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Effect of tillage and nutrient management practices on weed dynamics and yield of fingermillet (*Eleusine coracana* L.) under rainfed pigeonpea (*Cajanus cajan* L.) fingermillet system in *Alfisols* of Southern India

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Field experiments were conducted during the *Kharif* seasons of 2010 and 2011 at GKVK, UAS, Bangalore, Karnataka, India to study the influence of three tillage practices *viz*., conventional tillage (3 ploughings + 3 inter cultivations), reduced tillage (2 ploughings + 2 inter cultivations) and minimum tillage (1 ploughing + 1 inter cultivation) and three nutrient management practices *viz*., 100% N through Urea, 100% N through integrated supply (50% N through urea+ 25% N through FYM+ 25% N through Glyricidia) and 100% N through organic source (50% N through FYM+ 50% N through Glyricidia) on weed dynamics and yield of fingermillet (*Eleusine coracana* L.) under rainfed pigeonpea-fingermillet system in *Alfisols*. The results showed that conventional tillage reduced the infestation of *Borreria articularis, Cynodon dactylon* and *Cyperus rotundus* compared to other tillage practices. However, nutrient management practices did not influence weeds significantly. Among tillage practices conventional tillage recorded significantly higher fingermillet yield (3030 kg ha^{-1}) compared to other tillage practices and among nutrient management practices integrated supply of N recorded higher yield of 2666 kg ha^{-1} compared to other nutrient management practices. More weed seeds were distributed in upper 10 cm soil depth in minimum tillage where as in conventional tillage weed seed distribution was more or less uniform in the soil profile studied.

Key words: Tillage, nutrient management, glyricidia, weed dynamics, grain yield, weed seed bank.

INTRODUCTION

Pigeonpea (*Cajanus cajan* L.) is one of the important pulse crop rich in protein content. Pigeonpea being a legume fixes atmospheric nitrogen and also it sheds lot of leaves at maturity which improves organic matter content of soil. Fingermillet (*Eleusine coracana* L.) is a staple food for working class and also an ideal food for patients suffering from diabetes. The grains are rich in calcium and iron besides being rich in carbohydrate and protein.

Under rainfed conditions in southern India particularly in Karnataka state, pigeonpea-fingermillet cropping system is predominantly followed. Both crops are largely grown under rainfed conditions, experiencing moisture deficiency at different growth stages. Deficiency of moisture for both the crops affects normal growth and development resulting in lesser yield under rainfed conditions. Further nutrient deficiency particularly N and

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unchecked weed growth inflict considerable reduction in fingermillet yield. The role of tillage in conserving soil moisture and its subsequent beneficial effect on crop productivity has long been recognized. Adequate tillage operations controlled weeds and resulted in higher crop productivity, but caused more soil loss and were more capital intensive (Dogra et al., 2002). Tillage influences the vertical distribution of weed seeds in soil layer and weed diversity. No till cropping systems leave most seeds in top 1.0 cm layer of soil profile (Yenish et al., 1992). Differential distribution of seeds in the soil profile subsequently leads to change in weed population dynamics (Buhler, 1991). Use of organic manure is inevitable for sustained agricultural production by reducing dependence on inorganic fertilizers and to build the soil fertility and improve the soil biological activity. Keeping this in view, a study was under taken to find out the combined influence of tillage and nutrient management practices on weed dynamics and yield of fingermillet under pigeonpea-fingermillet system in *Alfisols* of Southern India.

MATERIALS AND METHODS

Field experiments were conducted during *Kharif* seasons of 2010 and 2011 at the University of Agricultural Sciences, G.K.V.K, Bangalore. The soil of the experimental field was red sandy clay loam having a pH 5.5, with 0.36% organic carbon, available nitrogen 175 kg ha^{-1}, phosphorus 68.40 kg ha^{-1} and potassium 160 kg ha^{-1}. The treatments consisting of three tillage practices *viz.,* conventional tillage (3 ploughings + 3 inter cultivations), reduced tillage (2 ploughings + 2 inter cultivations) and minimum tillage (1 ploughing + 1 inter cultivation) in main plots combined with three nutrient management practices *viz.,* 100% N through Urea, 100% N through integrated supply (50% N through urea+ 25% N through farm yard manure (FYM) + 25% N through Glyricidia) and 100% N through organic sources (50% N through FYM+ 50% N through Glyricidia) in sub plots were replicated thrice in split- plot design. Tillage practices were done as per treatment details *viz.*, conventional tillage: three ploughings (15 to 20 cm deep) and three inter cultivations during the crop period was done first after 30 days after sowing and remaining two at an interval of fifteen days. reduced tillage: two ploughings (15 to 20 cm deep) and two inter cultivations during the crop period was done first inter cultivation after 30 days after sowing and remaining one after an interval of fifteen days. Minimum tillage: one ploughing (15 to 20 cm deep) and one inter cultivations during the crop period was done after 30 days after sowing. Nutrient management practices were followed as per the treatment details *viz.,* 100% N through Urea: entire dose of nitrogen was applied through urea as basal in pigeonpea where as in fingermillet 50% N as basal and remaining 50% after 30 days after sowing, 100% N through organic sources: 50% of N through FYM and 50% of N through glyricidia was supplied to the crop by incorporating to the field 20 days before sowing of crop, 100% N through integrated supply: 50% N through urea, remaining nitrogen was supplied through farm yard manure and glyricidia in equal proportion to meet the remaining nitrogen based on their nitrogen equivalent before 20 days of sowing. Whereas recommended phosphorus and potassium was supplied through Single Super Phosphate and muraite of potash respectively to all the treatments as basal. Sowing of fingermillet was done at a spacing of 30 × 10 cm with a plant density of 3,33,333 per ha. Ear heads in the plot were harvested on maturity and were dried separately then hand threshed by beating with wooden sticks, winnowed and cleaned treatment wise and expressed as kg ha^{-1}.

In each treatment a quadrant of 0.5 × 0.5 m was selected at random for recording weed count. Accordingly the number of monocots, dicots and sedges present within quadrant were counted and expressed as No. m^{-2}. Later the original values were subjected to suitable transformations (square root or logarithmic) depending on the variation in the data and subjected to statistical analysis. For weed seed bank analysis, soil samples were collected two times, before sowing of pigeonpea in May 2010 and after harvest of fingermillet in November 2011 to determine the weed seed bank composition. Samples were taken from three soil depths (0-10, 10-20 and 20-30 cm) in the field. From each plot five samples of soils with a core auger were taken as at random. Soil samples from each plot were pooled within the same depth. Soil samples from each plot were thoroughly mixed air dried under shade and ground gently with hands in to the small pieces. Thereafter 1 kg each of soil, devoid of large rocks and root fragments, was transferred into 20 × 35 cm plastic trays and with 2 cm soil thickness, placed in light screen house. These were watered as and when needed to maintain adequate moisture. After weed seedlings emerged were identified, counted and removed. Seedlings of unidentified weeds were transplanted in to other pots and grown until their identities could be verified. After this, the soil was thoroughly mixed watering was continued for next flush of weed seed germination. The cycle of operation was repeated after every flush of germination, identification and removal of seedlings. Watering was continued for three weeks after weed seed germination ceased. The data were subjected to statistical analysis to determine differences among tillage, nutrient management practices and different soil depths.

RESULTS AND DISCUSSION

The dominant weed species observed both in experimental field and weed seed bank studies were *Borreria articularis*, *Cynodon dactylon* (L.) and *Cyperus rotundus* (L.).

Effect of tillage on weed dynamics and yield of fingermillet

Different tillage practices significantly influenced weed population. Irrespective of the weed species, conventional tillage significantly reduced the population of weeds compared to reduced tillage and minimum tillage. The inversion of soil by following conventional tillage resulted in deeper placement of weed seeds which could not emerge out, causing a significant reduction in the population of weeds. Similar result was observed by Chahal et al. (2003). In both years of experimentation the trend remained the same only dominance of perennial grass and sedge started to increase in the minimum tillage. In minimum tillage is due to less disturbance and falling of weed seeds on to the surface of soil both weed population and weed dry weight was significantly higher compared to reduced and conventional tillage treatments (Table 2). Satisfactory weed control in conventional tillage treatment may be attributed to the stimulatory effect of tillage in inducing weed seed germination and it might be due to the greater deposition of weed seed at

Table 1. Effect of Tillage and Nutrient management practices on growth and yield of fingermillet.

Treatments	Plant height (cm) at harvest	Number of tillers plant^{-1}	Grain weight plant^{-1}(g)	Grain yield (kg ha^{-1})	B:C ratio
Tillage practices (M)					
M_1:3Ploughings + 3Inter cultivations	79.16	6.16	12.00	3030	3.57
M_2:2Ploughings + 2 Inter cultivations	70.26	5.37	10.73	2256	2.83
M_3:1Ploughing + 1 Inter cultivation	61.21	4.47	8.27	1112	1.56
S.Em±	0.72	0.15	0.30	124.37	
CD at 5%	2.81	0.61	1.18	488.35	
Nutrient management practices(F)					
F_1: 100% N through urea	70.00	5.33	10.40	2067	3.02
F_2:25% N through FYM + 25% N through Glyricidia + 50% N through Urea	74.41	5.77	10.74	2666	3.23
F_3: 50% N through FYM + 50% N through Glyricidia	66.23	4.91	9.86	1665	1.71
S.Em±	1.49	0.14	0.17	81.35	
CD at 5%	3.60	0.40	0.31	250.65	
Interaction (M XF)					
F at same level of M					
S.Em±	2.58	0.24	0.30	140.90	
CD at 5%	NS	NS	NS	NS	
M at same or different levels of F					
S.Em±	2.23	0.25	0.39	169.42	
CD at 5%	NS	NS	NS	NS	

soil surface and ploughing each time might kill the germinated weeds. This research had a general agreement with several previous studies of Ball and Miller (1990), Amanuel and Tanner (1991) and Mohler (1993).

In conventional tillage, weed seeds were distributed uniformly among different soil depths compared to minimum tillage and reduced tillage (Tables 3 and 4). In minimum tillage all three types of weed species viz., broad, grass and sedges were significantly higher than other two tillage practices and most of the weed seeds were concentrated in top layers of soil. Plant height was significantly higher under conventional tillage (79.16 cm) than reduced tillage (70.26 cm) and minimum tillage (61.21 cm). Similarly conventional tillage produced significantly higher tiller number (6.16 per plant), grain weight (12 g per plant) and grain yield (3030 kg ha^{-1}) compared to other tillage practices (Table 1). This may be due to creation of favourable physical condition for seed germination, seedling emergence, stand establishment and subsequent growth which contributed for better growth, yield attributes and yield of fingermillet.

Soil depth and tillage interactions

The interaction between soil depth and tillage was significant. All the dominant weed species observed *viz.*, *Borreria articularis, Cyperus rotundus* and *Cynodon dactylon* were significantly reduced by conventional tillage (Table 3). The weed seed bank distribution differed between tillage practices. In the minimum tillage practices large number of weed seed was found in the depth of 0 to 10 cm followed by reduced tillage and conventional tillage. This may be attributed to greater deposition of weed seed at the soil surface due to fewer disturbances to weeds in minimum tillage which resulted in more addition of weed seeds at the end of their life cycle. In conventional tillage weed seeds were distributed more or less uniform compared to reduced and minimum tillage. The total weed seed bank was higher in minimum tillage and lowest weed seed bank was observed in conventional tillage (Table 4) this may be attributed satisfactory control of weeds by intensive tillage practices. Similar findings were reported by Ball and Miller (1990).

Effect of nutrient management practices on weed dynamics and yield of fingermillet

Nutrient management practices did not influence weed seed bank and weed dynamics significantly. However, nutrient management practices significantly influenced on growth and yield of fingermillet in the present study. The

Table 2. Effect of Tillage and Nutrient management practices on weed density (No. m^2) and weed dry weight (g 0.25 m^2) in finger millet at harvest.

Treatments	Monocots (+)	Dicots (+)	Sedges (+)	Total weed density (≠)	Total weed dry weight (≠)
Tillage practices (M)					
M_1: 3 Ploughings + 3 Inter cultivations	3.52 (11.53)	2.76 (6.66)	2.81 (6.98)	1.43 (25.17)	1.26 (16.6)
M_2: 2 Ploughings + 2 Inter cultivations	4.94 (23.50)	3.83 (13.75)	4.22 (16.91)	1.75 (54.16)	1.69 (46.87)
M_3: 1 Ploughing + 1 Inter cultivation	5.78 (32.59)	4.70 (21.15)	4.96 (23.78)	1.89 (77.52)	1.80 (61.85)
S.Em±	0.15	0.10	0.12	0.01	0.03
CD at 5%	0.59	0.41	0.37	0.08	0.10
Nutrient management practices (F)					
F_1: 100% N through Urea	4.64 (21.64)	3.71 (13.34)	3.90 (15.12)	1.67 (50.11)	1.56 (39.46)
F_2:25% N through FYM + 25% N through Glyricidia + 50% N through Urea	4.76 (22.64)	3.77 (13.93)	4.0 (15.89)	1.69 (52.46)	1.59 (41.84)
F_3: 50% N through FYM + 50% N through Glyricidia	4.84 (23.34)	3.81 (14.28)	4.10 (16.65)	1.71 (54.28)	1.61 (44.02)
S.Em±	0.10	0.04	0.09	0.01	0.02
CD at 5%	NS	NS	NS	NS	NS
Interaction (M XF)					
F at same level of M					
S.Em±	0.18	0.07	0.20	0.03	0.03
CD at 5%	NS	NS	NS	NS	NS
M at same or different levels of F					
S.Em±	0.21	0.12	0.19	0.02	0.03
CD at 5%	NS	NS	NS	NS	NS

*Figures in parenthesis indicate original values, NS- Non significant, Data subjected to, + = square root of X+1, ≠ = log (X + 2) transformations.

Table 3. Total weed no. per kg of soil as influenced by tillage, Soil depth and nutrient management practices.

Treatments	At 15 days		At 30 days		At 45 days		At 60 days	
Tillage practices								
M_1	1.16(13.05)		1.27(18.31)		0.99(8.93)		0.69(3.94)	
M_2	1.56(36.22)		1.66(49.89)		1.48(34.68)		1.06(11.70)	
M_3	1.63(44.78)		1.81(66.80)		1.64(46.19)		1.26(19.70)	
Nutrient management practices								
F_1	1.42(31.44)		1.55(41.49)		1.35(26.63)		0.97(9.89)	
F_2	1.45(33.04)		1.58(43.31)		1.37(28.33)		1.01(11.32)	
F_3	1.48(34.68)		1.60(45.07)		1.41(30.22)		1.04(10.52)	
Depth (cm)								
D_1-10	1.65(53.16)		1.74(60.52)		1.56(40.81)		1.26(20.33)	
D_2- 20	1.44(28.07)		1.59(41.73)		1.38(27.89)		1.01(10.04)	
D_3- 30	1.26(17.93)		1.40(27.3)		1.19(16.48)		0.75(4.98)	
	SEm±	**CD (0.05%)**	**SEm±**	**CD (0.05%)**	**SEm±**	**CD (0.05%)**	**SEm±**	**CD (0.05%)**
M	0.02	0.07	0.02	0.06	0.02	0.07	0.03	0.08
F	0.02	NS	0.02	NS	0.02	NS	0.03	NS
D	0.02	0.07	0.02	0.06	0.02	0.07	0.03	0.08
MF	0.03	NS	0.03	NS	0.03	NS	0.05	NS

Table 3. Contd**.**

MD	0.03	0.09	0.03	0.07	0.03	0.09	0.05	0.14
FD	0.03	NS	0.03	NS	0.03	NS	0.05	NS
MFD	0.05	NS	0.05	NS	0.06	NS	0.09	NS

M_1- 3 ploughings + 3 Inter cultivations, M_2- 2 ploughings + 2 Inter cultivations, M_3- 1 ploughing + 1 Inter cultivation, F_1-100% N through Urea, F_2-25% N through FYM, 25% N through Glyricidia and 50% N through Urea, F_3-50% N through FYM and 50% N through Glyricidia, NS - Non significant, *Figures in parenthesis indicate original values, Data subjected to log (X + 2) transformation.

Table 4. Total weed number per kg of soil as influenced by tillage at different soil depths.

Treatments	At 15 days	At 30 days	At 45 days	At 60 days
M_1D_1	1.26(16.59)	1.46(27.56)	1.21(14.89)	0.95(7.31)
M_1D_2	1.19(13.56)	1.29(18.15)	0.97(7.33)	0.74(4.00)
M_1D_3	1.03(9.00)	1.04(9.22)	0.81(4.56)	0.38(0.50)
M_2D_1	1.71(49.56)	1.77(57.56)	1.63(41.22)	1.25(17.67)
M_2D_2	1.55(33.67)	1.67(44.89)	1.46(27.33)	1.11(12.56)
M_2D_3	1.43(25.44)	1.53(31.89)	1.36(21.67)	0.82(4.89)
M_3D_1	1.98(93.33)	1.99(96.44)	1.83(66.33)	1.57(36.00)
M_3D_2	1.57(37.00)	1.80(62.17)	1.70(49.00)	1.17(13.56)
M_3D_3	1.33(19.33)	1.64(41.78)	1.39(23.22)	1.05(9.56)
SEm±	0.03	0.03	0.03	0.05
CD (0.05%)	0.09	0.07	0.09	0.14

M_1-3ploughings + 3 Inter cultivations, M_2-2 ploughings + 2 Inter cultivations, M_3- 1 ploughing +1 Inter cultivation, D_1- 10 cm depth, D_2- 20 cm depth, D_3- 30 cm depth,*Figures in parenthesis indicate original values, Data subjected to log (X + 2) transformation.

grain yield of fingermillet in 100% N supplied through urea was 2067 kg per ha, which increased to 2666 kg per ha due to 50% substitution of N with farm yard manure and Glyricidia leaf manure (Table 1). This has accounted for 28.97% increase in grain yield over 100% N supply through urea. Further, increasing the level of substitution of N by 100% with organics (FYM and Glyricidia) did not influence the grain yield rather result in reduction in yield and it was significant. Combined application of both the source of nitrogen has resulted in better availability of nitrogen throughout the crop growth period. Fertilizer source of N has met the nutrient requirement of the plant in the early growth stages and the mineralized nitrogen from FYM and Glyricidia could supply the nutrient in the later growth stages of the crop. Hence, there was continuous supply of nutrients throughout the crop growth period. Whereas, in 100% N substitution by farm yard manure and Glyricidia, mineralization occurs slowly and the supply of nitrogen in the early stages of crop growth was delayed and thus the crop has starved of nitrogen which has affected crop growth and yield. Similar results were obtained by Dass and Patnaik (2007), Aruna and Mohammad (2006) and Kumar et al. (2007).

Conclusion

Tillage and soil depth had significant effects on weed dynamics and weed seed bank. Weed seed bank size was greater in minimum tillage than conventional tillage or reduced tillage. This resulted in better performance of finger millet crop in southern India. Among nutrient management practices integrated supply of N found promising in getting better yield of fingermillet however, there was no effect of nutrient management practices on weed dynamics and weed seed bank. From the research results it could conclude that tillage is the limiting factor for weed seed bank size in the soil. This suggested that by intensive tillage practices could make considerable weed seed bank reduction in the soil. However, further research will be required to confirm these initial findings and to determine whether dynamics of individual species follows the same pattern as total weed density and which can be use for more accurate future predictions related to the population dynamics of the weed seed in the soil.

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