCoat-RR and Seed Plus-RR priming. The other treatments included half-rate seed priming of Seed Plus, Apron Star and TriCoat. Regarding *Nyota* bean variety, the tallest plants were observed in Apron Star-RR, DAP, Gro Plus-RR, Gro Plus-HRR, TriCoat-HRR, TriCoat-RR, Control, Seed Plus-RR, Seed Plus-HRR, and Apron Star-HRR.

During the short rain season, there were also significant variety effects in plant height (Figure 2B). The tallest plants for KAT B1 variety were in the treatment Gro Plus-RR, while the shortest were treated with Seed Plus-HRR. Regarding the *Nyota* variety, the tallest plants were those fertilized with DAP, while the shortest were treated with Seed Plus-HRR dressing.

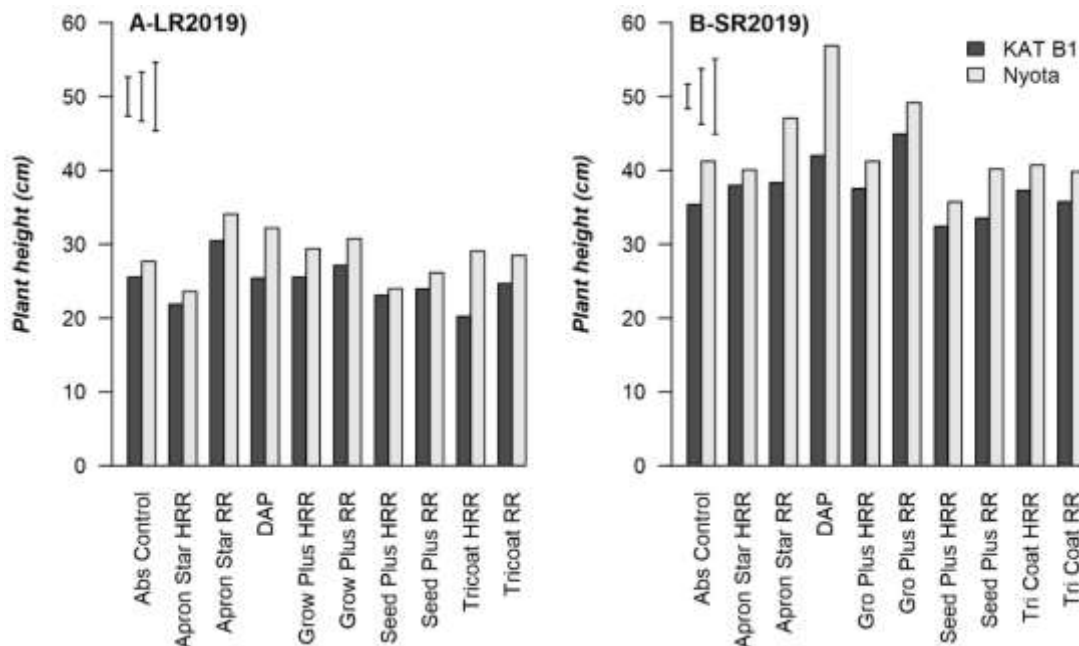


Figure 2. Effect of seed treatments on plant height: HRR = Half Recommended Rate, RR = Recommended Rate). The error bars are arranged as LSD (0.05) for variety (first error bar), seed treatment (second error bar), and the interaction (third error bar); LR= Long rain season, SR= Short rain season.

Table 4. Shoot and root biomass of beans at KALRO Kandara trial site, LR2019.

Treatment	Root biomass weight (g)		Above ground biomass weight (g)	
	KATB1	Nyota	KATB1	Nyota
Untreated Control	7.8	5.7	64.5	50.2
Apron Star HRR	7.3	5.7	65.2	45.4
Apron Star RR	10.4	9.9	88.1	80.5
Fertilizer DAP	7.9	8.1	57.4	64.9
Gro Plus HRR	9.5	7.9	76.6	49.1
Gro Plus RR	8.2	8.0	64.3	57.6
Seed Plus HRR	6.2	7.8	50.0	53.6
Seed Plus RR	5.9	6.6	58.0	33.2
TriCoat- HRR	5.4	5.2	52.0	40.2
TriCoat RR	7.0	7.1	54.8	59.5
Variety means	7.5	7.2	62.6	53.9
Sig (LSD-variety)	1.11 ^{ns}		19.35 ^{ns}	
Sig (LSD-seed)	1.16 ^{ns}		25.08 ^{ns}	
Sig (LSD-Interaction)	1.64 ^{ns}		34.80 ^{ns}	

Above ground and below ground biomass

The results for plant biomass indicated that there were no significant differences for shoot and root biomass between varieties, seed treatments and the interaction during the LR2019 (Table 4). In absolute terms, the Apron Star-RR treatment resulted in the highest biomass, including root and shoot weights during the LR2019 in

both varieties. For root weight, TriCoat HRR applications resulted in the lowest shoot biomass for both varieties, and the lowest shoot biomass for Nyota bean variety. For KAT B1, Seed Plus-HRR applications resulted in the lowest shoot biomass.

There were significant differences between seed treatments for above-ground biomass during the short rains season (Table 5). The experimental findings

Table 5. Shoot and root biomass of beans at KALRO Kandara trial site, SR2019.

Treatment	Root Biomass Weight (g)		Aboveground Biomass Weight (g)	
	KAT B1	Nyota	KAT B1	Nyota
Untreated Control	2.06	1.72	20.2	17.0
Apron Star-HRR	2.33	2.91	18.7	20.4
Apron Star-RR	2.20	2.78	21.9	23.0
DAP	2.78	2.96	31.3	34.9
Gro Plus-HRR	2.05	2.35	28.0	20.4
Gro Plus-RR	2.55	2.65	25.9	28.1
Seed Plus-HRR	2.05	2.11	16.3	12.4
Seed Plus-RR	1.53	2.65	17.5	21.0
Tri Coat-HRR	1.39	2.09	19.4	19.8
Tri Coat-RR	2.37	2.36	18.2	19.3
Variety means	2.16	2.48	21.7	21.6
Sig (LSD-Variety)		0.894 ^{ns}		4.488 ^{ns}
Sig (LSD-Seed)		0.781 ^{ns}		7.103 ^{**}
Sig (LSD-Seed x variety interaction)		1.133 ^{ns}		9.744 ^{ns}

**p ≤ 0.01, ns= not significant.

suggested that the seed treatments were translated into significant effects on above ground biomass in different seed treatments. The DAP treatment resulted in the highest biomass, including root and shoot weights during the SR2019 in both varieties. For the shoot weight, the DAP application and Gro Plus RR, provided similar effects on the above ground biomass, implying that bean fertilization with the nutrient primer and conventional fertilizers was important for crop performance and pest suppression (see also Figure 1). For root weight, TriCoat-HRR applications resulted in the lowest shoot biomass while the Untreated Control recorded the least root biomass in the *Nyota* variety. For the shoot biomass, the Seed Plus-HRR recorded the least weight in both varieties.

Bean grain yield

Grain yield differences were detected across the varieties and treatments during the LR2019 (Figure 3A). Apron Star RR recorded the highest KATB1 bean grain yield (1,158 kg/ha) followed by the Untreated Control treatment at 913 kg/ha and the least in TriCoat-HRR treatment (562.4 kg/ha). For *Nyota* variety the yields were 1,347 kg/ha for Apron Star RR followed by 1,084 kg/ha for Gro Plus RR with the least being Seed Plus RR (458 kg/ha) treatment. In general, the recommended seed treatment rates resulted in better bean performance compared to the half-recommended rates in the long rain season.

Apparently, during the long rains season, the Untreated Control treatment performed better than some of the seed-dressed treatments. For example, in the long rain season, application of the Seed Plus at the recommended

rate resulted in 140 and 583 kg/ha lower yields than the Untreated Control plot yields for *Nyota* and KATB1 beans, respectively. Some of the seed treatment products may have introduced stressors to plants under drought conditions, thus, affecting crop performance. Some of the seed dressing effects that may suppress crop performance include negative interactions with rhizobial bacteria in nodulating legume crops (Muthomi et al., 2007). Reduced bean productivity was also observed for the DAP fertilizer treatment where KATB1 recorded 632 kg/ha compared to the Untreated Control that recorded 913 kg/ha during the long rains season.

The long rains season was characterized by drought conditions that may have limited nutrient access and also caused stress in treatments receiving granulated inorganic fertilizer applications. Water is a key limiting factor for crop production especially with fertilizer application in the conditions. Tesfahunegn (2015) and Tesfahunegn (2019) observed moisture stress of teff at crop establishment and grain filling stages, mainly in the fields treated with fertilizer. This could be partly because field crops receiving fertilizer applications use more soil water at the grain filling stage than those with no fertilizer applications. Conversely, Gro Plus application, which is a phosphorus and potassium formulation applied as seed coating at planting did not induce any long-term fertilizer stress to the beans. This means fertilizer priming could be an alternative to the use of granulated basal fertilizers, especially when faced with dry spell risks.

During the short rain season, there were no significant differences between seed treatment and the interaction; however, there were variety differences (Figure 3B). Relative to the long rain season, the short rain season recorded high bean productivity across most treatments.

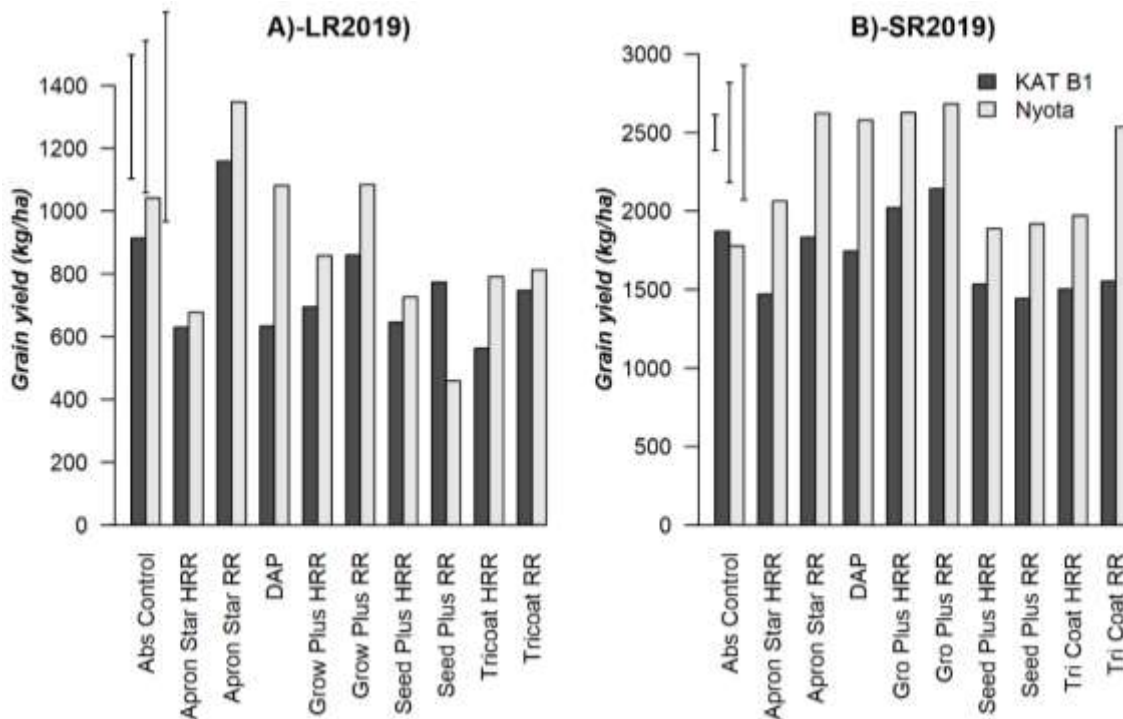


Figure 3. Effect of seed treatment on bean grain yield: HRR = Half Recommended Rate, RR = Recommended Rate). The error bars are arranged as LSD (0.05) for variety (First error bar), seed treatment (Second error bar), and the interaction (Third error bar); LR=Long rain season, SR=Short rain season.

This can be attributed to the favorable climatic conditions characterized by well-distributed rainfall and favorable temperatures, with *Nyota* variety performing better than KAT B1. *Nyota* variety under Gro Plus-RR, Gro Plus-HRR, DAP, Apron Star RR, Tricoat RR, and Apron Star HRR treatments recording bean productivity above 2t/ha. The highest yield difference above the Control was 269kg/ha for KATB1 and 904kg/ha for *Nyota* variety with the Gro Plus RR treatment. Gro Plus supplies both P and K in readily available forms for full legume development resulting in improved bean performance.

The TriCoat RR recorded 2,535kg/ha bean yields and was comparable to Apron Star RR, DAP, Gro Plus HRR, and Gro Plus RR treatments. Studies have shown that biofertilizers can mobilize nutritionally important elements from non-usable to usable form through biological processes and they have the potential to increase crop production by improving yield and quantity (Glazer and Nikado, 2007). TriCoat contains *Trichoderma* spp., a group of fungus which colonizes the rhizosphere and obtains organic nutrients from plants and in turn enhances nutrient uptake during moisture transport in the plants (Hajek, 2004). This improves the rate of seed germination, growth rate, yield, and resistance to diseases (Harman et al., 2004). Biofertilizers reduce chemical fertilizer use and are an important component of sustainable agriculture (IFPRI, 2010).

Pest severity and bean performance

There was a weak regression between plant height and pest severity during the SR2019 (data not shown). However, there was an inverse relationship between plant height and biomass measurements in the LR2019 season (Figure 4A). The relationship was however stronger for shoot weight (Figure 4A), compared to the root weight regression (Figure 4B). Higher pest severity resulted in reduced above ground biomass, root biomass and bean grain yields (Figure 4C). Mwanauta et al (2015) observed that aphid infestation led to between 18 and 31% yield losses in common beans. This implies that reducing the pest incidences using the seed dressing options would result in better plant development hence higher productivity. Increasing the aphid severity by one unit resulted in an average decline of 144 kg/ha in bean grain yields (Figure 4C), while the corresponding average declines for bean shoot and root biomass were 9.1 and 0.6 g, respectively.

Conclusion

The experiment offered an opportunity to understand crop response to different seed dressing options. Treatments with seed dressing showed better

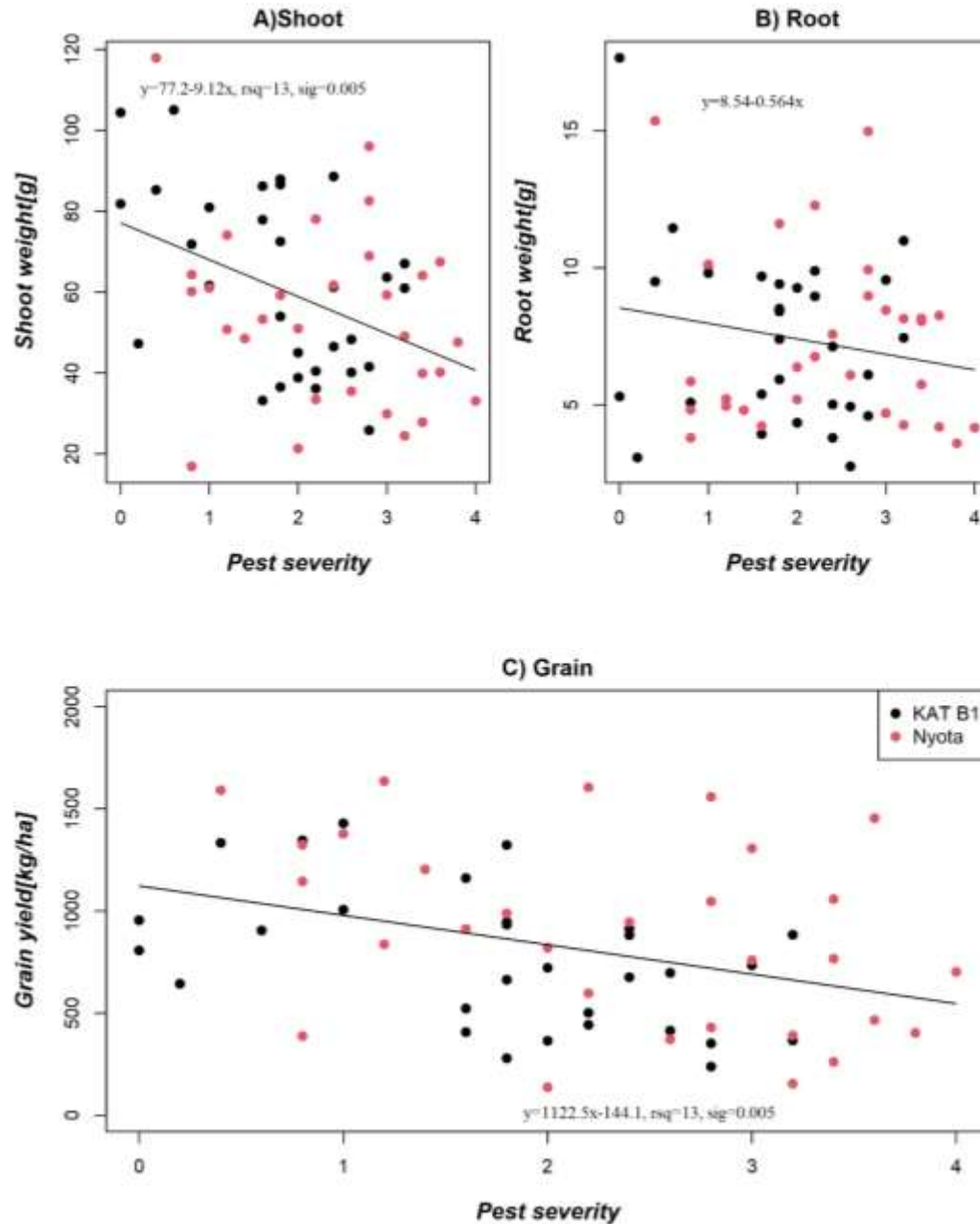


Figure 4. Regression between plant biomass components and pest severity during LR2019 for shoot biomass (A), root biomass (B) and bean grain yields (C).

establishment, less insect attack and improved vigour and productivity relative to the control treatments. There was an inverse relationship between plant height and aphid pest severity, showing that seed treatment resulted in improved legume performance (Figure 4). The use of the seed dressers even without fertilizer application resulted in a significant yield increase. This shows that in the event the farmer is not able to access fertilizer, the use of seed dressers both chemical and biologicals can help improve plant growth, minimize pest and disease

attacks and increase crop productivity. Further, reduction in pest severity following application of seed dressing product is a strategy to reduce use of expensive agrochemicals and also a strategy to ensure food safety. Mixed treatment responses were observed between the recommended and half rates of seed dressing rates. In some instances, use of half rates performed better than the recommended rates of application. Due to the other confounding effects of climate and management, it was not possible to make conclusive recommendations on the

consistency of the half rate application on crop production. There was evidence pointing to varietal differences in pest resistances and responses to seed treatments, which should be subjected to detailed investigations. Thus, more studies are needed to validate the responses of the bean varieties to seed treatments, under diverse climatic and management conditions of small-scale farming systems in the SSA region. Seed dressing is a potential environmentally friendly, sustainable and integrated strategy for improving productivity for cash strapped small-scale producers in the sub Saharan Africa region.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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