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Effects of Stubble Management on Yield of Tomato

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Abstract- Field experiments were conducted on-farm in the forest zone of Ghana to determine the effects of stubble mulch (*in-situ* residues from *Mucuna pruriens* var utilis or natural grass fallow) and method of land preparation on the yield of dry season tomato (*Lycopersicon esculentum*). Land preparation methods studied were slash burn and ridge; ridge and mulching with the existing residue; and zero tillage without burning. The design was randomized complete block with four replications. Tomato seedlings were transplanted at a spacing of 50 cm within plants and 90 cm between rows; 2 seedlings per hill. Results showed that stubble mulch resulted in significant reduction in soil temperature and an increase in soil moisture content. Ridging resulted in a higher content of soil nutrients. Mulching especially with Mucuna residue, was however associated with insect pest problems. Despite this problem, stubble mulching with mucuna resulted in up to 100% increase in tomato yield and resulted in the highest yields among the management options. Result of the studies showed that soil moisture and temperature might be more important than soil fertility in the short term in determining yield in dry season tomato in the study area.

Index Terms- Stubble management, tomato, dry season, vegetables

I. INTRODUCTION

Vegetable production in the dry season is an important source of income for many peri-urban farmers in Ghana. Although yields are low at this season, this is compensated for by high price they command during the dry period due to scarcity of vegetables during this season. Dry season vegetables are usually grown under manual irrigation close to streams. Due to the difficulties involved in this form of irrigation, farm sizes are usually smaller than the two main seasons and the amount of water applied to the crops is often inadequate. The low humidity during this time of the year couple with dry north easterly winds result in high rate of water loss through evapo-transpiration; the vegetables often suffer from water stress. Mulch farming is recommended as a sustainable management option for water conservation (Lar, 1993) especially for high value crops such as vegetables (Carsky *et al*., 1998). Nakashima *et al*. (1991) reported up to 20 times increase in yield of pepper grown with stubble mulch compared with those grown on bare ground. Increased yield of tomato due to mulching has also been reported (Kwapata, 1991). Shajari *et al.* (1990) observed that mulching was very efficient soil temperature regulator and that it resulted in improved water-use efficiency of Brassica. Legume cover crops provide a source of nitrogen for subsequent crop (People *et al*., 1995) reduces erosion (Flach, 1990), reduce runoff and contamination of soil water (Hoyt *et al*., 1994), utilize soil nitrogen that might otherwise be lost to leaching (Stivers and Shennan , 1989), improve soil physical properties (Barber and Navarro 1994), suppress nematode population (Crow *et al*., 1996) and reduce cost of weed management (Nancy *et al*., 1996). Mucuna cover crop produces large quantities of biomass that can be used as mulch. Furthermore, the legume is capable of restoring the fertility of degraded soils (Hulugalle *et al*., 1986, Osei-Bonsu and Buckles 1993). Tillage practices have been reported to have significant impact on crop production (Awe and Abegunrin, 2009). Adekiya *et al*. (2009) reported that ploughing plus harrowing and ridging increased tomato fruit yields by 40, 16, 24 and 62% over zero tillage, manual mounding, ploughing only and ploughing and harrowing respectively.

The objective of this study was to determine the effect of stubble mulch and method of land preparation on the yield of dry-season tomato

II. MATERIALS AND METHODS

Farmer managed on-farm trials were conducted between 1998 and 1999 in the forest zone of Ghana. The study area has a bimodal rainfall pattern. The major season begins in April and ends in July; the minor season begins in September and ends in mid-November. Mid-November to March is the dry season which is the harmattan period.

Four farmers participated in the study, one at Apatrapa and Duase, and two at Darko in the Ashanti Region of Ghana. The experimental plots had been cropped to maize in the major season followed by natural fallow in the minor season and vegetables in the dry season between 3 and 5 years depending on the site. The predominant weed at all sites was spear grass (*Imperata cylindrical*). Green maize was planted on the experimental fields during the major season of 1998. After harvesting the maize, the experimental fields were laid out (five plots/ site) and Mucuna was randomly planted in mid August 1998 on 3 of the plots after spraying the entire field with glyphosate at a rate of 3 l/ha. After planting, the Mucuna and the 2 other plots were left under Mucuna and grass (*Imperata cylindrical*) fallow respectively in the minor season.

The quantity of Mucuna and grass biomass was assessed by cutting all plant residues from four randomly selected areas before the whole area was slashed using cutlass in mid-November, 1998. The samples were dried in a forced oven at 80 ^oC for 48 hours and their masses determined. The following treatments were imposed: Mucuna residue burnt and the soil ridged (Mucuna burn and ridged), Grass residue burnt and soil ridged (Grass burn and ridged), soil ridged and mulched with in-situ Mucuna residue (Mucuna ridge and mulched), soil ridged and mulched with in-situ grass residue (Grass ridged and mulched), no burning and no tillage for Mucuna only (Zero till Mucuna).

Soil samples for nutrient analysis were taken at a depth of 0-15 cm from the ridges (and on the flat for the zero till option) immediately after land preparation at 5 cores per plot and analysed by standard laboratory procedures. Available phosphorus was determined using the Bray-1 method (Bray and Kurtz, 1945), organic carbon by the Walkey-Black wet dichromate method (Walkley and Black, 1965) and total nitrogen by the Kjeldahl digestion method. The experimental design was a randomized complete block with five treatments and sites as replication. Tomato seedlings were transplanted in the last week of November. Each plot measured 5.4 m x 5 m, having 6 rows of tomato spaced 50 cm within plants and 90 cm apart. Water was applied to the crops at 3-day intervals at a rate of 400 ml per hill in the evenings except during the days of rainfall. Fertilizer was applied at a rate of 125 kg/ha of NPK 15-15-15 1 week after transplanting followed by sulfate of ammonium at the same rate at flower bud stage. Weed assessment (5samples/plot) was done before weed control at 4 weeks after transplanting. Weed control was carried out once because dry weather conditions after the first weeding retarded weed growth. Soil temperatures and moisture content were measured at tomato flowering stage, which was the time most stress was observed. Soil temperature and moisture content at a depth of 5 cm was assessed four times at weekly interval during the morning at 8:00 GMT and during the afternoon at 1:00 GMT. In each case, six samples were taken per plot and the means calculated.

III. RESULTS

Results of the soil analysis are presented in Table 1. Potassium content ranged from 0.16 to 0.52 cmol/kg and organic carbon from 1.250 to 1.530. Potassium and organic carbon contents of the ridged and burnt plots were significantly ($p<0.05$) higher than the zero tilled plot but no difference was observed in phosphorous and nitrogen. For the same method of land preparation, soil nutrient status was consistently not significantly higher on the burned plots than unburned. There was also no significant effect on the type of stubble on soil nutrients. There were however, no significant differences between nitrogen and phosphorus content.

The soil temperature and moisture content of the stubble management options are presented in Table 2. There were no significant differences ($p<0.05$) in morning temperatures and moisture content of the soil soon after manual watering. However, afternoon temperatures were significantly ($p<0.05$) lower and moisture content just before manual watering was higher on the mulched than the burned plots. Soil under zero tillage had the highest moisture content (13.5%).

By November 1998, Mucuna and grass had accumulated mean dry matter of 4.2 t/ha 4.7 t/ha respectively (Data not shown). There was no significant difference ($p<0.05$) between the grass and Mucuna biomass.

Insect pests attacked tomato seedlings which resulted in 13% - 42 % destruction of the transplanted seedlings which necessitated refilling of vacancies (Table 3). Highest attack occurred on the plots mulched with Mucuna residues, compared with grass mulch and burned residues. After refilling, tomato plant stand remained statistically equal among the treatments.

Weed pressure in tomato was highest (883 kg/ha) on the plots mulched with grass and lowest (66kg/ha) on the zero till plot (Table 4).

Yields of tomato was low which is normal during this period. It ranged from 508 kg/ha to 1272 kg/ha (Table 4). Burning grass residues and ridging resulted in lowest yield but this was not significantly ($p<0.05$) different from yields obtained from grass ridge and mulch and Mucuna burned and ridge plots. Zero till Mucuna resulted in more than 100% increase in tomato yields compared with tomato after grass fallow either burned or unburned.

IV. DISCUSSION

The pilling up of top soil to form ridges might have accounted for increased levels of K and organic carbon on the ridged plots compared with zero tilled plots. The results partly agree with studies by Agebede *et al*. (2009) who observed that manual ridging resulted in higher soil N, P, K and Ca compared with untilled plots. Fallow on the other hand had no effect on soil fertility probably because the residues were not fully decomposed at the time of soil sampling.

The reason for weed buildup in the glass mulch may include infestation of rhizomes from the soil and weed seed from the mulch material. Fire might have destroyed some of the weed seed and contributed to the reduction in weed incidence on the burned plots. Mucuna on the other hand effectively controlled the weeds during the fellow period (Hulugalle *at al*., 1986, Osei Bonsu and Buckles 1993) and this might have reduced infestation and weed build up on Mucuna plots.

Mucuna mulch was however associated with insect pest problems. The insects (mainly grasshoppers and crickets) hid in the mulch and were responsible for the more than 40% seedling damaged on the plots mulched with Mucuna, which necessitated refilling. The relatively high incidence of pests in Mucuna mulch may be due to the fact that the mulch was more compact resulting in conditions more favorable to the insects. Zero till Mucuna resulted in more than 100% increase in tomato yields compared with tomato after grass fallow both burned and unburned. Low afternoon soil temperatures and high soil moisture content may have contributed to high yield on the zero till plots. High weed pressure on the spear grass plots might have contributed to the low yields from these plots.

V. CONCLUSION

The study revealed that soil moisture and temperature rather than soil nutrients may be most important factors determining yields of dry season vegetables in the study area especially when inorganic fertilizer is applied. Mucuna stubble suppressed weeds more than grass and resulted in higher soil moisture retention and tomato fruit yield.

Table 1: Effects of stubble management on soil nutrient status (0-15 cm depth) in 4 on-farm tomato trials.

Treatment	Ex K (cmol/kg)	Org C (%)	Total N (%)	Bray-1 P (mg/kg)
Grass burn & ridge	0.52	1.517	0.123	7.63
Grass ridge and mulch	0.34	1.395	0.119	8.80
Mucuna burn & ridge	0.42	1.530	0.129	7.45
Mucuna ridge and mulch	0.40	1.475	0.126	7.50
Mucuna zero till	0.16	1.250	0.105	8.30
CV%	36.4	7.5	10.3	32.5
LSD (0.05)	0.21	0.165	ns	ns

Table 2: Soil temperature (^{O}C) and moisture content (%) at 5 cm depth as affected by stubble management.

Treatment	Soil temperature		Soil moisture*	
	8:00GMT	13:00 GMT	A	B
Grass burn & ridge	20.0	35.0	14.3	8.4
Grass ridge and mulch	21.8	26.5	16.5	11.3
Mucuna burn & ridge	19.8	31.0	14.5	10.7
Mucuna ridge and mulch	20.8	27.0	14.4	11.2
Mucuna zero till	21.5	25.5	15.9	13.5
CV%	2.5	5.5	9.2	8.2
LSD (0.05)	ns	4.5	ns	2.4

*Soil moisture A assessed soon after rain fall and soil moisture B assessed after 2 weeks without rainfall

Table 3. Tomato establishment and weed dry weight as affected by stubble management.

Treatment	% stand vacancy filled	Plants/m^2 at harvest
Grass burn & ridge	14	4.3
Grass ridge and mulch	13	3.8
Mucuna burn & ridge	19	4.4
Mucuna ridge and mulch	42	4.3
Mucuna zero till	39	3.9
CV%	29	12.7
LSD (0.05)	18	ns

Table 4: Effects of stubble mulch and method of land preparation on weeds and fruit yield of tomato

Treatment	Weed dry weight (kg/ha)	Fruit Yield (kg/ha)
Grass burn & ridge	269	508
Grass ridge and mulch	833	579
Mucuna burn & ridge	207	648
Mucuna ridge and mulch	97	1013
Mucuna zero till	66	1272
CV%	23.6	31.4
LSD (0.05)	191	450

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