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Full Length Research Paper

Effect of different rates and methods of benomyl and mancozeb application on delay in senescence and grain yield of cowpea (*Vigna unguiculata (L) Walp*) under different cropping season

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Field assessment of different rates and methods of three fungicide applications on delay in senescence (DS) and grain yield of cowpea during the early and late cropping season of 1999 respectively was conducted. The benomyl treatment applied via the combination of seed and foliar methods at the highest rate of 0.75 + 0.75kg a.i/ha gave the highest percentage delay in senescence (100%) as well as highest grain yield of (2.1 t/ha) which were significantly different (p<0.05) from the untreated control plots and mancozeb plots. Application via the seed gave the lowest percentage delay in senescence (20.3%) and the lowest grain yield of (0.24 t/ha), respectively, for early cropping season. Similar trends were recorded during late season for all these parameters, though they were lower than that of early cropping season.

Key words: Benomyl, mancozeb, cowpea, delay in senescence, grain yield.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L) Walp) is a member of the family Leguminosae. Out of 170 species in the genus, *V. unguiculata* is the most important grain legume of the world (Onwueme and Sinha, 1991). Cowpea is the second most important food grain legume crop in tropical Africa. Nigeria, Niger, Burkina faso, Uganda and Senegal grows cowpea for the market (Rachie, 1985). Cowpea is widely grown as a subsistence crop for home use in nearly all Africa countries south of the Sahara. It is predominant source of plant protein for human nutrition in Africa especially Nigeria (Adebitan, 1991).

World Cowpea production was estimated at 12.27 million tones from 70.70 million hectares in 1992 (FAO, 1993). In most developing countries the average diet is high in starch and low in protein (Ranchie, 1985). Cereals are excellent sources of energy but comparatively poor source of protein, whereas cowpea provides some amounts of high-quality protein. The protein of cowpea contains relatively high amount of the essential amino acids, lysine and trytophan, and thus usefully compliments the protein supply by cereals, in which the contents of lysine and tryptophan are relatively low (Singh and Singh, 1992).

Unfortunately, the indiscriminate use of potentially hazardous fungicides poses a serious threat to the environment. The non-target effect of fungicides on beneficial organisms such as nitrogen fixers, residential antagonists and mycorrhizal are the other disadvantage of fungicide application (Vyas, 1988). To tackle these global problems, effective and compatible strategies are essential. It is therefore becomes imperative to ascertain specific effects of each fungicides on specific mycoflora populations because different mycoflora responds to diff-

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erently to different fungicides. Therefore, the objective of this study is to evaluate the effect of different rates and methods of benomyl and mancozeb application on the delay in senescence and grain yield.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the teaching and research farm of Faculty of Agricultural Sciences, Ladoke Akintola University of Technology (4°10[1] East and 8°10[1] North), Ogbomoso, Oyo State, Nigeria in 1999. The climate of Ogbomoso is mostly influenced by the North-east and the South-west Trade winds. The former is cold with drying effect which starts from November to March while the latter is warm and moist, starts from April and ends in October. The area has maximum temperature of 33°C and minimum temperature of 28°C. The humidity of this area is high (74%) all year round except in January, when the dry wind blows from the North. The annual rainfall is over 1,000 mm. The soil is a moderately well drained, ferruginous tropical soil (Browfield, 1969), with a sandy loam texture. The soil lies over metamorphic rocks.

The vegetation of the area is composed of weed species like *Tithonia diversifolia, Tridax procumbens, Talinum triangulae, Imperata cylindrica, sedges spp* etc. The site used has a cropping history of maize/cassava/cowpea intercrop spanning over eight years and was left fallow for a period of two years before the experiment. High level of brown blotch disease of cowpea has been observed in the past years on cowpea plant.

Experimental procedures and design

The experiment was conducted between the month of July and September, repeated between September and November, 1999 at the experimental field of the Teaching and Research farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria under artificial/natural inoculation conditions. Seeds of cowpea cultivar Ife brown (semi-erect determinate day length neutral and highly susceptible to brown blotch disease) was obtained from the International Institute of Tropical Agriculture (I.I.T.A), Ibadan.

Two fungicides, one from the class of benzimidazole (benomyl) and one from the class of dithiocarbamate (mancozeb), which are commonly used in the control of foliar disease of cowpea was applied at two different rates. R_1 recommended rate (1.0 and 2.5 kg a.i./ha) and R_2 (1.5 and 2.8 kg a.i./ha) for benomyl and mancozeb, respectively. In this experiment three different types of fungicidal application were employed. The experiment was 2 x 2 x 3 factorial design with three replication; that is, two fungicides, each having two rates; R_1 (1.0 and 2.5 kg a.i./ha) and R_2 (1.5 and 2.8 kg a.i./ha) for benomyl and mancozeb, respectively, using three methods of application; foliar, seed and combination of foliar and seed application methods. There were thirteen (13) plots per blocks including a control in which there was no fungicide for the whole experiment. The field was ploughed twice and marked with wooden pegs into plots and blocks according to the design of the experiments. The plot size was 3.0 m x 2.4 m while the spacing between the plots and blocks was 1.0 m. The plot treatments are as follows:

1. Benomyl-seed treatment at R_1;
2. Benomyl-seed treatment at R_2;
3. Mancozeb-seed treatment at R_1;
4. Mancozeb-seed treatment at R_2;
5. Benomyl-Foliar treatment at R_1;
6. Benomyl-foliar treatment at R_2;
7. Mancozeb-foliar treatment at R_1;
8. Mancozeb-foliar treatment at R_2;
9. Benomyl-seed + foliar treatment at R_1;
10. Benomyl-seed + foliar treatment at R_2;
11. Mancozeb-seed +foliar treatment at R_1;
12. Mancozeb-seed +foliar treatment at R_2; and
13. Control (no fungicides).

For benomyl, R_1= recommended rate = 1.0 kg a.i./ha; R_2= higher than recommended rate = 1.5 kg a.i./ha. For mancozeb, R_1= recommended rate 1 = 2.5 kg a.i./ha; R_2 = higher than recommended = 2.8 kg a.i./ha.

When a combination of seed and foliar application method was used, the rates of fungicides application was divided into two equal halves, in which one part was for seed treatment and the other half foliar treatments application. The choice of fungicides and their rates of application were based on the recommendation of Oladiran (1990) and Fontem and Bounda (1998).

Seeds of Ife brown that was used for planting seed treatment method plots was thoroughly treated with different fungicides separately according to the plot treatments while that of foliar treatments and control plots was not treated before planting. Three seeds were planted per hole at the spacing of 30 cm intra row and 60 cm inter row in the months of July and September 1999, respectively, in all the plots. Seedlings were then thinned to one healthy seedling per hole a week later. The uprooted seedlings were transplanted to empty stands as necessary to obtain a complete stand in each plot. Culture of *Colletotrichum truncatum*, the fungus responsible for brown blotch disease of cowpea was collected from I.I.T.A. pathogen culture laboratory unit, which was later multiplied on potato dextrose agar (PDA). The spores at concentration of 10^4 per ml of inoculum determined with hemocytometer was sprayed thrice during the evening hours at 5 days intervals starting from three weeks after planting (Adebitan, 1991). The fungicide was mixed separately in water and applied foliarly according to the plot treatment using CP 10 Knapsack sprayer, starting from 35 days after planting i.e. at the onset of flowering. Karate insecticide was also applied at recommended dose of 60 ml/10 litres of water uniformly on all the cowpea plants in all the plots for crop protection against pod borers and enhancements of flower formation. This was repeated every fortnightly till the pods started to dry.

Data collection

Disease incidence due to brown blotch was scored according to Oladiran (1990) and Adebitan (1991), which is as follows: 0.0 = no symptoms, 0.5 = 1 - 10% total surface area of the plant part infected, 1.0 = 11 - 20% total surface area of the plant part infected, 1.5 = 21-30% total surface area of plants part infected, 2.0 = 31-40% total surface area of plants part infected, 2.5 = 41-50% total surface area of plants part infected, 3.0 = 51 - 60% total surface area of plants part infected, 4.0 = 71 - 80% total surface area of plants part infected, 4.5 = 81 - 90% total surface area of plants part infected, and 5.0 = 91 - 100% total surface area of plants part infected. The disease incidence was scored at weekly intervals starting from seven days after the last spray of inoculum. Infected plant parts per plot were assessed and the disease severity index (DSI) was calculated by the formula:

$$D.S.I = \frac{On_o + 1n_1 + 2n_2 + \ldots + 5n_5 \text{ X100}}{nt\,(n_{c-1})}$$

Table 1. 1999 average monthly rainfall data for Ogbomoso Area (Southern Guinea Savanna Zone).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Rainfall (mm)	0.0	15.1	68.0	118.3	171.3	296.2	179.4	138.1	268.9	218.5	35.7	-

Source: Nigeria Airport Authority Meterology Station Ilorin, Kwara State, Nigeria.

Table 2a. Effects of different rates and methods of benomyl and mancozeb application on brown blotch disease severity (DSI)[a], delay of senescence (DS) (%)[b], total mycoflora population (10^6), percentage pod fill and grain yield (t/ha) of cowpea during 1999 early (July-Sept.) cropping season.

Early cropping season 1999						
Treatment	**Rate kg a.i/ha**	**DSI**	**DS (%)**	**Total mycoflora population (10^6)**	**Pods fill (%)**	**Grain yield (t/ha)**
SBR_1	1.0	2.5	61.5	105.0	48.1	0.91
SBR_2	1.5	2.0	66.2	91.0	50.1	1.00
SMR_1	2.0	4.5	20.3	111.0	20.1	0.24
SMR_2	2.8	4.5	20.3	109.0	20.1	o.24
FBR_1	1.0	2.0	70.4	83.0	66.1	1.15
FBR_2	1.5	1.5	75.1	77.0	72.3	1.30
FMR_1	2.0	4.0	30.1	48.0	42.3	0.33
FMR_2	2.8	3.5	30.1	32.0	50.1	1.00
$F+SBR_1$	0.50+0.50	1.2	92.3	98.O	88.2	1.80
$F+SBR_2$	0.75+0.75	1.0	100.0	90.0	94.1	2.10
$F+SMR_1$	1.00+1.00	4.0	30.2	48.0	43.1	0.83
$F+SMR_2$	1.40+1.40	3.5	30.2	32.0	50.1	1.00
Control (water)	00.0	4.5	20.3	114.5	20.1	0.24
S.E		0.02				0.01
C.V		12.3				15.5
$L_{SD0.05}$		1.0				0.43

Data are derived from three replications. a = brown blotch disease caused by *C. truncatum*; c = delay in senescence was low (50%), moderated (75%) and high (100%) and showed presence of high level chlorophyll in the leaves; S = seed treated; B = benomyl; M = mancozeb; F = foliar treated; F+S = combination of seed and foliar treated; R_1 = recommended rate, 1.0 kg a.i/ha for benomyl and 2.0 kg a.i/ha for mancozeb; R_2 = higher than recommended rate, 1.5 kg a.i/ha for benomyl and 2.8 kg a.i/ha for mancozeb.

Where, n = number of diseased plants in each categories, nt = total number of plants, nc = total number of diseased plants (Oladiran, 1990; Adebitan, 1991).
Proportion of pod fill was also estimated according to Ojo, 1994 as:

$$\% \text{ pod fill} = \frac{\text{No of filled loculi in 20 pods}}{\text{Total no of loculi in 20 pods}} \times 100$$

Delay in senescence was scored following the standard rating of Gachichi (1981), which is as follows; low 1-50%; moderate = 51-75%; High = 76-100% and showed presence of high level of chlorophyll in the leaves. In addition, the total grain weight per plot was determined. Table 1 shows the average monthly rainfall data for the area in 1999. It shows that rains started in February (becoming steady in April) and end in November.

RESULTS

Results on the different rates and methods of benomyl and mancozeb application on brown blotch disease severity, delay of senescence, total mycoflora population, percentage pod fill and grain yield of cowpea during early and late season cropping of 1999 are presented in Table 2. The data showed that in the early cropping season of 1999, all the fungicidal treatments except that of mancozeb at both rates gave lower disease severity index compared to that of the control via seed and foliar application. But the benomyl applied via seed and foliar at the rate of 1.5 kg a.i /ha gave the lowest disease severity index of 1.0, which was significantly different ($p<0.05$) from all other treatments except that of the same treatments at R_1 (1.0 kg a.i/ha) (Table 2a). This was followed by the same treatment at 1.0 kg a.i/ha. While highest disease severity of 4.5 was recorded for the mancozeb treatment when applied via seed at the two rates as well as for the control untreated plot.

The data also showed that benomyl treated plots gave high percentage delay in senescence, which ranges between 61.5 - 100%; but the lowest percentage delay in senescence of 20.3% was noticed in the mancozeb treated plot when applied via the seed as well as in the control untreated plot (Table 2b). The highest percentage

Table 2b. Effects of different rates and methods of benomyl and mancozeb application on brown blotch disease severity (DSI)[a], delay of senescence (DS) (%)[b], total mycoflora population (10^6), percentage pod fill and grain yield (t/ha) of cowpea during 1999 late (Sept - Nov) cropping season.

			Late Cropping season 1999			
Treatment	**Rates kg a.i/ha**	**DSI**	**DS (%)**	**Total mycoflora population (10^6)**	**Pod fill (%)**	**Grain yield (t/ha)**
SBR_1	1.0	2.5	50.2	90.0	40.2	0.70
SBR_2	1.5	2.0	55.1	80.0	45.3	0.81
SMR_1	2.0	4.5	20.1	100.0	18.1	0.15
SMR_2	2.8	4.5	20.1	96.0	18.1	0.15
FBR_1	1.0	2.0	60.3	65.0	60.1	1.00
FBR_2	1.5	1.5	65.3	56.0	65.3	1.20
FMR_1	2.0	4.0	20.1	36.0	36.1	0.68
FMR_2	2.8	3.5	20.1	22.0	45.1	0.90
$F+SBR_1$	0.50+0.50	1.5	82.1	78.0	80.1	1.60
$F+SBR_2$	0.75+0.75	1.0	90.1	70.0	89.3	1.90
$F+SMR_1$	1.00+1.00	4.5	20.1	34.0	38.1	0.56
$F+SMR_2$	1.40+1.40	3.5	20.1	20.0	45.3	0.82
Control (water)	00.0	4.5	10.2	99.0	18.1	0.15
S.E		0.03				0.02
C.V		12.3				14.6
$L_{SD0.05}$		0.9				2.50

Data are derived from three replications. a = brown blotch disease caused by *C. truncatum*; c = delay in senescence was low (50%), moderated (75%) and high (100%) and showed presence of high level chlorophyll in the leaves; S = seed treated; B = benomyl; M = mancozeb; F = foliar treated; F+S = combination of seed and foliar treated; R_1 = recommended rate, 1.0 kg a.i/ha for benomyl and 2.0 kg a.i/ha for mancozeb; R_2 = higher than recommended rate, 1.5 kg a.i/ha for benomyl and 2.8 kg a.i/ha for mancozeb.

Figure 1. Cowpea plant from both the treated plot with benomyl and untreated plot at 90 days after plant during the early cropping season (Sept. – Nov. 1999).

delay in senescence of 100% was noticed in the benomyl treated plot when applied via the combination of seed and foliar method at the highest rate of 1.5kg a.i/ha, which was not significantly different from the same treatments at the lowest rate of 1.0 kg a.i/ha under the early cropping season (Table 2a). Infact, the crop from this benomyl treated plots was still green and producing pods at 90 days after planting (fifteen days after harvest) when crops in other treatment plots have completely dried up during the early cropping season (Figure 1). This treatment method gave a higher delay in senescence than when the same benomyl was foliarly applied.

Furthermore, there was a differential response from the mycoflora to fungicidal treatments as revealed in (Table 2). Mancozeb, when applied foliarly at higher rate of 2.8 kg a.i/ha, gave the lowest total mycoflora population of 32 x 10^6 which was significantly lower ($p<0.05$) compared to other treatments. The highest total mycoflora population of 114 x 10^6 was recorded on the untreated control plot it was also observed that increase in the rate of fungicidal application results in decrease in the population of mycoflora. Benomyl when applied via the combination of seed and foliar method gave a total mycoflora population of 98.0 x 10^6 and 90 x 10^6, respectively, at the two rates of application during the early cropping seasons (Table 2a).

Also, this treatment of benomyl when applied via the combination of seed and foliar method gave the highest percentage cowpea pod fill of 94.0% at the highest rate of fungicidal application which was not so much different from that of lower rate of fungicidal application (Table 2). The lowest percentage pod fill was recorded for the control plot (20.1%) and mancozeb when it was applied via the seed (20.1%) at both rates during the early cropping season (Table 2). It is worth noting that the percent pod fill was higher when benomyl was applied via the combination of seed and foliar method than when it was foliarly applied (Table 2).

The highest grain yield of 2.1 t/ha was recorded for benomyl when applied via the combination of seed and foliar treatment at the highest rate of 1.5 kg a.i/ha, which was significantly different ($p<0.05$) from all other treatments except that of the same fungicidal treatments at the lowest rate of 1.0 kg a.i/ha which gave 1.8 t/ha grain yield during the early cropping season (Table 2a). When benomyl applied via the combination of seed and foliar method, the grain yield (1.8 t/ha) at the lower fungicidal rate of 1.0 kg a.i/ha was significantly different ($p<0.05$) from when it was applied via foliar method only the yield 1.0 t/ha (at higher rate of 1.5 kg a.i/ha). While the lowest grain yield of 0.24 t/ha was recorded for the control - untreated plots as well as mancozeb when applied via seed at both rates, respectively, during the early cropping season.

Similar trends of early cropping season 1999 results were observed during the late cropping season of 1999 for disease severity index, delay in senescence, percentage pod fill and grain yield respectively. But the results for all these parameters were higher during the early season than late season of 1999 except that of disease severity index which was the same (Table 2).

DISCUSSION

The result of this study showed that benomyl treated plot gave high percentage delay in senescence. The treatment combination of seed and foliar application of benomyl gave 100% delay in senescence while the mancozeb treated and control plots, respectively, gave 20.3% delay in senescence. The prolonged maintenance of green leaf area by benomyl is well known. Ross (1975) observed the same phenomenon on soybeans sprayed with benomyl. This perhaps is due to the fact that benomyl acts like growth hormone (cytokinin) which was not common to mancozeb as reported by Vyas (1988).

It is also evident from the result of this study that benomyl when applied via the combination of seed and foliar treatment gave the highest grain yield of 2.1 and 1.9 t/ha for the early and late cropping seasons, respectively. The lowest yield of 0.19 and 0.11 t/ha was obtained from the uncontrolled plot for both cropping seasons, respectively. In addition, there was a significant different between the yield of benomyl, when foliarly applied alone and when applied via the combination of seed and foliar method. The high level of grain yield obtained when benomyl was applied via the combination of seed and foliar application over that of benomyl foliarly applied could probably be due to high percentage pod fill, low disease severity index (1.0), as well as high level of delay in senescence. This method of benomyl application have characteristics of keeping the foliage, stem and cowpea pod green longer than other methods of application and the control plots. This caused delay in harvesting; that at 90 days after planting, the cowpea plants was still flowering and producing pods. This delay induced by this benomyl via seed and foliar method of application may contribute to yield increases simply by providing a few more days, for seed to fill as reflected in the percentage pod fill which was higher than that of benomyl when only foliarly applied. The prolonged maintenance of green leaf area by benomyl is well known. Horn et al. (1975) and Ross (1975) observed the same phenomenon on soybean sprayed with benomyl as well as Oladiran (1990) on cowpea and Vyas (1988) on groundnut. Ojehomons (1970) and Rachi (1985) have suggested that delayed senescence would be a positive advantage towards increased grain production in cowpea

Conclusively, the composition of phylloplane mycoflora of cowpea leaves is determined by the inter play of many factors, including fungicides and their methods of application. It is clear that fungicides applied to cowpea plants have more than one role; they may alter the mycoflora directly by affecting particular components. They may also affect the balance of phylloplane mycoflora, so that antagonistic action for these fungi may be inhibited, and potential bio-control agents may be affected leading to an aggravated disease situation. Non-specific (non-systemic) fungicide results in major shifts in the micro biological equilibrium and induce resistance in pathogens more frequently than do selective or systemic fungicides which cause minimal disturbance in the component of mycoflora on the leaves. Thus, it is clear that indiscriminate use of benomyl and mancozeb may have indirect effect on plant, diseases and phylloplane mycoflora. Therefore, understanding the interacting factors that affect the phylloplane mycoflora of cowpea in the presence of fungicides might lead to a way of fostering indigenous biological control agents and eventually facilitate an integrated approach of plant disease management with reductions in cost as well as environmental pollution by the fungicides.

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