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Effects of fungicide application and different nitrogen fertilizer levels on yield components of three varieties of common bean *Phaseolus vulgaris* L.

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In Cameroon, common bean is produced and highly consumed as a source of protein and means of generating income by small farm holders. However, diseases like angular leaf spot caused by *Phaeoisariopsis griseola* (Sacc), poor agronomic practices and low soil fertility are negatively impacting the production of the crop. A field experiment was conducted under natural conditions in the University of Dschang during the 2017 main cropping season. The experiment was laid out in a RCBD in a split-split plot arrangement with three replications: Fungicide application (sprayed and unsprayed); Fertilizer level: F1 (Control), F2 (10 t/ha *Tithonia*), F3 (3.5 t/ha poultry manure) and F4 (0.4 t/ha 14.24.14 NPK fertilizer). Bean varieties that occupied each experimental unit were V1 (GLP-190 S), V2 (PH201) and V3 (PNG). There was a significant difference (P<0.05) between sprayed and unsprayed plots with respect to disease severity. The highest number of pods was obtained from the *Tithonia* treatment (F2) while the lowest was gotten from the mineral fertilizer treatment (F4). As concerns the interactions, fertilization and variety, spray and variety, there was a significant difference (P<0.05) among the various components. In all varieties, sprayed plots had more pods, seed weight, 100-seed weight compared to unsprayed plots. From the study, it shows that fungicide treatment reduced disease severity and the different nitrogen fertilizers greatly improved yield components of the crop.

Key words: Angular leaf spot, common bean, fungicide spray, nitrogen fertilizers, Western Highlands, yield components.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is a major grain legume crop grown worldwide for its nutritional value (Amin et al., 2014), supplying about 20% of the protein intake per person worldwide (CIAT, 2001). The FAO (2014) reports that half of the world's common bean production occurs in low income food deficit countries

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where this staple crop contributes to food security. The other half is produced in countries like in US, where common bean is an important economic crop. In Cameroon, common beans is mainly cultivated and marketed in the Western Highlands of Cameroon (Tatchago, 1987; Siri et al., 2017). This region contributes more than 90% of the national bean production (Anonymous, 2010). It is grown for its high nutritional value and potential as a source of income for the smallholder farmer. This makes haricot beans an ideal crop for simultaneously achieving three developmental goals: reducing poverty, hunger and improving human health (Akibode and Maredia, 2011). Bean is a good source of protein, folic acid, dietary fibre and complex carbohydrates (Jones, 1999). Even though the crop is very important, the national average yield of common bean in Cameroon is very low, around 0.5 t/ha (Pamo et al., 2005) compared to the potential of the crop which is estimated at 1.5 t/ha for promising varieties. The low national yield has been attributed to various constraints (Wachenje, 2002). Among these are diseases, insects and low soil fertility. Common bean diseases such as Angular Leaf Spot (ALS) caused by *Phaeoisariopsis griseola* (Sacc.) Ferraris is one of the most widely distributed and damaging disease of crop, causing yield losses as high as 80% (Mahuku et al., 2004; Buruchara et al., 2010). When weather conditions are favourable for its development, ALS is a very destructive disease with crop losses resulting mainly from premature defoliation (Mwamgombe et al., 1994). The disease affects foliage and pods throughout the growing season and is particularly destructive in areas where warm and moist conditions are accompanied by abundant inoculums from infected plant residues and contaminated seeds. ALS incidence and severity increased in many areas where beans are cultivated (Stenglein et al., 2003). Yield losses due to ALS have been estimated at 50% in USA, 70% in Brazil and 80% in Columbia and Cameroon (Tiomo, 1994; Jesus et al., 2001). Different management options such as use of resistant varieties, use of disease free seeds, fungicide application and crop rotation are known to be the ideal way to manage this disease (Mekonen, 2017). However, in Cameroon, resistant varieties are insufficient due to the fact that the pathogen has been developing virulent resistant genotypes (Mahuku et al., 2009; Wagara et al., 2011). Different fungicides applications and use of nitrogen fertilizers remain a better option in controlling disease spread as well as improving yields. Nitrogen is the most important element limiting crop production in the tropics.

Previous surveys estimated that over 60% of the bean production areas in Central, Southern, and Eastern Africa was affected by N Deficiency (Thung and Rao, 1999). This caused yield losses of up to 40% compared to the N-fertilized areas (Thung and Rao, 1999). Beans are legumes that can fix atmospheric nitrogen (N_2) into the soil in symbiosis with soil rhizobia. However, common bean is considered to be a poor fixer of atmospheric N when compared with other crop legumes (Piha and Munns, 1987). It generally responds poorly to inoculation of rhizobia in the field conditions (Buttery et al., 1987) and rarely derives more than 50% of their N from the atmosphere (Wortmann, 2001). Various organic and inorganic fertilizer sources have been used to improve soil fertility as well as improving quality of yields of beans and other vegetables (Mohammad et al., 2016). Application of inorganic fertilizer is a faster way to maintain the productivity of crop because the nutrients are releasing nutrients like NPK which is easily available to plants. On the other hand, organic fertilizers (cow manure, poultry manure, and green manure) have been shown to help preserve natural resources and reduce degradation of ecosystem (Mäder et al., 2002; Francis and Daniel, 2004). Application of chemical fertilizers containing N, P, and K not only increase crop yields but also improve nutritional quality of crop yields, such as protein, oil, starch, essential amino acids and vitamins in pulses, oil seeds, tubers and vegetables (Wang et al., 2008). The present work was carried out with the objective of improving the production system of beans through the contributions of fungicide spray against angular leaf spot disease and the use of appropriate nutrient sources (nitrogen fertilizers).

MATERIALS AND METHODS

Description of the study area

The field experiment for the management of common bean angular leaf spot through fungicides and nitrogen fertilizers was conducted at the Faculty of Agronomy and Agricultural Sciences (FASA) experimental farm, University of Dschang (UDs), West Region, during the main cropping season (March - July) of 2017. Dschang is located at 5° 26'N, 10° 04'E at an altitude of 1400 m above sea level. The precipitation of Dschang varies between 1800 and 2000 mm annually while temperatures range from 21 to 25°C. Its relative humidity is generally above 60%. Dschang receives an average insulation of 2000 h a year. The soil type of the experimental site is sandy loam with a pH value of 6.1 (Soil Science Laboratory, FASA, UDs, 2017).

Experimental materials used

Three common varieties, namely GLP 190-S (MIDENO), PH201 (Meringue) and PNG (Koussi) were used for the experiment. These varieties are widely used in these localities because of their growth habit, taste and productivity. The seeds were obtained from IRAD Dschang Cameroon. The contact fungicide Agreb (Agreb 80WP) with the active ingredient Maneb, the poultry manure and the mineral fertilizer (14.24.14) were obtained from the local market. The Mexican sunflower leaves/shoots were harvested around the experimental farms of FASA.

Experimental design and treatments

The experiment was laid out in a randomized complete block design (RCBD) in a split-split plot arrangement with three replications. The main plots were the fungicide treatments while the sub-plots were the fertilizer treatment and the sub-sub plots were for the bean varieties. There were 12 plots, each consisting of 5 rows. Plant to plant distance and row to row distance was maintained at 35 and 20 cm, respectively. Each main plot had a length of 24.5 m and width of`19.7 m. There were four levels of fertilizer application as thus: F1- control (unfertilized), F2- *Tithonia*, F3- Poultry manure and F4-NPK (14.24.14) formed main plots. Each subplot has a length of 9.8 m and a width of 1.5 m. The size of each experimental unit (sub-subplot) was 2.6 m × 1.5 m (3.9 m^2) having five rows each containing 26 plants. A distance of 1 and 1.1 m were left between plots and blocks, respectively. This gave a total experimental plot surface area of 482.7 m^2. Two seeds per hole were sown at the recommended planting depth of 6 cm. All agronomic practices such as cultivation, weeding and mulching were done manually when the crops were at vegetative stage (three weeks after sowing) and mid reproductive stage (Fontem et al., 2007; Mboussi et al., 2012).

Soil sampling and laboratory analysis

Prior to planting of seeds, soil samples were collected at a depth of 0 to 30 cm from representative spots of the entire experimental field by using diagonal sampling method (Turuko and Amin, 2014). The composite soil sample was air dried and made fine by using mortar and pestle. The sample was later taken to the laboratory of Soil Science of FASA, UDs where the physical and chemical properties of the soil were analyzed.

Fungicide application

Each main plot was divided into two halves spray (Sp) and unsprayed (Unsp). Sprayed plots were separated from unsprayed plots by a bean-free zone of 1.1 m. The contact foliar fungicide Agreb was applied using the manual Solo Knapsack sprayer with a single flat fan nozzle that delivers about 600 L/ha at a maximum pressure of 3 kg/cm^2 (Fontem et al., 2007). The first treatment was applied at first foliar symptoms (35 days after planting, DAP) and subsequent sprayings were done during flowering (45-55 DAP) and at podding stage (60-65 DAP). Plants were sprayed in the early hours of the day when the wind speed was low.

Angular leaf spot disease assessment

Bean crops were inoculated by naturally occurring inocula of angular leaf spot pathogen in the field. Percentage disease severity was scored at eight days interval on five randomly selected plants in the centre rows of each experimental unit. This was done using the standard disease grading scales of 1 to 9, where 1 = no visible disease symptoms; 3 = plants with 5 to 10% leaf area having lesions; 5 = plants with 20% leaf are having lesions and sporulation; 7 = plants with up to 60% leaf are having lesions, associated with chlorosis necrotic tissue, and 9 = plants with 90% leaf area having lesions, associated with early leaf fall and death (VanSchoonhoven and Pastor-Corrales, 1991). Five ratings of disease severity were collected starting from the 35 DAP.

Microscopic confirmation of the pathogen

Representative samples of all diseased leaves of plants (two leaves) of each variety showing symptoms of angular leaf spot, were collected, placed between two clean papers, labeled and taken to the laboratory of the Catholic University of Cameroon (CATUC) Bamenda in order to confirm field identifications through microscopic observation. Each sample having suspected disease symptom(s) was cut into smaller pieces of 2 cm from the edge of the diseased leaf and surface sterilized for) min in 10% sodium hypochlorite solution and rinsed in sterilized water. The sterilized pieces were placed on 2.5% Potato Dextrose Agar (PDA) medium. The plates were kept at room temperature in the laboratory for 4 to 7 days. Fungal growths on each plate were sub-cultured to a new plate and the plates were kept in an incubator at 27 to 29°C. The growth of fungus was observed daily for its typical characteristics. Later pure culture of the isolated fungus was identified morphologically using a compound microscope and observed at magnification of 10 and 40 ×.

Harvesting and yield assessment

Mature pods (more than 90% ripe) of each cultivar per sub-subplot were harvested from the two central rows excluding one border row on both sides to minimize border effects. These were used to assess number of pods, and number of seeds per experimental unit and weight of 100-seeds. Marketable yields were measured as weight of clean dry seed per subplot and expressed in tons per hectare. Amount of shriveled or discoloured seeds were counted from randomly selected hundred seeds and converted to percentage (Hirpa and Selvaraj, 2016). Yield loss and gain were determined using the formula of Nkalubo et al. (2007) as thus:

% Yield loss or reduction = $\frac{PPY - IPY}{PPY} x100$

% Yield gain = $\frac{PPY - IPY}{IPY} x100$

where PPY = Protected or sprayed plot yield and IPY = Unprotected or unsprayed plot yield.

Data analysis

Data on disease severity, fungicide and fertilizer treatment and yield components (number of pods, number of seeds per plant, weight of seeds) were subjected to an analysis of variance (ANOVA) using an MSTAT (or GENSTAT) statistical package. Means were separated using Fisher's least significance difference at P=0.05.

RESULTS

Disease severity and fungicide application

There was a high significant difference between sprayed and unsprayed plots with respect to disease severity (P< 0.05). Unsprayed plots were thrice more infected with ALS than sprayed plots at all periods of recording for the three varieties of common bean.

The severities of ALS infection increased with time from 35 DAP onward. The mean severity of ALS infection was least at period 1 or 35 DAP (0.90%) and highest period 5 (48.35%). Variety 1 (GLP-190-S) had the highest disease severity for both sprayed and unsprayed plots, while variety 3 (V3 or PNG) was least severed. There was no significant difference (P>0.05) among the severities in terms of fertilization and severity. Severity was highest for poultry manure (F3) and inorganic fertilizers (22.3 and

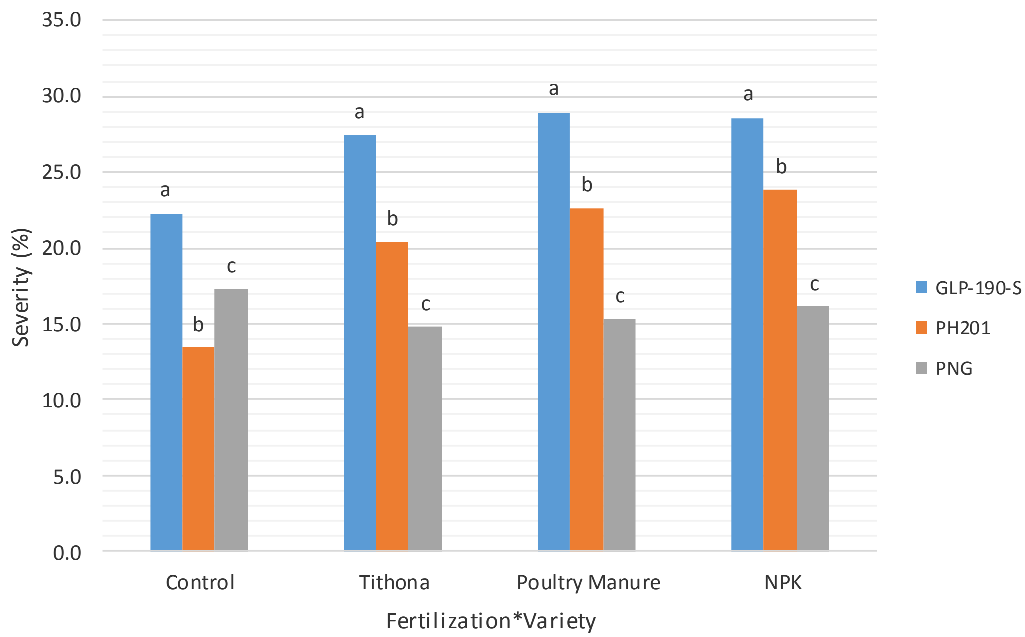

Figure 1. Percentage disease severity for sprayed and unsprayed plots at different fertilization levels for three varieties of common bean.

22.8%, respectively) while the control or unfertilized (F1) had the least (17.7%). This indicated that the disease response to fungicide treatment varied from cultivar to cultivar. There was no significant difference (P>0.05) between the interaction fertilization and period for all varieties (Figure 1).

Yield components at different fertilization levels

There was a high significant difference (P< 0.05) among the different yields components (number of pods per subplot, pods per plant, weight of seed per variety, mean seed weight and 100-seed weight) at the four levels of fertilizer application.

Number of pods

Tithonia (F2) applied at 10 t/ha had the highest number of pods (260.2) while mineral fertilizer (F4) recorded the least (230.2). Thus the number of pods and number of pods per plant was significantly affected by all treatments at P<0.05.

Seed weight, mean seed-weight and 100-seed weight at different fertilization level

F2 had the highest seed weight (376.4 g) and mean seed weight of 18.8 g, while F1 (control) had the least seed weight of 320.3 g and a mean seed weight of 16.0 g. For 100-seed weight F1 had the lowest (35.0 g) while F4 (inorganic fertilizer) was the highest. Thus all fertilizer treatment significantly increased the pods, weight of seed per plant in comparison with the control.

Shriveled seed at different fertilization level

The percentage of shriveled seed was least at F1 (6.7%) and highest at F2 (9.3%) (Figure 2).

Variety

There was a significantly different among the different yield components at (P< 0.05) for the three varieties. For number of pods and pods per plant, PNG (V3) had the highest number of pods and mean pod per plant (299.9 and 15.1 respectively), while GLP 190-S (V1) had the lowest (183.4). In terms of weight, meringue (V2) was the highest (396.4 g) and mean of 19.8 g, while GLP – 190-S (MIDENO) was the lowest (250.4 g) and a mean of 12.5 g. For 100-seed weight, GLP – 190-S (V1) had the highest weight (50.2g) while PNG (V3) was the least (27.0 g). PNG (V3) had the highest percentage of shriveled seeds (11.5%) as compared to GLP – 190-S (V1) with a percentage of 4.3%. For this interaction, there was a high significant difference (P<0.05) among the yield components at various levels of fertilization. Variety 3 (PNG) had the highest number of pods (329.2) at

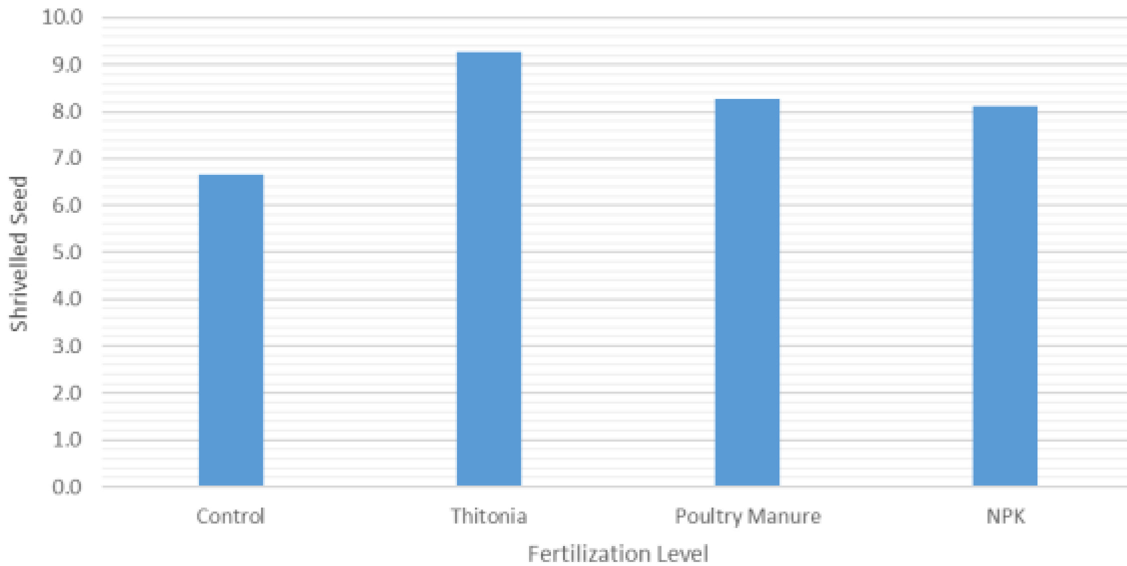

Figure 2. Percentage of shriveled seeds at different fertilization level.

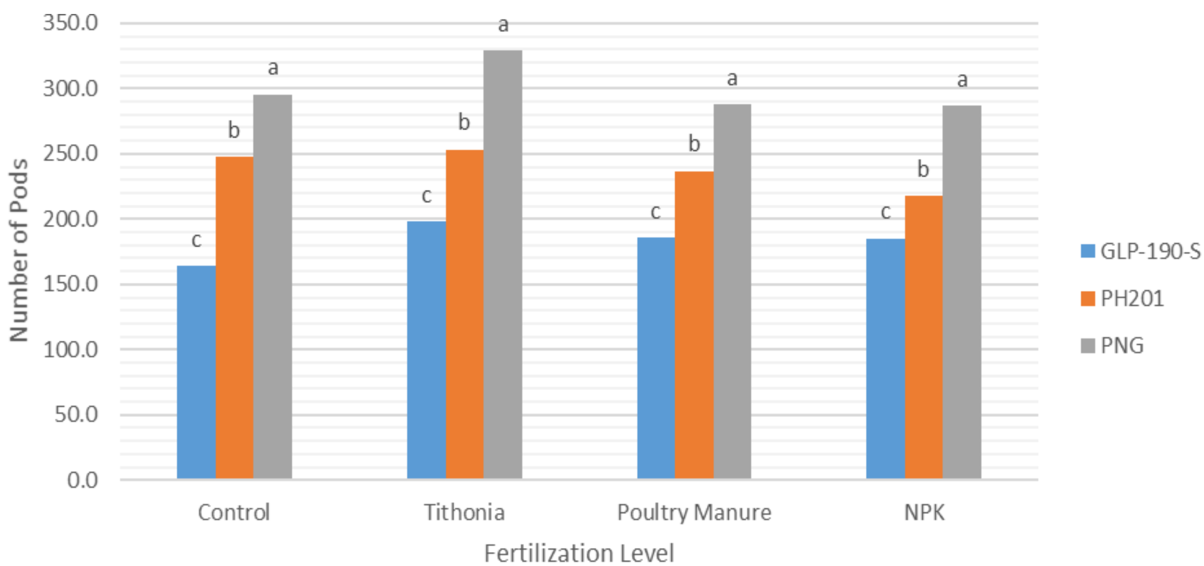

Figure 3. Interaction of fertilization and variety with respect to number of pods.

fertilization level 2 (*Tithonia*) while the least was obtained from GLP 190-S (164.3) at fertilization level 1 (control). Thus *Tithonia* (F2) had the highest number of pods per subplot/plant for all varieties, while control or no fertilizer (F1) had the lowest. The same trend applies to seed weight. Highest seed weight was at fertilization level 2 (*Tithonia*) for all varieties of bean, while control (F1) had the least. PNG (V3) had the highest seed weight at all levels of fertilization. Highest seed weight was obtained from PNG (V3) (436.0 g) at fertilization level 2 (*Tithonia*), while the lowest was from GLP 190-S (V1) at fertilization level 1 (F1) (Figures 3 and 4).

100-Seed weight

The highest weight (50.2 g) was obtained at fertilization level 4 (inorganic or mineral fertilizer) in the variety GLP 190-S (V1), while PNG (V3) had the least (27.0 g).

With respect to shriveled seeds, PNG (V3) had the highest mean percentage of shriveled seeds at all levels of fertilization, while GLP-190-S (V1) had the lowest. V3

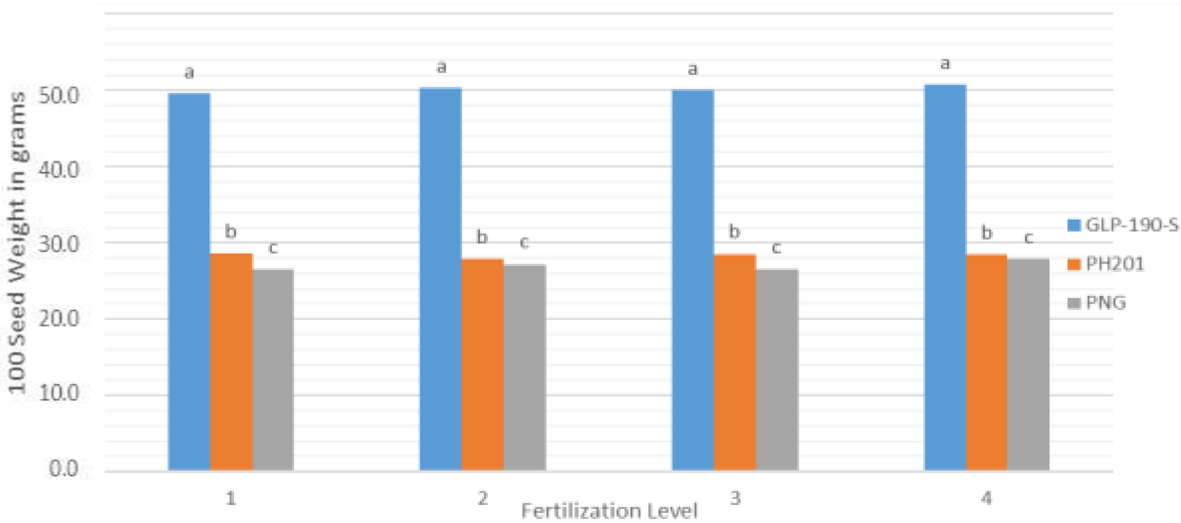

Figure 4. Interaction between varieties with respect to 100- seed weight.

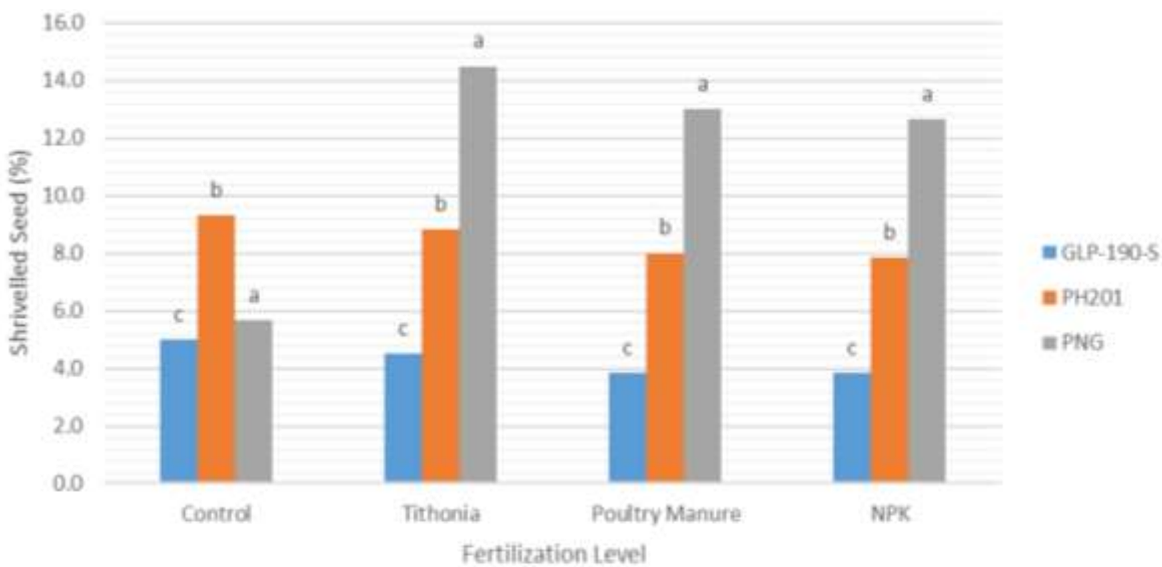

Figure 5. Interaction between fertilization and varieties with respect to shrivelled seeds(%).

or PNG at fertilization level 2 (*Tithonia*) had the highest number of shriveled seeds (14.5). GLP-190-S had the lowest percentage of shriveled seeds at fertilization levels 3 (poultry) and 4 (mineral fertilizer) (3.8%) (Figure 5).

Variety and fungicide treatment

In all aspects of yield components, sprayed plots had the highest values compared to unsprayed plots. Number of pods in sprayed plots (258.3) was higher than unsprayed plots (223.2). The same applies to number of pods per plant, weight of seeds, mean seed weight and 100-seed weight. Unsprayed plots had a greater percentage of shriveled seeds (11.1%).

Interaction of fertilization and spray

Number of pods per subplot, per plant, weight of seed and mean seed weight were comparatively higher in sprayed plots than in unsprayed plots at all levels of fertilization. Fertilization level 2 (*Tithonia*) had the highest number of pods (281.7) in sprayed plots while in unsprayed plots, the number of pods (217.3) was observed at fertilization levels 1, 3 and 4 in that

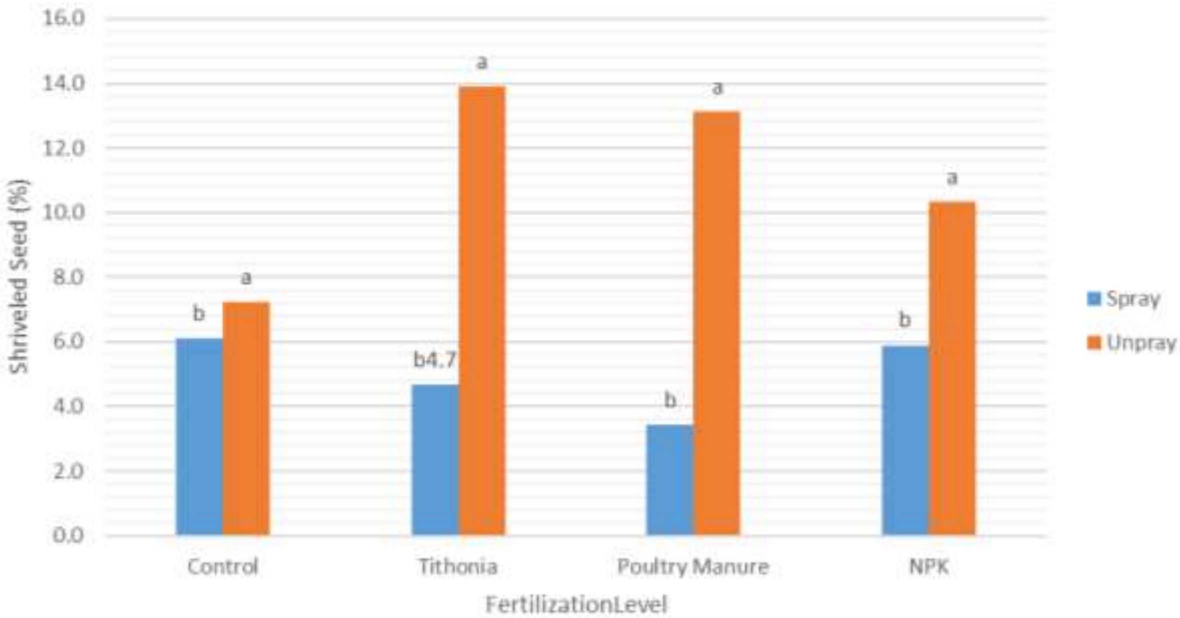

Figure 6. Interaction between fertilization and fungicide application with respect to percentage shriveled seed.

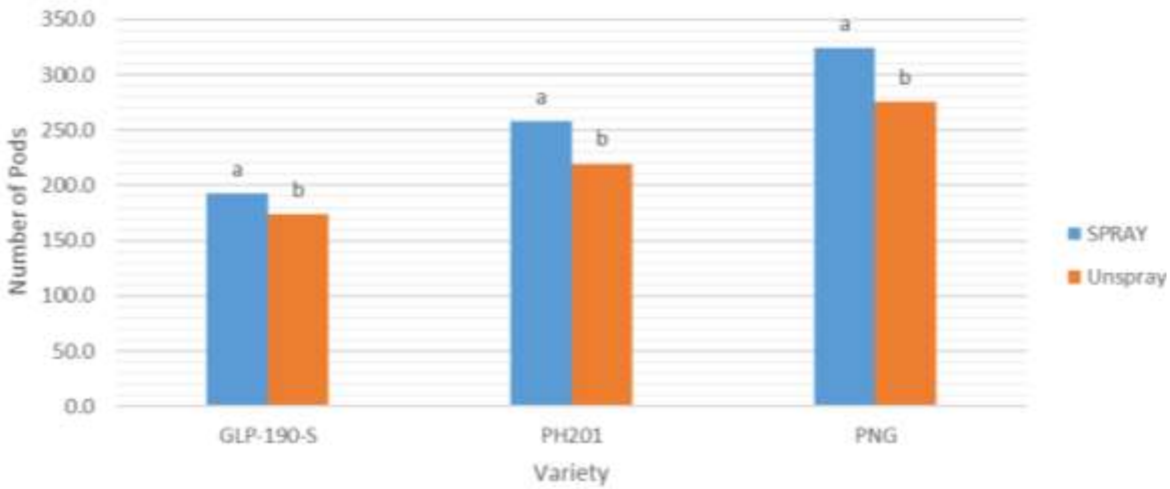

Figure 7. Interaction between fungicide treatment and varieties with respect to number of pods.

descending order. With respect to seed weight, the organic fertilizer-*Tithonia* (F2) had the greatest seed weight (448.6 g) in sprayed plots compared to the lowest (262.7 g) at fertilization level 4 (inorganic fertilizer). In terms of 100-seed weight, sprayed plots at fertilization level 4 had the highest number of seed weight (40.2 g) while fertilization level 3 (poultry fertilizer) had the lowest weight (30.7 g). The least percentage of shriveled seeds (3.4%) was observed at fertilization level 3 (poultry fertilizer) in the sprayed plots, while the highest percentage (13.9%) was seen at fertilization level 2 (*Tithonia*) in unsprayed plots. Thus, there was significant difference ($P \leq 0.05$) in percentage of shriveled seeds for this interaction (Figure 6).

Spray and variety

In all varieties, sprayed plots had more pods per subplots, pods per plant, weight of seeds, mean seed weight and 100-seed weight. PNG (V3) had the highest pods/subplot (323.9 g) for the sprayed plots while in unsprayed plots, GLP-190-S had the lowest number of pods (173.9 g) (Figure 7). In terms of pods/per plant, GLP-190-S had the lowest for both sprayed and unsprayed plots (9.7 and 8.8 g), respectively. On the

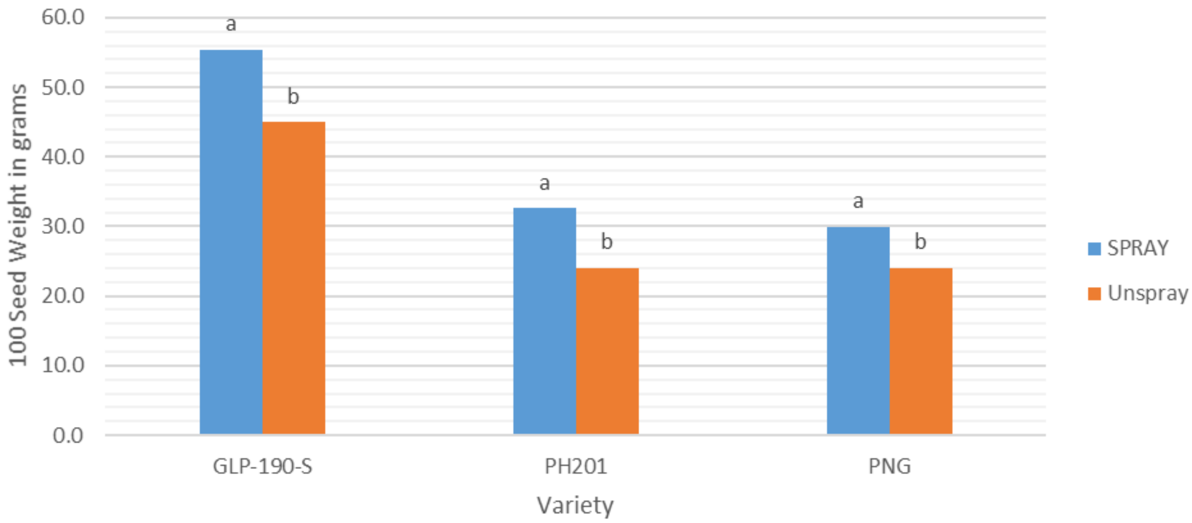

Figure 8. Interaction between fungicide treatment and varieties with respect to 100-seed weight.

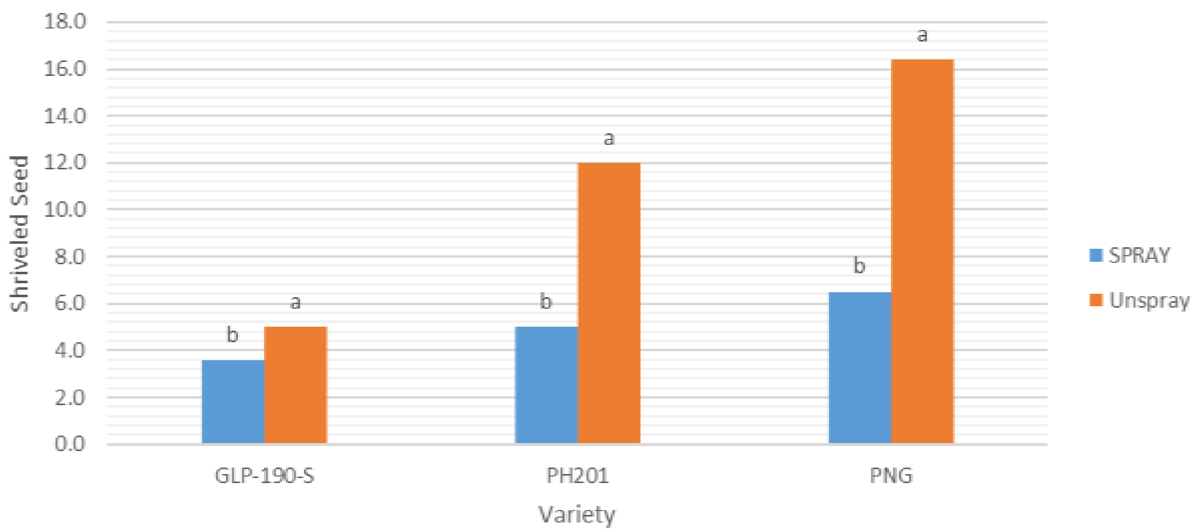

Figure 9. Interaction between fungicide treatment and varieties with respect to percentage shriveled seeds.

other hand, PNG had the highest (16.3 and 13.3 g, respectively). Meringue (V2) had the greatest seed weight (469.9g) and mean seed weight for the sprayed plots. The least was observed in GLP-190-S (288.4 and 14.4 g). In the unsprayed plots, GLP-190-S had the lowest seed weight (212.4 g) and mean weight (14.4 g) compared to the other two varieties. For 100-seed weight GLP-190-S had the highest (55.4 g) compared to the lowest in PNG (30.0) in sprayed plots. In the unsprayed plots GLP-190-S also had the highest 100 seed weight (45.0 g) compared to Meringue and PNG (Figure 8).

The percentage of shriveled seeds in sprayed plots was far lower than those in unsprayed plots for all varieties of bean. The variety, GLP-190-S had the lowest percentage of shriveled seeds in both sprayed and unsprayed plots (3.6 and 5.0%, respectively). PNG (V3) had the highest percentage of shriveled seeds for both sprayed and unsprayed plots (6.5 and 16.4%) (Figure 9).

Percentage yield loss and gain for the three varieties

The three varieties showed differences in yield loss and gain for both treated and untreated plots. PNG (V3) had the highest yield loss and gain of 25.6 and 52.7%, respectively. On the other hand, PH201 (V2) had the lowest yield (18.2%) for unsprayed plots while the yield gain for the same variety almost tripled in value (50.0%).

Thus yield losses were highly reduced by the fungicide chemical Agreb compared to the untreated control.

DISCUSSION

Fungicide application and severity

The pathogen, *P. griseola*, the causal pathogen of angular leaf spot (ALS) is known to have greatly affected yields and yield components of common bean in different parts of the world, especially Cameroon. In the present study, ALS was found to naturally infect the three varieties of common bean though with varying degrees of severity for both sprayed and unsprayed plots. The symptoms observed macroscopically on natural infected leaves, petioles and stems confirm the disease as angular leaf spot (ALS). This is in line with similar observations made by Stenglein et al. (2006) and Djeugap et al. (2014). There was considerable reduction of ALS severity in all sprayed plots treated with the fungicide Agreb (Agreb®80WP) compared to unsprayed plots. From the findings, the climbing cultivar (PNG) was least susceptible, followed by the cultivar PH201 (Meringue) while the dwarf cultivar (GLP 190.S) was the most susceptible. These results are similar to those of Nibod (2003) and Fontem et al. (2007) who showed that the climbing cultivar (PNG) in Cameroon is less susceptible to ALS compared to dwarf cultivars. Increase in yield components (number of pods, seed weights, and 100-seed weights) in the sprayed plots was largely due to fungicide treatment. There was a significant difference between sprayed and unsprayed plots with respect to shriveled seeds in the different varieties. Paparu et al. (2014) observed that the use of the fungicide ORIUS to control ALS and rust in common bean resulted in significant yield increments. Amin et al. (2014) working on anthracnose disease of common bean concluded that plots which received various fungicide treatments significantly reduced disease severity. It has been suggested that fungicide sprays particularly permitted the crop to reach physiological maturity without being under severe anthracnose infection. The climbing cultivar (PNG) was more productive in terms of yield components, followed by PH201 and the least was observed in GLP.190-S. Ngwa (1998) also reported that the dwarf cultivar GLP 190-S had a low production potential compared to climbing cultivars. Similar findings associated with severity and yields have been reported for diseases of beans and several crop plants like, Anthracnose disease of common beans (Nkalubo et al., 2007), *Sclerotinia* stem rot of Canola (Del Rio et al., 2007). CIAT (2001), categorized bean cultivars into three groups based on their response to ALS and other diseases. Thus, from the present findings, cultivar PNG with rating severity of less than 4 was considered as resistant while PH201 (Meringue) and GLP. 190.S were intermediate. The resistance of PNG to ALS is in confirmation with other research findings carried out with this variety and others under different ecological conditions (Fontem et al., 2007; Ngueguim et al., 2011; Sanglard et al., 2013). This resistance to ALS has been largely attributed to the genetic makeup (genotypes) of this variety and other local ones. According to Djeugap et al. (2014) the identification and characterization of the genes of interest can be a good base for the amelioration of the genotypes of different varieties of common bean in Cameroon. There was a progressive increase in disease severity from the initial date (35 DAP) of notification of disease symptoms to full bloom appearance during flowering and maturity stage. This can be attributed to inoculum density and environmental conditions. Since infection is natural, there was inoculum built up and spread among crops as days pass by and rate of humidity increased. This was particularly noticed in the unsprayed plots of all three varieties. The highest mean disease severity (48.4%) was recorded at period five (67 DAP) compared to the least (0.90%) at period one (35 DAP). At a more than 50% flowering environmental conditions like increase in rain fall and temperatures favour infection and disease development. According to Celetti et al. (2006), high ALS severity and occurrence is often experienced under conditions of warm temperature (24°C) but it also occurs within a temperature of 16 to 28°C, if accompanied by high relative humidity (95-100%) alternating with windy conditions.

Disease severity was not affected by the fertilization level, despite the fact that unsprayed plots were significantly infected compared to sprayed plots at all levels of fertilization. From the present study, severity was highest for poultry manure (F3) (22.9%) as against (17.7%) for control (F1). These results can be explained in that poultry manure is rich in organic matter such as potassium and phosphorus and this can serve as a good source of inoculum for the pathogen causing ALS. This can easily infect the crops especially unsprayed plots. Tarla (2008) suggested that increase in late blight of huckleberry in plots treated with poultry manure was due to the fact that the poultry manure contains more nitrogen than the control.

Nutrient application and yield components

It was generally observed that application of organic and inorganic fertilizers have a positive effect on the yield components of common bean though to a varying degree for the three varieties. Fertilization level 2 (*Tithonia*) had the highest number of pods and highest seed weight for all varieties, while control or no fertilizer (F1) had the lowest. Highest seed weight was obtained from PNG at fertilization level 2 (F2), while the lowest value was from GLP.190.S (V1) at fertilization level 1 (F1). However, the highest 100-seed weight was obtained at fertilization level

4 (F4) in the variety GLP.190.S (V1), while PNG (V3) had the least. Thus there was a significant difference in the weight of 100 bean grains among the varieties tested. The mass of 100 bean grains is an agronomic characteristic that depends on the variety and is measured in grams. GLP-190S with the highest 100-seed weight has large grains while PNG with small grains had the least weight. According to Mboussi et al. (2012), this characteristic which is variety specific can also be influenced by environmental factors like diseases (web blight, ALS) and drought that can reduce the grain mass. From the findings, it showed that the application of increasing doses of both organic and inorganic fertilizer produced significant effects for all yield components. These results corroborate with the results presented by Zucareli et al. (2006) and Pela et al. (2009) who reported significant increases in yield components of common bean with increasing rates of fertilizer application. In the present study, the physicochemical properties of the soil were moderate in organic matter (OM), nitrogen, potassium, calcium, magnesium, phosphorus and also moderate soil pH, thus favouring the growth and productivity of common bean. Both organic and inorganic fertilizers contain the essential elements nitrogen, phosphorus and potassium (NPK) which are very important in promoting the growth and yield of plants. However, their composition (percentage) and their effects on growth of the plant differ significantly, as evident from the present study. Here *Tithonia* (Mexican flower) as organic fertilizer produced the highest pod number and seed weight for all varieties compared to the other nutrients. This can be partially attributed to the fact that *Tithonia* contains a higher amount of organic matter which tends to reduce bulk density. Organic matter is known to reduce soil compaction. Also, increased organic matter and associated improvement in soil texture should have enhanced infiltration of rain water leading to improved retention and availability of water in the soil. Atayese and Liasu (2001) found that soil under *Tithonia* and siam weed have higher pH propensity, moisture content, N, P, K, Ca, Na, mycorrhizal fungi spores and earthworm casts density and lower bulk density compared with bare soil. *Tithonia* is known to be rich in N, P, and Ca (Liasu and Achakzai, 2007). These qualities greatly favour the growth and development of common beans. Just like *Tithonia*, poultry manure (F3) greatly improved the various yield components compared to mineral fertilizer (F4) and control (F1). Poultry manure is also known to be an excellent organic fertilizer as it contains high N, P, K and other essential nutrients (Farhad et al., 2009). It has been reported to supply P more readily to plants than other organic sources (Garg and Bahla, 2008). Uwah et al. (2012) reported that poultry manure increased soil pH, organic matter content, available P, exchangeable cation and micro nutrients, reduced exchangeable Al and Fe contents and bulk density. The positive response of common bean to chicken manure application could be due to the reduction of soil pH by the manure that makes the nutrient such as phosphorus more available to the plants. Some researchers have concluded that increasing levels of phosphorus fertilizer application have been known to improve the number of pods and seeds per plant (Turuko and Amin, 2014). Phosphorus is known to promote the formation of nodes and pods in legumes (Buttery et al., 1987). In addition to increasing the soil fertility, poultry manure amends the soil by adding organic matter to the soil. Although the rate of organic matter decomposition in poultry manure varies with temperature, drainage, rainfall and other environmental factors like organic matter of the soil, poultry manure greatly improves water holding, soil aeration, soil structure, nutrient retention and microbial activities. Yields of beans can be reduced as much as 60 to 75% in soils that are unable to release sufficient P levels during the growing season. Balbhim et al. (2015) found out that organic fertilizer increased growth, yield pods in cluster bean followed by chemical fertilizer as compared with the control. Organic fertilizer like cow dung has been known to increase pod weight, pod dry weight, and total yield of French bean (Olfati et al., 2012). All the aforementioned results agreed with the present results which indicated that all treatments increased the productivity of common bean over control (F1).

Although organic manures (OM) have to mineralize to release their nutrients, which may lead to poor response in the season of application, *Tithonia* is classified as a high-quality OM (Jama et al., 2000) hence it decomposes very fast and is able to release N at rates that match the crop demand. In addition, OM such as *Tithonia* has been found to reduce P-fixation therefore increasing P availability in soils (Nziguheba et al., 2000). When the soil is fertile, the plant spacing is optimum and the climatic conditions are ideal, the number of pods per plant and the number of grains per pod will be expression of the genetic potential of the variety. A deficiency in soil nutrients or water deficit during flowering may reduce the number of pods per plant, but if these deficiencies occurred at grain filling stage, it may result in reduction of the mass of 100 grains, but number of grains per pods will be constant as it is variety dependent (Mboussie et al., 2012). The varieties with the higher number per pod did not necessarily have the higher number of grains per pod.

Conclusion

The study indicated that the use of the fungicide Agreb greatly reduced ALS disease severity and improved yields of the sprayed crops. The least severity was recorded in V3 (PNG), while the highest severity was recorded in V1 (GLP-190-S). The research work also revealed that fertilization, whether organic or inorganic, was found to enhance yield components of the three varieties of common bean. Highest number of pods and seeds were obtained from crops that received *Tithonia* treatment (F2) while the lowest number of pods was obtained from mineral fertilizer treatment (F4). In terms of weight, PH201 (V2) had the highest seed weight while GLP-190-S (V1) had the lowest. For 100 seed weight V1 had the highest weight while V3 was the least.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

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