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Influence of Mulch Materials on Population of Plant Parasitic Nematode, Growth and Yield of Okra (*Abelmoschus esculentus* L. Moench)

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Abstract: *A field experiment was conducted at National Horticultural Research Institute Idi-ishin, Ibadan to investigate the influence of mulching materials on population of plant parasitic nematodes, weed density, soil moisture, temperature content, growth and yields of okra (Abelmoschus esculentus L. Moench). The mulch materials were dried leaves of Azadirachta indica , Terminalia catappa , Eugenia uniflora, Pannicum maximum (grass straw) and plastic mulch with hoeing and no weeding as control. The experiment was conducted between June to September 2010. The experimental design was randomized complete block design in three replications. Data were collected on Vegetative Growth (VG), Gall Indices (GI), nematode reproduction. All data were analysed using ANOVA (p=0.05).*

GI was reduced by 76.91% in black plastic mulch, 69.28% in Azadirachta indica, 61.43% in no weeding control, 46% in Eugenia uniflora, 23.09% in Terminalia catappa and 15.24% in Pannicum maximum as compared to Hoeing weeding control. The root-knot nematode in the soil were also reduced by 96.63%, 89.28%, 76.81%, 53.63%, 50.72% and 24.63% in black plastic, no weeding control, Eugenia uniflora, Terminalia catappa, Azadirachta indica and Pannicum maximum mulching materials respectively as compared to hoe weeding control. The mulching materials significantly affected the growth and yield of okra (P≤0.05) with black plastic mulch resulting in the highest number of pods (30.0), fresh weight (378.0g) and dry weight (58.3g) per plant. Highest soil moisture retention was observed from hoe weeding plot (6%) while the highest soil temperature was recorded from black plastic mulch (25^{o}C) and the least weed density (6.0 plant/m^{2}) weed fresh weight (100.0g) and weed dry weight (34.0g) was also recorded on plastic mulch plot. These were significantly lower P≤0.05 compared with other mulched materials and no weeding control.
Therefore mulch materials reduced the root-knot nematodes in the soil, weed interference in okra production while, enhancing moisture retention promotes faster plant growth and yield of okra.
Keywords: *Gall indices, Mulch materials, Nematode population, soil moisture and weed density*

I. Introduction

Okra (*Abelmoschus esculentus* L. Moench) is a member of the family Malvaceae and is a popular vegetable of considerable value. It is a widely cultivated vegetable of nutritional importance that provides essential components of the daily food intake in most rural and urban areas, and contributes to the nutritional balance of the diet. It is among the most commonly cultivated vegetables throughout Nigeria and other tropical regions because of its much liked mucilaginous or 'draw' property of the fruit and its ability to grow well under most tropical conditions (Akoroda *et al.,* 1985, Vincent *et al.,* 2005).

In Nigeria, okra is mostly cultivated by small scale farmers and it is mainly grown for home consumption and often intercropped with yam and maize. Common okra (*A. esculentus* L. Moench) is mainly grown for market gardening in areas with a limited rainfall or under irrigation. In the wet season, the tender fruits are sliced, boiled and used as vegetable, while excess of it are sliced, dried and stored for use in the dry season. It is a good source of calcium derived from fruits and leaves (90 mg/100g and 70 mg/100g) respectively while its secondary use is the oil from its seeds whose oil content is about 20%. Amino acids found in *A. esculentus* seeds compare favourably with those in poultry eggs and soybean (Hamon and Charrier, 1997).

Root-knot nematodes affect a wide range of crops, particularly vegetables. *M. incognita* is a major economic pest of food legumes in the tropics and subtropics. Many crops grown as vegetables are susceptible to the nematode particularly tomato, aubergine, okra, cucumber, melon, carrot, gourds, lettuce and peppers (Dobson *et al.* 2002)

The control of these nematodes by nematicides has been effective but they are costly, cause ecological hazards and are environmentally unsafe. This has greatly reduced their use by many farmers (Salawu, 1988; Adesiyan *et al*., 1990). Today, the world is becoming more and more aware of the environmental dangers posed by these chemicals. They are now currently being withdrawn from the market for various reasons including water and atmospheric pollution which continue to render the earth planet unsafe for mankind (Egunjobi, 1992). Therefore, there is an urgent need to evaluate alternative control methods that are cost-effective, environmentally-safe and accessible to farmers for effective control of the nematodes.

II. Materials And Methods

Field experiments were conducted between June to September, 2010 at one of the vegetable experimental fields noted to be infested with root-knot nematode over the year was cleared, ploughed, harrowed and divided into seven plots, each plot had an area of $9m^{2.}$ The experimental site was situated at National Horticultural Research Institute, Idi – Ishin, Ibadan (Latitude 7^0 54'N, and Longitude 3^0 54'E, 213 metres above the sea level), Nigeria. Ibadan lies in the Derived savannah of south-west Nigeria. Generally, the monthly rainfall distribution pattern for Ibadan is bimodal with peaks in June and September. Annual rainfall ranges from 1200 to 1450 mm spanning over eight months (March to October) with a dry spell in August. Okra seeds LD 88-1 variety was obtained from the National Horticultural Research Institute (NIHORT) Ibadan, Oyo State, which is a very popular, early maturing and high yielding variety grown in Nigeria.

The experiment consisted of seven treatments laid out in a randomized complete block
design with three replications. The treatments consisted of using Black plastic, *Terminalia catappa* (Tropical almond), *Azadirachta indica* (Neem), *Eugenia uniflora* (Pitanga) leaves and grass straw (*Pannicum maximum*) as mulching materials. The mulch material was applied at 10 t/ha, which resulted to 9 kg mulch material per plot of 3 m x 3 m.

Soil samples were collected from each of the 21 plots into labeled polyethylene bags before planting. These were taken to the laboratory for extraction of nematodes using the method of (Whitehead and Hemming, 1965). The nematodes were identified under a light microscope while population estimation was done with the aid of Doncaster counting dish and stereomicroscope.

The okra was sown on June 2010. Two seeds were planted per hole at a spacing of 60 x 30cm to give a plant population of 55, 556 plants /ha. The emerged seedlings were later thinned to one. Weeding was manually done on plots with hoeing as treatment 3 WAS and 7 WAS using hoe.

Fresh mature okra pods were harvested at three days interval from 8 WAS. The fruits collected from each of the plants sampled were weighed and recorded accordingly.

Data were taken from four plants in the middle rows and the parameter taken included: plant height (PH) cm, stem diameter (SD) cm, number of leaves (NL), number of harvested pods, fresh and dry weight of pods (g), fresh root weight, Gall indices (GI) were assessed on a 0-to-5 scale (0 = no infection, 1 = 1%-20% of roots galled; 2 = 21%-40% of roots galled; 3 = 41%-60% of roots galled; 4 = 61%-80% of roots galled; and 5 = 81%-100% of roots galled, Nematode populations were estimated from 250ml soil and entire okra roots at the end of the experiment. Species composition and weed density were also determined. Dry weight was determined after the plants were dried for 48 hours at 75^0C in an oven to constant weight. Soil temperature was taken using soil thermometer at 5cm depth and soil moisture taken using tensiometer.

The data collected were subjected to analysis of variance (ANOVA) using SAS analysis and means separated by Duncan Multiple Range Test (DMRT).

III. Results And Discussions

Effects of mulch materials on growth and yield parameters of okra

Plant height, stem diameter, number of leaves and leaf area were significantly ($P \leq 0.05$) influenced by the mulching materials. The highest plant height was recorded from the plot covered with plastic mulch which was significantly from other mulch materials used. However, the least plant height was recorded from no weeding plot control (Fig. 1). Mulching increased the nutrient composition of soil, provides a good protection against raindrops and runoff energy and limits weed competition (Akobundu, 1984).

The highest fresh shoot weight was produced by plots covered with plastic mulch which was significantly different from plots treated with other amendments. No weeding control had the least fresh shoot weight. However, the highest fruits were recorded on plot that was covered with plastic mulch which was significantly different from other mulching materials (Table 1)

Effects of mulch materials on Plant Parasitic Nematodes population, Root damage of Okra plant, soil moisture, soil temperature and root architecture

The plots covered with plastic mulch had the lowest mean galling indices while hoe weeding control had the highest galling index. The plots covered with plastic were the least galled (1.00) this was not significantly lower than the galling in plot covered with *Azadirachta indica* (1.33) (Table 2). The highest number of eggs in root were recorded from the hoe weeding control which was significantly different from other soil mulching materials. However, the least number of eggs in the root and juveniles in soil was obtained from the plot covered with plastic mulch (Table 2). The highest soil moisture was obtained from hoeing plot but not significantly different from other mulched plots Table 2. Black plastic and other mulch materials significantly ($P \leq 0.05$) affected soil temperature, meanwhile, the high temperatures induce changes in soil volatile compounds that are toxic to organisms already weakened by high temperature (Ramesh Pokharel, 2011). The plant parasitic nematodes found in the soil were also reduced especially in soil covered with black plastic, this findings was collaborated with Ramesh Pokharel (2011) in which the plant parasitic nematodes found in soil solarized with plastic mulch reduced drastically. Similar trend was also observed for root length, while root spread was highly influenced. The surface mulch favourably influences the soil moisture regime by controlling evaporation from the soil surface (Pawar *et al.*, 2004; Adekalu *et al.*, 2008) and facilitates condensation of soil water at night due to temperature reversal. Mulches also promote crop development, early harvest and increase yields as found by Adekalu *et al*. (2008).

The present results also indicated that non mulched plots had the least soil moisture content than mulched plots. It means that mulch prevents soil water evaporation and helps in retaining soil water. According to Ramakrishna *et al.* (2006), evaporation from soil accounts for 25-50% of the total quantity of water used, while Sharma *et al*. (1990) noted that higher moisture increased root proliferation and thus enhanced availability of nutrients to crop roots. The mulch materials raised soil temperature and increase root density (Lal, 1975). This could also cause lateral growth and abundance of root under these mulch materials, which results in higher nutrient use efficiency from the soil surface.

Effects of mulching materials on total plant parasitic nematode population, weed density, weed biomass and weed specie composition

Black plastic mulch recorded the least total plant parasitic nematode, weed density, weed fresh and dry weight and weed specie composition which was significantly ($P \leq 0.05$) lower than other mulched plots and the control (Table 3). Highest total plant parasitic nematode was obtained from hoe weeding control. Meanwhile the highest weed density, fresh and dry weight of weeds and weed specie composition was obtained from no weeding control plot and was significantly higher than other mulched plot. Degree of weed suppression, however, often depends on the type and amount of residue used, the weed species present, and on prevailing environmental conditions. For instance, in field trials by Teasdale and Mohler (1993), several weed species had greater emergence in plots receiving low rates of rye or hairy vetch (*Vicia villosa*) residue than in plots receiving none, or high rates. Increased emergence at low mulch rates has been observed in subsequent studies. It is most evident during drought periods, and when the weed seeds are on the soil surface. Soil moisture is higher in mulched plots relative to bare controls (Teasdale and Mohler 1993). Thus, small amounts of residues on the soil surface may provide more favorable soil moisture conditions for germination than bare soil, but lack sufficient soil coverage to appreciably reduce emergence of weed seedlings (Hamrick and Lee 1987, Teasdale and Mohler 1993, Buhler *et al.*, 1996).

These findings are in accordance with Ramakrishna *et al*. (2006), who reported that optimum soil moisture ensures good emergence and seedling growth during early and mid season, and these results also agreed with those reported by Olabode *et al*. (2004). A better understanding of the way in which crop residues affect soil water potential and ultimately emergence patterns for different annual weed species will allow extension of the mulch-weed emergence model of Teasdale and Mohler (2000). Better understanding of when and to what extent mulch suppresses weeds will improve use of mulch for weed management.

The plant parasitic nematodes found majorly in the soil after the experiment was root-knot nematode *Meloidogyne incognita*, which was significantly higher in number than other plant parasitic nematodes found such as *Pratylenchus* spp, *Scutellonema* spp, *Xiphinema* spp. and *Helicotylenchus* spp. (Table 4)

IV. Conclusion

In this study, covering soil surface with mulch materials such as neem leaves, almond leaves, black plastic and crop residue through moisture retention enhanced vegetative growth and yield of okra compared with un-mulched (hoeing) plots. Also, these mulch materials reduced the need for fertilizer application, and reduced weed emergence and weeding regime in okra production. Mulches may help decrease herbicide use by providing a non-chemical means of reducing impact of weed interference in okra farm.

Plastic mulches have various beneficial effects on crops including an increase in soil temperature, the conservation of soil moisture, improve soil tilth and increase availability of essential plant nutrients, weed and plant parasitic nematodes control.

Mulching may be a useful tool for producers especially organic growers, to treat infested soil with parasitic nematodes and help control weeds. This might serve as an alternative to toxic, costly and non- friendly soil fumigants.

Table 1: Influence of mulching materials on growth and yield parameters of okra

Mulching materials (Treatments)	Plant height (cm)	Stem diameter (cm)	No of Leaves	Leaf Area (cm^2)	Shoot weight (g)	No of Pods/ plant	Pod fresh weight/ plant (g)	Pod fresh weight (m/ha)	Pod dry weight/plant (g)
Terminalia catappa	115.0b	2.0d	9.8a	234a	81.67cd	27.0b	284.0c	15.8c	36.3c *
Azadirachta indica	113c	2.2b	10.3a	265a	153.33b	24.0d	240.0e	13.3e	31.3d
Eugenia uniflora	95f	1.8e	12.0a	294a	120.00cb	25.0c	288.0b	16.0b	41.0b
Pannicum maximum	101e	1.8e	7.8a	287a	68.33cd	19.0f	162.0f	9.0f	19.0f
Black Plastic	127a	2.3a	15.0a	309a	245.00a	30.0a	378.0a	21.0a	58.3.0a
Hoeing **(control)**	108d	2.1c	11.1a	311a	63.33cd	23.0e	253.0d	14.1d	26.3e
No weeding (control)	63g	0.9f	8.8a	228a	48.33d	7.0g	146.0g	8.1.0g	11.3g

Means followed by the same letter in a column are not significantly different by DMRT at ($P<0.05$).

Table 2: Influence of mulching materials on Plant Parasitic Nematodes population, Root damage of Okra plant, soil moisture, soil temperature and root architecture

Treatments	Root weight (g)	Root Length (cm)	Gall indices	Egg Population in Root	J2 Population in 250ml soil	Soil Moisture (%)	Soil Temperature (^oC)
Terminalia catappa	65.00b	19.0d	3.33b	4200c	533.3bc	4.2a	24.0ab
Azadirachta indica	33.33c	21.3dc	1.33d	1467c	566.7bc	5.5a	23.3b
Eugenia uniflora	56.67cd	26.0a	2.33c	5267c	266.7cd	4.8a	24.1ab
Pannicum maximum	55.67cb	19.0d	3.67ab	42333b	866.7ab	5.8a	24.7ab
Black Plastic	33.0c	22.0bc	1.00d	1133c	38.7d	5.8a	25.0ab
Hoeing	115.00a	22.0bc	4.33a	103667a	1150a	6.0a	24.1ab
No weeding (control)	36.67c	24.4ab	1.67cd	1467c	123.3d	5.7a	24.3ab

Means followed by the same letter in a column are not significantly different by DMRT at ($P\leq0.05$).

Table 3: Influence of mulching materials on Nematode populations, weed density, weed biomass and weed specie compositon.

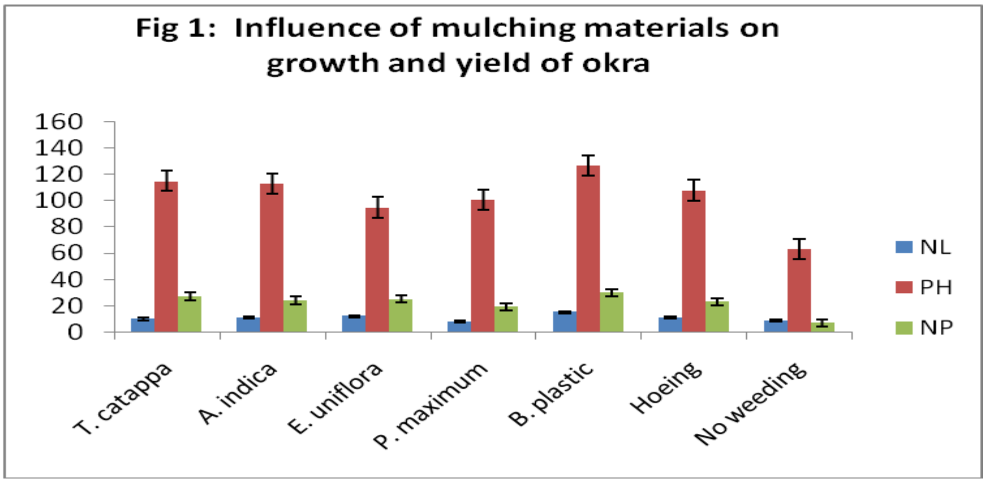
Mulching materials (Treatments)	Total Nematode Population	Weed Density (Plant/m^2)	Fresh weight of weeds (g/m^2)	Dry weight of weeds (g/m^2)	Weed specie composition (%)
Terminalia catappa	4733c	24.0f	390.0f	77.0f	9.0d
Azadirachta indica	2033c	32.0d	640.0c	118.0c	9.0d
Eugenia uniflora	5533c	53.0c	610.0d	114.0d	11.0c
Pannicum maximum	43200b	30.0e	400.0e	88.0e	13.0a
Black Plastic	1172c	6.0g	100.0g	34.0g	4.0e
Hoeing (control)	104817a	59.0b	730.0b	144.0b	11.0c
No weeding (control)	1590c	64.0e	850.0a	163.0a	12.0b

Means followed by the same letter in a column are not significantly different by DMRT at (P≤0.05).

Table 4: Plant Parasitic Nematodes found majorly in the soil mulch with *T. catappa*, *A. indica*, *E. uniflora*, Black plastic, Hoeing and No weeding.

Mulching materials (Treatments)	Root knot Nematode	Pratylenchus spp.	Xiphinema spp	Scrutellonema Spp	Helicotylenchus spp.
Terminalia catappa	400bc	65bc	20bc	10ab	38b
Azadirachta indica	453bc	58bc	10c	20a	25bc
Eugenia uniflora	200c	25c	5d	10bc	27bc
Pannicum maximum	520b	100a	50a	25a	120a
Black Plastic	20e	5d	3d	4c	7d
Hoeing (control)	950a	80a	15c	10bc	45b
No weeding (control)	50d	25c	10cd	8c	30b

Means followed by the same letter in a column are not significantly different by DMRT at (P≤0.05)



NL = Number of leaves
PH = Plant Height
Np = Number of pods

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