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INFLUENCE OF MUCUNA FALLOW ON TURMERIC PERFORMANCE, WEED FLORA DIVERSITY AND SOIL FERTILITY

UTJECAJ MUCUNE KAO ZELENOG UGARA NA ZNAČAJKE KURKUME, RAZNOVRSNOST KOROVNE FLORE I PLODNOST TLA

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ABSTRACT

A study to determine the performance of turmeric, weed species diversity and soil attributes using mucuna as a fallow crop to replace *Panicum maximum* vegetation on non fallowed land was carried out at the National Horticultural Research Institute (NIHORT), Ibadan between 2009 and 2010 cropping seasons. The experimental site was completely and highly infested by *Panicum maximum* prior to the commencement of the experiment. In the early growing season of 2009, the land was ploughed and harrowed and the seeds of *Mucuna jaspeada* were sown at 0.40 m × 0.40 m in May, 2009 to serve as a fallow crop. The mucuna seeds were harvested at maturity while the plant residue and litters that remained on the soil during the dry season were ploughed into the soil before 2m × 2m beds were prepared in the following cropping season for planting turmeric. Three treatments were imposed which included the mucuna fallowed land alone, mucuna fallowed land + inorganic fertilizer of NPK 15:15:15 at 60 kg/ha and mucuna fallowed land + organic fertilizer at 5 t/ha, were arranged in a randomized complete block design with three replicates. Results showed that the application of inorganic fertilizer to turmeric planted and sown with mucuna significantly increased plant height, average number of tillers and rhizome yield to 47.3 cm, 14.00 per plant, 0.81 t/ha compared with 30.0 cm, 10.0 tillers per plant and 0.60 t/ha for mucuna fallow plus organic matter and 26.0 cm, 6.7 tillers per plant and 0.37 t/ha for mucuna fallow alone. Soil N and available P increased slightly from 0.75 g/kg and 10.1 mg/kg respectively the previous year before the land was fallowed to 1.00 g/kg and 11.5 mg/kg respectively after mucuna crop. Five weed species: *Amaranthus spinosus, Brachiaria deflexa, Calopogonium mucunoides, Gomphrena* *celosoides* and *Panicum maximum* occurred all through the sampling periods. However, the incidence of *Panicum maximum* was greatly reduced by the mucuna fallow 10 months after the establishment of mucuna as its relative density reduced to 18.28% as opposed to 100% land cover visually rated before the commencement of the experiment.

Key words: fallow crop, soil fertility, *Panicum maximum,* organic fertilizer, inorganic fertilizer

SAŽETAK

Istraživanje s ciljem utvrđivanja značajki kurkume, raznovrsnosti korovne flore i plodnosti tla korištenjem mucune kao zelenog ugara sa svrhom zamjene populacije *Panicum maximum* na neobrađenom tlu obavljeno je u Nacionalnom istraživačkom institutu za hortikulturu (NIHORT) u Ibadanu tijekom vegetacijske sezone 2009. i 2010. godine. Prije početka istraživanja pokusna parcela bila je potpuno zakorovljena vrstom *Panicum maximum.* Početkom vegetacijske sezone u 2009. godini parcela je izorana i drljana te je u svibnju za zeleni ugar posijana *Mucuna jaspeada* na razmak 0,40 x 0,40 m. Žetva mucune je obavljena u punoj zriobi sjemena, dok su biljni ostaci ostali na površini tla tijekom sušnog razdoblja. Zaorani su u narednoj vegetacijskoj sezoni prije pripreme gredica veličine 2 m x 2 m za sadnju kurkume. Istraživana su tri tretmana koji su obuhvaćali: površinu zasijanu samo macunom, površinu zasijanu macunom+mineralno gnojivo NPK 15:15:15 u količini od 60 kg/ha i površinu zasijanu macunom+organsko gnojivo u količini 5 t/ha. Tretmani su postavljeni po slučajnom bloknom rasporedu u tri ponavljanja. Rezultati su pokazali da je primjena mineralnog gnojiva i mucune signifikantno povećala visinu biljka kurkume, prosječan broj izdanaka po biljci i prinos rizoma na 47,3 cm, 14.00 po biljci i 0,81t/ha u usporedbi s 30,0cm, 10,0 izdanaka po biljci i 0,60 t/ha kod tretmana s mucunom + organsko gnojivo i 26,0 cm, 6.7 izdanaka po biljci i 0.37 t/ha kod tretmana gdje je primijenjena samo mucuna. Dušik (N) i pristupačni fosfor (P) u tlu su neznatno porasli s 0,75 g/kg i 10,1 mg/kg koliko su iznosili prije nego je posijana mucuna, na 1,00 g/kg i 11,5 mg/kg nakon primjene tretmana s mucunom. Pet korovnih vrsta: *Amaranthus spinosus, Brachiaria deflexa, Calopogonium mucunoides, Gomphrena celosoides* i *Panicum maximum* javljale su se tijekom čitavog istraživanja. Međutim, primjenom macune pojava *Panicum maximum* znatno se smanjila 10 mjeseci nakon etabliranja mucune. Tako se relativna gustoća ove vrste smanjila na 18,28% u odnosu na 100%-tno pokrivenost tla utvrđenu vizalnom procjenom prije postavljanja pokusa

Ključne riječi: zeleni ugar, macuna, plodnost tla, *Panicum maximum*, organsko gnojivo, mineralno gnojivo

INTRODUCTION

Traditionally – based cropping systems in West Africa rely on periods of fallow to restore soil fertility and prevent the build - up of insect pests and weeds. The introduction of mucuna system into the existing alternative bush fallow system has been reported to be more profitable due to higher returns to land and labour resulting from higher yields , lower weeding and land preparation costs and reduced risk of stress (Buckles and Triomphe, 1999). Gallagher, *et al.* (1999) have also observed that fallow management that promotes vegetative soil cover may reduce weed infestation due to alternation of soil temperature and/or shift in light quality at soil surface and also influence weed seed predation. Improved fallows can be an important component of an integrated weed management (Gallagher, *et al*., 1999) as weeds can be intensively controlled during fallows (Derksen *et al*., 2002). Sanginga *et al.* (1996) reported an accumulation of about 167 kg N/ha in 12 weeks in Mucuna fields. Many studies have shown that the use of cover crop fallows have led to a significant reduction in speargrass density within 2-5 years (Udensi *et al*., 1999; Akobundu *et al*., 2000; Chikoye *et al*., 2001) while the incorporation of cover crops has been said to inhibit seedling emergence and growth (Weston, 1996; Olorunmaiye, 2010).

Turmeric is a rhizomatous root-crop that is important not only as a spice and cosmetic, but also as a medicinal plant worldwide (Hermann and Martin, 1991; Osawa *et al*., 1995; Sugiyama *et al*., 1996; Nakamura *et al*., 1998; Ishimine *et al*., 2003; Hossain *et al*., 2005).

It is one of the most important medicinal plants due to its antioxidant properties and protective powers for our health (Majeed *et al*., 1995). Curcumin and volatile oils in the rhizome of turmeric are known to prevent cancer diseases, tumors and the production of free radicals, and to improve liver and kidney functions (Hermann and Martin, 1991; Majeed *et al*., 1995).

Turmeric requires a well drained soil rich in humus with a high demand for plant mineral nutrients for good yield. The quantity of fertilizers (inorganic or organic) required by the crop depends on the soil and weather conditions prevailing during crop growth (Karthikeyan *et al.,*2009). Thamburaj (1991) reported a favorable effect on the rhizome yield of Turmeric with increased potassium of up to 90 kg K_2O/ha while Singh *et al.* (1992), observed significant improvements in rhizome yield of turmeric with increased N levels up to 120 kg N/ha. Kerala Agricultural University (KAU) in 1996 recommended a fertilizer level of 30-30-60 kg N-P_2O_5-K_2O/ha for turmeric grown in open field conditions. Similarly Meerabai *et al*., (2000) recommended an application of 120 kg N and 120 kg K_2O/ha for turmeric planted in coconut gardens. Sanyal and Dhar, (2006) noted that nitrogen at 150 kg/ha and potassium at 160 kg/ha had significantly better independent effect on almost all the parameters observed while a combination of mulching and the application of nitrogen and potassium at 120 and 160 kg/ha gave the highest yield and curcumin content. Information on the use of mucuna fallow, weed flora diversity, turmeric performance and soil nutrient status at NIHORT is scarce. It is therefore the objective of this study to investigate the use of mucuna fallow to enhance both turmeric yield through soil enrichment and weed management strategy at National Horticultural Research Institute (NIHORT), Ibadan, Nigeria.

MATERIALS AND METHODS

The experiment was carried out at the experimental field of the National Horticultural Research Institute (NIHORT), Ibadan in 2009 and 2010 cropping seasons. The field has been exposed to continuous cropping for over 10 years (with and without the application of inorganic fertilizer). The field was ploughed and harrowed before *Mucuna jaspeada* seeds were planted at a spacing of 0.40m × 0.40m at two seeds per hole on May 27, 2009 and later thinned to one seed per stand to serve as a fallow crop in the next cropping season before planting turmeric. Hoe-weeding was done at 2 and 4 weeks after sowing to allow good establishment of the mucuna seeds and harvesting was done at maturity while the plants residue and its litters were left on the soil throughout the dry season. At the following cropping season, the plant residues were ploughed into the soil before 2m ×2m beds were made manually. Turmeric rhizomes were planted on June 11 at 0.20m × 0.20m spacing. Three treatments were imposed which were mucuna fallowed land + NPK 15:15:15 fertilizer at

60 kg/ha, the mucuna fallowed land + organic fertilizer at 5 tonnes/ha and mucuna fallowed land alone to serve as control. These treatments were arranged in a randomized complete block design with three replications while fertilizer application was done at 2 months after planting turmeric. Data collection was done as follows:

Soil samples were collected from the topsoil (0 – 15 cm) shortly before planting mucuna in May, 2009 and that of turmeric on the same land on June 11, 2010 for soil analyses. The samples were air-dried, crushed with the aid of a pestle and mortar and pass through a 2 mm sieve. Routine analysis was done on the soil to determine soil pH in water, total N by Kjeldahl approach, available P using Bray- P1 extraction followed by molybdenum blue colorimetry, Exchangeable K, Ca and Mg were extracted using ammonium acetate, K was determined on flame photometer and Ca and Mg by EDTA titration. Soil organic matter was determined by wet dichromate method.

Weeds were visually observed in May, 2009 before planting the mucuna seeds while five 0.5m × 0.5m quadrats were used to evaluate weed flora in August, 2009 [3 months after planting (MAP) mucuna], and March, 2010 (10MAP) before the land was prepared for planting turmeric. Permanent 0.5m×5m quadrat placed in the middle of each 2m × 2m bed was used to evaluate weed flora in August, 2010 (4 weeks after planting of Turmeric). Weeds collected within each quadrat were sorted into broadleaves, grasses and sedges, identified, counted and recorded to compute relative frequency, relative density and relative importance value. Weed biomass was determined.

Turmeric plant height and number of tillers were evaluated at 2 and 4 months after planting while rhizome yield was determined at harvest. The weed data collected were subjected to ecological analysis (relative frequency, relative density and relative importance value) while the turmeric data were subjected to analysis of variance (ANOVA) using SAS PROC, GLM and the means separated using LSD.

RESULTS AND DISCUSSION

Results of the pre-cropping soil analysis of the experimental field before the introduction of mucuna as a fallow crop indicated that the textural classification of the soil was loamy sand and that the macro elements were limiting in the soil

(Table 1). The limiting macro elements in the soil indicated that the soil was depleted and thereby unsuitable for the cultivation of economic crops e.g. turmeric and in particular those with high nutrient requirements. Turmeric as a root crop requires high nutrient especially N and K. However, the result of the soil analysis after the short mucuna fallow revealed a slight improvement in N and P values. Incorporation of the mucuna litters probably improved the soil physical properties and microbial activities, reduced the bulk density, enriched soil fertility and increased water holding capacity of the soil. A similar result was obtained by Mazid (1993) and Seobi *et al*. (2005) with application of grasses to soil.

Table 1: Soil characteristics of the experimental plot before and after mucuna establishment

Tablica 1.: Karakteristike tla pokusne površine prije i nakon etabliranja mucine

Soil properties	Before fallow	After fallow
pH (H_2O)	5.55	5.65
Ca (cmol/kg)	2.04	2.105
Mg (cmol/kg)	0.41	0.38
Na (cmol/kg)	0.07	0.065
K (cmol/kg)	0.11	0.135
ECEC (cmol/kg)	2.73	2.77
% base sat.	96.17	96.91
% C	0.8	0.885
N g/kg	0.75	1
Av. P (mg/kg)	10.1	11.5
Cu (mg/kg)	1.65	3.025
Zn (mg/kg)	3.35	2.75
Mn (mg/kg)	11.16	10.15
Sand (g/kg)	855	845
Silt (g/kg)	100	110
Clay (g/kg)	45	45

Turmeric plant height was not significantly affected as there were no significant differences among the treatment means at 2MAP (Table 2). However, at 4MAP, the mucuna fallowed plots that received the inorganic fertilizer produced significantly higher plant height than the other treatments while the mucuna fallowed plot + organic fertilizer in turn produced significantly taller plants than the mucuna fallowed plot alone (control) (Table 2). Number of tillers in turmeric was significantly higher in the mucuna fallowed plot plus inorganic fertilizers than the other treatments at 2MAP. This same trend was recorded at 4 MAP, however the mucuna fallowed plot + organic fertilizers produced significantly higher number of tillers than mucuna fallowed plot alone (control). Turmeric rhizome yield was of significant increase in the order of mucuna fallowed land + inorganic fertilizers > mucuna fallowed land + organic fertilizers > mucuna fallowed land alone (control). Singh *et. al.,* (1992) also observed significant improvements in rhizome yield of turmeric with increased N levels up to 120 kg N/ha. The poor growth and low yield of the turmeric plants on the mucuna fallowed plots without additional fertilizers is an indication that the cultivation of mucuna for a year is not sufficient for the soil to support the growth and yield of turmeric after several years of continuous cultivation.

Table 2: Effect of mucuna fallow on turmeric growth and yield.

Tablica 2: Učinak mucine kao zelenog ugara na rast i prinos kurkume

	Plant height (cm)		Number of tillers (no/plant)		Yield t/ha
Treatments	2MAP	4MAP	2 MAP	4 MAP	
Mucuna (control)	15.00	26.00	3.67	6.67	0.37
Mucuna + Organic	14.67	30.00	3.67	10.00	0.60
Mucuna + Inorganic	19.00	47.33	5.00	14.00	0.81
LSD	Ns	2.390	0.7557	3.8900	0.1687

MAP = Months After Planting

Mjeseci nakon sadnje

Table 3. Relative Frequencies (%) of weed species encountered at the experimental plot before and after mucuna establishment in 2009 and 2010 at NIHORT, Ibadan, Nigeria.

Tablica 3: Relativna učestalost (%) korovnih vrsta na pokusnoj površini prije i poslije etabliranja mucune 2009. i 2010. u NIHORT-u, Ibadan, Nigerija

Weed species	Growth form	Families	Relative Frequency (%)		
			3MAP mucuna	10MAP mucuna	4WAP turmeric
Amaranthus spinosus L.	ABL	Amaranthaceae	11.76	2.04	5.88
Boerhavia diffusa L.	ABL	Nyctaginaceae	-	2.04	-
Brachiaria deflexa (Schumach)	AG	Poaceae	5.88	2.04	5.88
Bulbistylis arbotiva (Steudel)	AG	Poaceae	11.76	18.37	-
Calopogonium mucunoides Desv.	ABL	Fabaceae	5.88	12.24	17.64
Celosia sp	ABL	Amaranthaceae	5.88	-	-
Chromolaena odorata (L.) R.M. Kings & Robinson	ABL	Asteraceae	-	-	5.88
Commelina benghalensis L.	ABL	Commelinaceae	11.76	2.04	-
Commelina erecta	ABL	Commelinaceae	-	2.04	-
Cleome viscosa L.	ABL	Cleomaceae	-	4.08	-
Cyperus esculentus L.	PS	Cyperaceae	-	10.20	-
Cynodon dactylon (L.) Pers	PG	Poaceae	-	-	5.88
Digitaria horizontalis Willd	AG	Poaceae	-	4.08	-
Gomphrena celosoides Mart.	ABL	Amaranthaceae	5.88	12.24	11.76
Mariscus alternifolius Vahl	PS	Cyperaceae	5.88	-	-
Merremia aegyptia (Linn.) Urban	ABL	Convolvulaceae	5.88	-	5.88
Mitracarpus villosus (Sw.) DC.	ABL		5.88	-	-
Panicum maximum Jacq. O. Ktze	AG	Poaceae	5.88	12.25	23.53
Paspalum obiculare Forst.	AG	Poaceae	-	2.04	-
Portulaca oleracea Linn.	ABL	Portulacaceae	5.88	-	-
*Pouzolzia guineensis B*enth.	ABL	Urticaceae	11.76	2.04	-
Talinum triangulare (Jacq.) Willd.	PBL	Porulacaceae	-	-	5.88
Tridax procumbens L.	ABL	Asteraceae	-	8.16	11.76

Note:
ABL = Annual Broadleaf
AG = Annual grass
PBL = Perennial Broadleaf
PG = Perennial grass
PS = Perennial sedge

Table 4: Relative Densities (%) of weeds species encountered at the experimental plot before and after mucuna establishment in 2009 and 2010 at NIHORT, Ibadan, Nigeria.

Tablica 4: Relativna gustoća (%) korovnih vrsta na pokusnoj površini prije i poslije etabliranja mucinom 2009. i 2010.u NIHORT-u. Ibadan, Nigerija

Weed species	Relative Density (%)		
	3MAP mucuna	10MAP mucuna	4WAP turmeric
Amaranthus spinosus L.	41.75	0.32	18.18
Boerhavia diffusa L.	-	0.16	-
Brachiaria deflexa (Schumach)	3.85	1.59	72.27
Bulbistylis arbotiva (Steudel)	9.34	56.44	-
Calopogonium mucunoides Desv.	1.09	2.54	9.09
Celosia sp	0.55	-	-
Chromolaena odorata (L.) R.M. Kings & Robinson	-	-	2.59
Commelina benghalensis L.	2.19	0.16	-
Commelina erecta	-	0.16	-
Cleome viscosa L.	-	0.79	-
Cyperus esculentus L.	-	8.74	-
Cynodon dactylon (L.) Pers	-	-	3.89
Digitaria horizontalis Willd	-	1.91	-
Gomphrena celosoides Mart.	16.48	4.29	15.58
Mariscus alternifolius Vahl	2.75	-	-
Merremia aegyptia (Linn.) Urban	0.55	-	1.29
Mitracarpus villosus (Sw.) DC.	10.99	-	-
Panicum maximum Jacq. O. Ktze	3.29	18.28	16.88
Paspalum obiculare Forst.	-	1.59	-
Portulaca oleracea Linn.	4.39	-	-
Pouzolzia guineensis Benth.	2.75	0.16	-
Talinum triangulare (Jacq.) Willd.	-	-	2.59
Tridax procumbens L.	-	1.43	2.59

The influence of one year mucuna fallow period on the weed species diversity is shown in Table 3. A total of 23 weed species were encountered during the experiment out of which 15 weeds were broadleaves, 6 were grasses and 2 sedges. These weeds belonged to 11 families with Poaceae having 6 weed species, Amaranthaceae 3, Asteraceae, Commelinaceae and Portulacaceae had 2 weed species each while Fabaceae, Cleomaceae, Nyctaginaceae, Convolvulaceae, Urticaceae and Rubiaceae had 1 species each. The experimental plot

Table 5: Relative Importance Values of weed species encountered at the experimental plot before and after mucuna establishment in 2009 and 2010 NIHORT, Ibadan, Nigeria.

Tablica 5: Relativne vrijednosti učešća korovnih vrsta na pokusnoj površini prije i poslije etabliranja mucine 2009. i 2010. u NIHORT-u, Ibadan, Nigerija

Weed species	Relative Importance Value (%)		
	3MAP mucuna	10MAP mucuna	4WAP turmeric
Amaranthus spinosus L.	26.76	1.18	12.03
Boerhavia diffusa L.	-	1.10	-
Brachiaria deflexa (Schumach)	4.87	1.82	39.08
Bulbistylis arbotiva (Steudel)	10.55	37.41	-
Calopogonium mucunoides Desv.	3.49	7.39	13.37
Celosia sp	3.22	-	-
Chromolaena odorata (L.) R.M. Kings & Robinson	-	-	4.24
Commelina benghalensis L.	6.98	1.10	-
Commelina erecta	-	1.10	-
Cleome viscosa L.	-	2.44	-
Cyperus esculentus L.	-	9.47	-
Cynodon dactylon (L.) Pers	-	-	4.88
Digitaria horizontalis Willd	-	2.99	-
Gomphrena celosoides Mart.	11.18	8.27	13.67
Mariscus alternifolius Vahl	4.32	-	-
Merremia aegyptia (Linn.) Urban	3.22	-	3.59
Mitracarpus villosus (Sw.) DC.	8.44	-	-
Panicum maximum Jacq. O. Ktze	4.59	15.27	20.21
Paspalum obiculare Forst.	-	1.82	-
Portulaca oleracea Linn.	5.14	-	-
*Pouzolzia guineensis B*enth.	7.26	1.10	-
Talinum triangulare (Jacq.) Willd.	-	-	4.24
Tridax procumbens L.	-	4.79	7.18

was totally dominated by *P. maximum* when visually observed before the commencement of the experiment. At 3 months after mucuna establishment, *A. spinosus, B. arbotiva, C. benghalensis* and *P. guineensis* had Relative Frequencies (RF) > 5% with11.76% each while the remaining weeds had 5.88% RF each. At 10 months after mucuna establishment, 6 weeds occurred at RF >5% with *B. arbotiva* (18.37%) being the most frequent followed by *P.*

maximum (12.25%) while *C. mucunoides* and *G. celosoides* had 12.24% each. At 4WAP turmeric, the relative frequencies of weeds followed the same trend as in 3months after mucuna establishment.

Amaranthus. spinosus had the highest Relative Density (RD) (41.75%) at 3 months after mucuna establishment followed by *G. celosoides* (16.48%), *M. villosus* (10.99%), *B. arbotiva* (9.34) while others were less than 5%. At 10 months after mucuna establishment, *B. arbortiva* had the highest RD of 56.44% followed by *P. maximum* (18.20%) while others except *C. esculentus* (8.47%) had < 5% RD (Table 4). At 4 weeks after planting turmeric, four (4) weed species had high RD with the highest in *B. deflexa* (72.27%) while *A. spinosus, P. maximum* and *G. celosoides* followed in descending order (18.18,16.85 and 15.58% RD respectively).

The Relative Importance Value (IVI) was highest in *A. spinosus* with 26.76% 3MAP after mucuna establishment while *B. arbotiva* and *B. deflexa* gave 37.41 and 39.08% at 10MAP mucuna and 4WAP turmeric respectively (Table 5).

CONCLUSION

From this study, the use of *M. jaspeada* alone as a short fallow crop was not sufficient for high rhizome production in turmeric. There is the need to supplement with fertilizers specifically, inorganic fertilizers to make it suitable for the cultivation of crops with high nutrient requirements like turmeric. However, the one year mucuna fallow was able to reduce the incidence of *P. maximum* by 79. 72%.

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