Agronomic potential of some agricultural wastes as surface mulches in hot pepper and tomato production in the Central Region of Ghana

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SUMMARY

Studies were carried out at the Teaching and Research Farm of the University of Cape Coast, in the minor seasons of 1992 and 1993, to assess the agronomic potential of some common agricultural wastes as surface mulches in terms of weed control, nematode population in soil, root-knot incidence and growth and yield of pepper (*Capsicum frutescens* L.) and tomato *(Lycopersicon esculentum* Mill.). There were six mulch treatments, namely grass, sawdust, baggasse, palm fruit fibre, chopped palm bunch, corn cob and a no-mulch control arranged in a randomized complete block design with four replications in the pepper trial. Corn cob was not included in the tomato trial which was also replicated four times. Mulching promoted early flowering in both pepper and tomato probably through its reduction of soil surface temperature. Fresh weight of weeds was also significantly reduced by mulching. The degree was, however, related to type of mulch, with bagasse and chopped palm bunch as the best on account of the size and density of the aggregates and compactness of the cover. Even though mulching tended to increase population of nematodes in the soil with time, there was relatively fewer incidence of root-knots in mulched pepper and tomato than in no-mulching. With the exception of palm fruit fibre, mulching significantly increased yields of both crops with bagasse and sawdust being outstanding in this regard. Superiority of the two might derive from their capacity to soak up and conserve more moisture than the rest due to the absorbent nature of their aggregates. Analysis of the nutrient composition of the different mulching materials showed that apart from grass which contained a little more than 1 per cent nitrogen, the rest were very low in nitrogen and phosphorus but high in carbon with C:N ratio of over 187:1; that would rather require application of starter fertilizer to compensate for the initial depression of nitrification.

RÉSUMÉ

CARSON, A. G. & WILSON, T. J.: *La potentialité agronomique de quelques déchets agricoles en tant que paillis de surface dans la production de piment rouge et de tomate dans la région centrale du Ghana.* Des études se sont déroulées au Champ d' Enseignement et de Recherche de l' Université de Cape Coast pendant les saisons mineures de 1992 et 1993 pour estimer la potentialité agronomique de quelque déchets agricoles communs comme des paillis de surface à l'égard de contrôle de mauvaise herbe, de la population de nématode dans le sol, de l'incidence de noeud radical et de croissance et le rendement du piment (*Capsicum frutesens* L.) et du tomate (*Lycopersicon esculentum* Mill.). Il y avaient six traitements, à savoir, l' herbe, la sciure de bois, la bagasse, la fibre de fruit de palme, le régime de palme haché, l' épi de maïs et un contrôle sans paillis arrangé dans un dessin de bloc complet choisi au hasard avec quatre reproduction par mitose dans l'essai du poivron. L' épi de maïs n' était pas inclus dans l'essai de tomate qui était également reproduit par mitose quatre fois. Le paillis promouvait la floraison précoce dans le poivron et la tomate à travers sa réduction de la température de surface du sol. Le poids frais de mauvaise herbe était également réduit considérablement par le paillis. Le dégré était cependant, lié au type de paillis, avec la bagasse et le régime de palme haché comme les meilleurs en raison de la dimension et la densité des agrégats et la nature compacte de la couche. Malgré le fait que le paillis avait la tendance d' augmenter la population de nématodes dans le sol avec le temps' il y avait relativement moins d'incidence des noeuds radicaux dans le poivron et la tomate paillés que dans le sans-paillis à l'exception de la fibre de fruit de palme, le paillis augmentait considérablement les rendements des deux cultures, avec la bagasse et la sciure de bois étant remarquable à cet égard. La supériorité des deux pourrait provenir de leur capacité d' absorber et de conserver plus d'humidité que dans les autres due à la nature absorbante de leurs agrégats. L' analyse de la composition nutritive de différentes matérielles de paillis montrait qu' à partir de l'herbe qui contenait un peu plus de 1 pour cent

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d' azote, le reste étaient très faible en azote et en phosphore mais fort en carbone avec une proportion de C:N d' au-dessus de 187:1; que pourrait plutôt exiger l' application d' engrais démarreur pour compenser la dépression initiale de nitrification.

Introduction

Tomato (*Lycopersicon esculentum* Mill.), pepper (*Capsicum frutescens* L.), garden egg (*Solanum gilo* L.) and okra (*Abelmoschus esculentus* (L.) Moench) are the most widely cultivated vegetable crops in Ghana. They are mainly utilized as condiments and/or spices in soups, stews and sauces and to a lesser extent in fresh salad. Pepper is cultivated throughout the country with a mean, fresh weight yield of 6.6-22.0 t/ha (Sinnadurai, 1992). Total production of tomato was estimated at 80 000 ha with an average yield of 5 t/ha (FAO, 1988). It is obvious then that the yields of the two vegetable crops, pepper and tomato, are only a small fraction of their potential yields of 20-60 t/ha (Sinnadurai, 1972).

Two important agronomic factors contribute to the low yields obtained from the crops. The first is that the crops are cultivated year round and sometimes under less than optimum soil moisture level in order to meet the market demand for fresh fruits.

Secondly, because production is frequent without recourse to a defined land-use system or crop rotation involving legumes, the organic matter content of the top soil is seriously degraded, thus lowering its water-holding and cation-exchange capacities.

Small-scale farmers who produce the bulk of the two crops do not have the financial means to purchase and use fertilizers; and even when they do, are reluctant to invest in fertilizers because of the high risk of drought.

One of the simplest and cost-effective ways of improving productivity is to enhance the quality of the cultivated soils by applying organic mulches to the surface at least to improve the water-holding capacity.

Organic mulches abound in various forms throughout the Central Region of Ghana as waste products of artisanal and industrial agro-processing schemes. For example, baggasse can be obtained from the small-scale sugar-cane mills dotted throughout the region. Dry palm fibre (mesocarp) and empty palm fruit bunches are available at small and large oil palm processing plants. Sawdust abounds at the small and large sawmills in the forest areas of the region while corn cobs can be obtained all over the region at maize-producing centres. Dry grass is available on mowed lawns, fields, aprons of highways, etc.

While the agronomic potential of the large volumes of agricultural wastes remain unexploited, some are constituting a menace to the environment and inhabitants around the dumping grounds.

The justification for these studies was to assess the value of the organic mulches in terms of their effect on the growth and fresh yield of pepper and tomato, weed control, soil nematode population, and root-knot incidence.

Materials and methods

Two experiments were conducted at the Teaching and Research Farm of the School of Agriculture, University of Cape Coast. The site has a climax vegetation described as Coastal Scrub and Thicket and a bimodally-distributed annual rainfall ranging from 930 to 1200 mm. The soils have been classified by Asamoah (1973) as belonging to the Benya series under the Edina-Eguafo-Atabadze-Udu compound association.

The selected field was ploughed, harrowed, levelled and demarcated into plots. A randomized complete block design with four replications was used in both experiments. Treatments were organic mulches whose sources and nutrient composition were as shown in Table 1.

Experiment 1

The experiment on pepper was carried out from

TABLE 1

Type and Nutrient Content of Organic Mulch Treatments

Mulch	*Source*	*Nutrient composition (%)* *N*	*C*	P_2O_5	K_2O	*Carbon: Nitrogen*
Grass	Mowed lawns	1.42	53.38	0.21	0.98	38:1
Sawdust	Sawmills	0.31	63.19	0.01	0.25	204:1
Baggasse	Pieces of crushed sugar-cane stems	0.30	59.68	0.09	1.13	199:1
Palm fruit fibre	Dry mesocarp fibre of palm fruits	0.71	61.50	0.07	0.53	87:1
Chopped palm bunch	Pieces of empty fresh palm bunch	0.86	52.34	0.13	2.03	61:1
Ground corn cob	Split corn cobs	0.26	48.68	0.03	0.74	187:1

August 1993 to January 1994. There were seven treatments consisting of grass, sawdust, baggasse, palm fruit fibre, chopped palm bunch, corn cob and a no-mulch. Plot size was 3 m × 2.7 m; spacing was 90 cm between rows and 50 cm between plants in the same row. Five-week-old seedlings of a local cultivar of *Capsicum frutescens* L. were transplanted according to stipulated spacing.

The mulches were spread in the fresh state to a thickness of about 5 cm on designated plots one day soon after transplanting. Compound fertilizer (15:15:15) was first ring applied at a rate of 200 kg/ha (10 g/plant) one week after transplanting.

Sulphate of ammonia was also topdressed 2 weeks later at the rate of 200 kg/ha (10 g/plant). Two hand-pulling of weeds were carried out in mulched plots and three in the no-mulch treatment. The soil around the plants was stirred once every fortnight using a hand-held tine weeder. Dimethoate was applied during the 4th and 7th week after transplanting at a rate of 0.4 kg a.i./ha against insect pests.

Experiment 2

The other experiment on tomato was conducted from August 1992 to November 1992. Three-week-old tomato seedlings, local cultivar, were transplanted in a randomized complete block design lay-out at a spacing of 75 cm between rows and 60 cm between plants in the same row. With the exclusion of corn cob, the treatments and their application were the same as in the pepper experiment. Fertilization, insecticide application and weeding regimes were the same as in the pepper experiment.

Observations were made on the following parameters in both experiments:

1) Days to 50 per cent flowering;
2) Fruit number per plant;
3) Fruit yield per hectare;
4) Percentage weed control at 6 weeks after transplanting (w.a.t.). A quadrat, 30 × 30 cm, was randomly sited at four locations within each plot for assessment of weediness. Weeds within each quadrat were hand-pulled, sorted into species, counted and the fresh weight of individual species determined. Percentage weed control (PWC) was calculated as:

$$\% \text{ PWC} = 100 - \left(\frac{\text{Fresh weed weight per treatment}}{\text{Fresh weed weight per control}} \times 100\right)$$

5) Nematode counts. Five core soil samples were taken at random along the diagonals of each plot with a 15 cm soil auger. Samples were bulked, thoroughly mixed and 100 g was taken for the extraction using Baemann's Tray Technique (Viglierchio & Schmitt, 1983). Counts were made prior to the spread of the mulches and at 9 and 12 weeks after transplanting (w.a.t.), with respect to the pepper experiment. In the tomato experiment,

nematode counts were carried out before mulching and at 6 w.a.t.

6) Root-knot count and dry matter weight of pepper and tomato. Three plants were uprooted randomly in each plot and the root-knots counted and expressed as mean root-knot per plant.

7) Dry matter weight per plant. The three plants were chopped into pieces, placed in paper bags, and oven-dried at 80 °C for 4 days after the soil had been washed off the roots. The mean dry matter weight per plant was determined.

Results

Onset of flowering was about 40 days after transplanting (d.a.t.) in the no-mulch treatment of both pepper and tomato (Table 2). There were no significant differences among the various mulches, but the differences between the palm bunch mulch as well as the baggasse mulch and the no-mulch treatment were significant in pepper. In tomato, even though all the mulches significantly induced early flowering, differences among them were not significant.

Weed control

Baggasse, chopped palm bunch and corn cob were the best among the mulches in supppressing weed growth in pepper (Table 3). These three mulches were significantly better in suppressing the level of weed growth in pepper than the no-mulch, grass, palm fruit fibre, and sawdust mulches. Corn cob was non-significantly inferior to baggasse and chopped palm bunch, but significantly superior to grass and no-mulch in weed suppression.

In tomato, all the mulches were significantly more effective in reducing weed infestation than no-mulch, even though differences among them were not significant. Chopped palm bunch and baggasse mulches were, however, relatively better than the rest of the mulches in this regard.

Besides baggasse and chopped palm bunch, none of the other mulches could effectively suppress the dominant and most pernicious weed, *Cyperus rotundus* in pepper and tomato. Other weeds encountered included *Trianthema portulacastrum, Boerhavia diffusa, Tridax procumbense, Ageratum conyzoides, Elensine indica* and *Euphorbia heterophylla.*

TABLE 2

Effect of Mulching on Flowering of Pepper and Tomato

Treatment	Days to 50 % flowering	
	Pepper	Tomato
Grass	36 ab*	38 b*
Sawdust	35 ab	38 b
Baggasse	32 b	37 b
Palm fruit fibre	34 ab	37 b
Chopped palm bunch	31 b	36 b
Split corn cob	35 ab	-
No-mulch	40 a	41 a

*Means within column and followed by similar letters are not significantly different at P=0.05, according to DMRT.

TABLE 3

Effect of Mulching on Weed Control in Pepper and Tomato

Treatment	Pepper % weed control (fresh wt) 6 w.a.t.		Tomato % weed control (fresh wt) 6 w.a.t.	
	Total weeds	Cyperus rotundus	Total weeds	Cyperus rotundus
Grass	10 d*	16	75 a*	40
Sawdust	36 bc	26	80 a	0
Baggasse	79 a	80	87 a	50
Palm fruit bunch	20 cd	8	70 a	0
Chopped palm bunch	68 a	75	88 a	43
Split corn cob	50 ab	66	-	-
No-mulch	0 d	0	0 b	0

*Means within column and followed by similar letters are not significantly different at P=0.05, according to DMRT.

Nematode population

Fig. 1 shows the trend in nematode population at 0, 9 and 12 weeks after mulching in pepper. The dominant nematode was a species of the genus

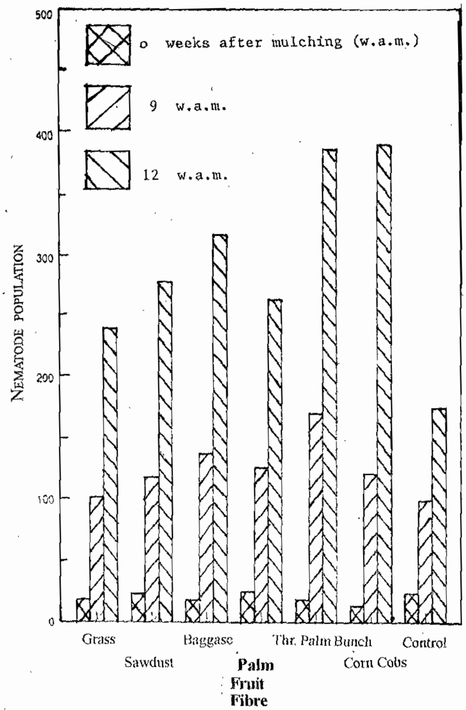

Fig. 1. Effect of mulching on number of nematodes per 100 g soil at 0, 9, 12 w.a.t. in pepper.

Meloidogyne, and its population ranged from 14 to 25 per 100 g soil prior to mulching. By the 9th week after transplanting, there were considerable increases in population from 404 per cent in palm fruit fibre to 795 per cent in chopped palm bunch mulch, as against 308 per cent increase in no-mulch. There were further increases in population albeit at diminishing rate from the 9th to the 12th w.a.t. Corn cob mulch supported the highest cumulative number of nematodes of 390 per 100 g soil followed by chopped palm bunch with 386 and then baggasse with 317 per 100 g soil. The no-mulch treatment had the lowest population of nematodes at 12 w.a.t. These differences in population at 12 w.a.t. among the mulches, though substantial, were not significant as a result of a high inter-plot variability.

Results of nematode counts in the tomato trial

TABLE 4

Effect of Mulching on Number of Nematodes per 100 g of Soil in Tomato

Treatment	Mean no. nematodes per 100 g soil		% increase
	Before mulching	6 w.a.t.	
Grass	5.0	9.5	90
Sawdust	5.5	7.5	36
Baggasse	6.0	8.5	42
Palm fruit fibre	5.5	7.5	36
Chopped palm bunch	6.8	9.8	44
No-mulch	8.5	8.0	-0.6

are shown in Table 4. The benchmark populations of nematodes prior to mulching ranged from 5.0 to 8.5 per 100 g of soil. An overall increase in nematode population was observed as a result of mulching. Grass produced the highest increase of 90 per cent whilst sawdust and palm fruit fibre produced the lowest increase of 36 per cent from among the mulches. There was even a slight decrease in nematode population in the no-mulch at 6 w.a.t.

Root-knot count and dry matter weight of plants

In pepper, the highest number of root-knots of 35 per plant was obtained in the no-mulch followed by sawdust with 16, chopped palm bunch with 14, grass with seven palm fruit fibre with six, and baggasse and corn cob each with one root-knot per plant, (Table 5). The no-mulch treatment in tomato, on the other hand, supported fewer root-knots than its counterpart in pepper. Palm fruit fibre produced the highest root-knot count followed by baggasse, sawdust, chopped palm bunch and grass, in that order of decreasing count.

Sawdust and chopped palm bunch mulches appeared to support more root-knots across crops. The trend in dry matter weight per plant was the same in both crops with no-mulching bearing relatively smaller statured and light weight plants than the mulches (Table 5).

TABLE 5

Effect of Mulching on Root-knot Count and Total Dry Matter per Plant at Harvest in Pepper and Tomato

Treatment	Pepper		Tomato	
	Root-knot number per plant	Total dry matter weight per plant (kg)	Root-knot number per plant	Total dry matter weight per plant (kg)
Grass	7	0.11[a] *	26	.072
Sawdust	16	0.10[a]	39	.066
Baggasse	1	0.13[a]	41	.057
Palm fruit fibre	6	0.12[a]	46	.068
Chopped palm bunch	14	0.13[a]	39	.060
Split corn cobs	1	0.11[a]	-	-
No-mulch	35	0.06[b]	55	.051
CV	25.3	8.0	22.9	12.5

* Means within column and followed by similar letters are not significantly different at P=0.05, according to DMRT.

TABLE 6

Effect of Mulching on Fruit Yield of Pepper and Tomato

Treatment	Pepper		Tomato	
	Fresh fruit yield(t/ha)	No. of fruits per plant	Fresh fruit yield(t/ha)	No. of fruits per plant
Grass	5.94 [b]*	102 [a]	25.1 [a]	24 [a]
Sawdust	7.03 [b]	111 [a]	40.0	28 [a]
Baggasse	9.57 [a]	133 [a]	29.7 [a]	18 [ab]
Palm fruit fibre	5.18 [bc]	84 [a]	36.1 [a]	24 [a]
Chopped palm bunch	6.44 [b]	93 [a]	31.1 [a]	27 [a]
Split corn cobs	7.02 [b]	97 [a]	-	-
No-mulch	2.18 [c]	35 [b]	17.8 [b]	14 [b]

* Means within column and followed by similar letters are not significantly different at P=0.05, according to DMRT.

Fruit yield

The results showed that in both crops, mulched plants significantly outyielded their no-mulch counterparts (Table 6). Baggasse was significantly better in terms of yield than the others with a yield of 9.6 t/ha in pepper. Both sawdust and corn cob produced yields of over 7 t/ha, which were substantially higher than in the other mulches though the differences were not significant.

In tomato, sawdust mulch produced the highest yield of 40 t/ha followed by palm fruit fibre and chopped palm bunch with yields of 36 and 31 t/ha respectively. Yield differences among the mulches were, however, not significant.

The trend in response of fruit number per plant to the various mulches was similar to that of yield per unit area. With the exception of baggasse mulch in tomato, mulching on the whole produced fruit numbers per plant that were significantly better than no-mulch in both pepper and tomato. Baggasse and chopped palm bunch produced the highest fruit number per plant in pepper and tomato, respectively. Differences in fruit number per plant, though substantial, were not significant among the mulches.

Discussion

It was evident that mulching promoted early flowering in tomato. This was to some extent, true of pepper also. Similar observation was made by Boakye-Boateng & Hume (1975) in soybean. This ability of mulches to induce early flowering and thereby shorten the growth period of some crops was attributed by researchers, including Webster & Wilson (1980) and Morgan (1986), to their reduction of soil surface temperature and consequent promotion of better seedling growth. Reduction of soil surface temperature by mulching could be as much as 4.5 - 7.2 °C (Einert, Gindry & Hunneycutt, 1975).

Mulching was also noticed to significantly reduce fresh weight of weeds at 6 w.a.t. and thereby offer some measure of weed control, but this varied with the type of mulch applied. Baggasse and chopped palm bunch mulches proved to be the best mulches both in terms of induction of early flowering and suppression of weeds across crops. Their ability to produce these two consequences might be to a large extent related to the size and density of the aggregates that enabled them to pack easily and provide an impenetrable cover on soil surface. Thus, they were able to intercept most of the light rays reaching them and thereby lower the intensity of light which reached the weeds to below their 'compensation point', where compensation point of light was defined as the light intensity at which the rate of photosynthesis equals rate of respiration and net dry weight accumulation of the weeds is zero (Swarbrick & Mercado, 1987).

Conversely, the relative ineffectiveness of the grass and palm fibre mulches in suppressing weeds, as was also found by Janick (1979), might be a function of their low light interception and thereby allowing a high light intensity greater than the compensation point to reach the weeds.

Again baggasse and chopped palm bunch were the only mulches which provided some measure of long-lasting control of the pernicious *Cyperus rotundus* weed. This was partly because of the physical barrier presented by the dense cover and partly because of the slow rate of decomposition of the mulches.

Populations of nematodes, mainly species of *Meloidogyne*, were relatively higher in the mulched soils than in the no-mulch soils of both pepper and tomato trials. Similar observation had already been made by several researchers including Wallace (1963) who ascribed the cause to the creation of more favourable soil moisture, temperature and aeration conditions under mulching. From this it was reasonable to assume that the low incidence of nematodes in soils under no-mulching was the result of unfavourable conditions of limiting soil moisture, high soil temperature and soil compaction.

There was an inverse relationship between the nematode population in the soil and the root-knot count per plant in both mulched and no-mulch soils. The higher the population of nematodes in the soil, the lower the corresponding root-knot count on per plant basis. Root-knot counts were relatively much lower than the corresponding nematode population in all the mulches whilst the reverse was true in no-mulching. According to Wallace (1963), nematodes would tend to survive as eggs or by infesting roots of host plant to derive nutrients and water for their survival in unfavourable conditions such as found under no-mulching.

Mulching was observed to substantially increase the fruit yields of pepper and tomato as measured per unit area and/or plant basis. It would appear that the range of yield increases of 270 to 400 per cent obtained over no-mulching in pepper was far in excess of 47 to 58 per cent increases in yield realized elsewhere from mulching chili pepper with black plastic, sawdust and rice straw (Mosley, 1975; Filvo, Noda & Ranzchi, 1988). If it was, however, considered that the trials were carried out in the minor season where moisture was limiting and water-holding capacity of the topsoil was crucial, then it was possible to expect the excellent water-holding capacities of mulches which enhanced water conservation to be amplified over the long fruiting period of pepper and result in substantial yield gains over the no-mulching treatments.

Yield increases of the order of 141 to 225 per cent were obtained from mulching tomato over no-mulching. These were, however, comparable with increases obtained elsewhere (Yusupov, 1977; Filvo, Noda & Ranzchi, 1988).

Baggasse and sawdust were the best mulches in terms of fruit yield in pepper and tomato, respectively. Their superiority over the other mulches might stem from improvement of water infiltration and water holding-capacity of the topsoil due to the spongy nature of their aggregates. Other consequences of mulching with baggasse and sawdust were the enhanced capacity to suppress weed growth during the first 6 weeks of critical weed competition, more so in the case of baggasse, and their ability to protect the soil against splash and wind erosion.

Some authors including Gartner (1978) and

Webster & Wilson (1980) have reported that application of organic mulches to soil surface improved the soil's organic matter content and the supply of plant nutrients to crops. On the contrary, the nutrient composition of the mulches clearly showed that apart from grass mulch which contained more than 1 per cent nitrogen and a narrow C:N ratio of 38:1, the rest particularly baggasse, sawdust, and corn cob were very low in nitrogen and phosphorus and high in carbon with C:N ratio over 187:1 and above.

Apart from contributing very little nutrients to the soil, high carbon mulches with C:N ratio of over 30:1 would instead require the addition of a starter nitrogen fertilizer to compensate for the initial depression of nitrification or imbalance (Wright, 1982).

In spite of the poor nutrient status of most of the available by-products of agro-processing, some could be used as soil surface organic mulches to improve the productivity of pepper and tomato by reducing soil surface temperatures, enhancing soil and water conservation, suppressing weeds, reducing the incidence of root-knot attack, and in the long term improving the humus content of the soils.

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