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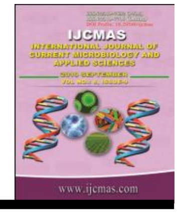

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Study on Maize-Sesamum Cropping System as Influenced by Weed and Organic Nutrient Management on Yield and Soil Health under Rainfed Condition of North East India

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A B S T R A C T

An experiment was carried out at the Instructional-Cum-Research farm, Assam Agricultural University, Jorhat during 2013 and 2014 to study the effect of fertility management (F_0 - control, F_1 - 2.5 t/ha enriched compost, F_2 - 5.0 t/ha enriched compost) and weed management (W_0-weedy check, W_1- hand hoeing and earthing up at 20 and 50 DAS, W_2-*in situ* cowpea mulching upto 50 DAS,W_3- *in situ* blackgram mulching upto 50 DAS) in maize and also to study the carry-over effects of these treatments on the succeeding sesamum crop in a split-plot design with 3 replications. The soil of the experimental field was sandy loam in texture, acidic in reaction (pH 5.33), medium in soil organic C (0.51%), medium in available N (318.93 kg/ha), P_2O_5 (32.95 kg/ha) and K_2O (167.54 kg/ha). Application of F_2 significantly produced the highest yield of maize (2322.33 kg/ha in 2013 and 2178.29 kg/ha in 2014) as compared to application of F_1 and F_0. Fertility management interacted with weed management significantly and the best combination was F_2W_1 (grain yield of 4723.81 kg/ha in 2013 and 4507.24 kg/ha in 2014). Fertility management during maize seemed to significantly improve the growth and yield of sesamum and the best treatment was application of F_2 in maize (seed yield of 589.08 kg/ha in 2013 and 402.78 kg/ha in 2014). The interaction effect of F and W on succeeding sesamum was significant only during 2014 for yield. Application of F_2 and W_1 in maize maintained significantly higher organic C, residual soil available N, P_2O_5 and K_2O in the maize-sesamum cropping sequence compared to other treatments.

Introduction

In India, maize (*Zea mays* L.) is the third most important food crop mainly grown during *kharif* season covering 80% of the total maize growing area. It is reported that maize being a rainy season wide spaced crop meets heavy competition from weeds (Patel *et al.*, 2006; Dass *et al.*, 2012) and thereby a huge negative impact on its yield due to this strive (Rao *et al.*, 2009; Bijanzadeh and Ghadiri, 2006; Alok *et al.*, 2012). Cropping system in the NE hill region is also predominantly rice based mono cropping with little exception in the state of Sikkim where maize is the main food crop. Rice and maize cultivation in the region is under low-input low-risk and low yield condition. In order to make the region self sufficient in food grain production, the productivity of rice and maize has to be increased from the present level. The farming in the north-eastern region is organic by default without application of any chemical fertilizers resulting in lower production level when compared to the rest of the country. However, simply by adopting low cost agro-techniques like improved variety, proper time of sowing, intercultural practices, effective recycling of resources etc., yield can be increased significantly. Organic manures improves soil physical, biological and chemical properties (Delate and Camberdella, 2004; Tiwari *et al.*, 2002 and Edmeades, 2003; Efthimiadou *et al.*, 2009) of the soil which in turn increases the yield of crops (Kumar *et al.*, 2007; Mehta *et al.*, 2005; Mugwe *et al.*, 2007). Taking into all the above points under consideration, the experiment was initiated to study the influence of live mulching and organic nutrient management on yield of crop and soil health in maize-sesamum cropping systems.

Materials and Methods

The experiment was conducted at the Instructional-cum-Research (ICR) farm, Assam Agricultural University, Jorhat during the year 2012-2013 and 2013-2014. The experiment was laid out in Split Plot Design (SPD) comprising of fertility management (F_0 - control, F_1 - 2.5 t/ha enriched compost, F_2 - 5.0 t/ha enriched compost) as the main factor and weed management (W_0-weedy check, W_1-hand hoeing and earthing up 20 and 50 DAS, W_2-*in situ* cowpea mulching upto 50 DAS,W_3- *in situ* blackgram mulching upto 50 DAS) as the sub factor in maize and these treatments were carried over to the succeeding crop sesamum to study the residual effect. The soil was sandy loam with pH 5.33, organic carbon (OC) 0.51%, available N 318.93kg/ha, available P_2O_5 32.95, available K_2O 167.54 kg/ha. Maize variety Dekalb 900 m Gold and sesamum Koliabor Til were used for undertaking the experiment, whereas, cowpea variety UPC-212 and blackgram variety T9 were taken up as live mulching. Soil moisture content (%) at 15 days interval during maize and sesamum crop was determined from the soil depth of 0-15 cm and 15-30 cm. Soil samples from 0-15 cm depth were collected at the harvest of the first crop, before sowing of the second crop, after harvest of the second crop and various chemical analysis (pH, available N, available P_2O_5, available K_2O as in Jackson, 1973 and organic carbon- Walkey and Black, 1934 were performed.

Results and Discussion

Grain yield (kg/ha) of maize

It was observed that the highest maize grain yield (2322.33 kg/ha and 2178.29 kg/ha grain during 2013 and 2014, respectively) was obtained with the application of F_2 followed by F_1 (Table 1).

The data further revealed that W_1 could significantly increase the maize grain yield (3014.59 kg/ha, 2849.24 kg/ha in 2013 and 2014, respectively) as compared to the rest of the treatments (Table 1).

The interaction effect revealed that at the same level of organic nutrition (F), hand hoeing and earthing up at 20 and 50 days (W_1) outyielded the other treatments. At the same or different level of non-herbicidal weed management (W), 5.0 t/ha enriched compost (F_2) application recorded the best grain and stover yield of maize as compared to the other treatments. Considering all the treatment combinations, it was observed that the application of F_2W_1 resulted in significantly the best grain yield of maize (4723.81 kg/ha, 4507.24 kg/ha in 2013 and 2014, respectively). The next best treatment was F_2W_1 which recorded the grain yield of 3468.14 kg/ha, 3293.16 kg/ha respectively (Table 1).

As due to adoption of non-herbicidal weed management, weeds were efficiently controlled; significant improvement in growth of maize could be achieved by organic nutrition through application of enriched compost. Thus, F_2W_1 followed by F_1W_1 proved to be effective in weed suppression and efficient in producing higher maize yield. The efficacy of non-herbicidal methods in managing the weeds and increasing the yield in maize was highlighted by several workers (Kamble *et al*., 2005; Nagalakshmi *et al*., 2006 and Sarma and Gautam, 2010). Efficacy of organic nutrition for improving both growth and yield of maize too was reported by some workers (Sekhon and Agarwal, 1994; Khan *et al*., 2008; Ogundare *et al*., 2012 and Choudhary and Kumar, 2013). Similar to our findings regarding efficacy of W_2 or W_3, Echtenkamp and Moomaw (1989) and Uchino *et al.*, (2009) also reported that living mulches competed for nutrients and water with the main crop which might reduce the crop yield.

Seed yield (kg/ha) of sesamum

The data pertaining to table 1 reveals the yield of the sesamum crop where a significant carryover effect on the yield of sesamum was observed where the application of F_2 in maize resulted in highest seed yield (589.08 kg/ha in 2013, 402.78 kg/ha in 2014) as compared to the rest of the treatments. However, non-herbicidal weed management in maize had no significant effect on seed yield of succeeding crop sesamum (Table 1).

The carryover effect of the treatment interaction was found to be significant only during 2014. Perusal of the data indicated that at the same level of F_0, in terms of seed yield of sesamum, W_1 was significantly superior compared to W_0, W_2 and W_3. W_1 and W_3 being *at par*, both recorded significantly more seed of sesamum than W_0 and W_2. Now at F_2 application in maize, in respect of seed yield of sesamum, W_0 and W_2, both being statistically similar, were significantly superior to W_1 and W_3. At the same or different level of W in maize, F_2W_0, F_2W_2 and F_2W_3 were statistically similar with regard to seed yield of sesamum but significantly better than the rest of the combinations (Table 1).

Considering the seed yield, it can be seen that although non-herbicidal weed management in maize did not had any carry over effect, organic nutrition in maize with enriched compost application either at 2.5 t/ha or 5.0 t/ha had significant carry over effects on seed yield of the succeeding crop sesamum. As due to carry over effect of application of enriched compost significantly contributed towards improvement of growth parameters in sesamum as already discussed yield of sesamum was significantly improved as a result.

Perhaps the carry over effect of fertility management helped sesamum plants to be resilient enough vis-à-vis competition of associated weeds. Chopra and Ganguly (1988), Mahala *et al.*, (2006), Jamwal (2006) and Kumar and Dhar (2010) too reported positive residual effects of organic manures in succeeding crops like wheat, rapeseed, etc following maize.

Soil organic C (%), pH, available N, P_2O_5 and K_2O (kg/ha) at harvest of maize during 2013

Application of F_2 resulted in significantly higher soil organic C (0.54%), available soil N (258.49 kg/ha), P_2O_5 (31.22 kg/ha) and K_2O (118.00 kg/ha) than F_0 and the former treatment was *at par* with F_1 in respect of soil available K_2O. On the other hand, F_0 and F_1 were found to be *at par* in respect of soil organic C (0.51%, 0.53%, respectively). Higher soil pH was observed due to F_0 (5.30) while the least was found in F_2 (5.19) (Table 2).

W_0 recorded the highest soil available N (261.89 kg/ha), P_2O_5 (30.53 kg/ha) and K_2O (121.64 kg/ha). W_2 and W_3 were noted to be *at par* in respect of available soil N, the later being the worst. Treatments W_1, W_2 and W_2, W_3 were *at par* respectively in case of soil available P_2O_5. W_1, W_2 and W_3 were *at par*, in respect of soil available K_2O.

The interaction effect reveals that at the same level of F_0, both W_0 and W_1 being statistically *at par*, were significantly better in respect of soil available P_2O_5 whereas, in case of soil available K_2O, W_0 was significantly better than the W_1, W_2 and W_3. Now, at the same level of F_1, W_0 was significantly better than rest of the treatments for soil available P_2O_5 and K_2O. In case of F_2, both W_0 and W_3 were statically *at par*, and significantly better than W_1 and W_2 for soil available P_2O_5 whereas for soil available K_2O, W_0 was significantly the best (Table 3).

On the other hand, at the same or different level of W in maize, F_2W_0 and F_2W_3 were statistically similar and significantly better in respect of soil available P_2O_5 and K_2O than the rest of the treatment combinations.

Soil organic C (%), pH, available N, P_2O_5 and K_2O (kg/ha) before sowing of sesamum in 2013

The data revealed that application of F_1 or F_2 resulted in significantly more soil organic C (0.53 and 0.54%, respectively) compared to the F_0. In respect of soil pH, on the other hand, F_1 and F_2 registered significantly lesser soil pH than F_0 (5.29). In case of soil available N, F_1 (254.20 kg/ha) and F_2 (265.50 kg/ha) both *at par*, were significantly better than F_0. Similar result was obtained with respect to soil available K_2O (126.14 and 132.75 kg/ha in case of F_1 and F_2, respectively). Soil available P_2O_5 was found to be significantly the highest with F_2 (33.64 kg/ha) (Table 2).

No treatment of weed management in maize was found to be significantly better than the W_0 which registered 264.57 kg/ha soil available N and 31.80 kg/ha soil available P_2O_5. In case of soil available K_2O, W_0 (125.43 kg/ha) was found to *at par* with W_2 (125.22 kg/ha) and better than the rest (Table 2).

Study on the treatment interactions revealed that, at the same level of F_0, it was observed W_0 and W_1, both being *at par*, were significantly better than W_2 and W_3 in respect of soil available P_2O_5. In case of soil available K_2O, W_1 registered the significantly highest (124.12 kg/ha). At the same level of F_1, no treatment was significantly better than W_0 in respect of soil available P_2O_5. In respect of soil available K_2O, W_0 and W_2 both being statistically similar, were significantly better than the other treatments. For the same level of F_2 application, W_0 and W_3 for soil available P_2O_5, *at par* themselves were significantly superior to W_1 and W_2. W_0, W_2 and W_3 for soil available K_2O, being statistically similar, were significantly better than W_1 (Table 3).

Now, at the same or different level of non-herbicidal weed management (W) in maize, in case of soil available P_2O_5, F_2W_0 and F_2W_3, both statistically *at par*, and in case of soil available K_2O, F_1W_0, F_1W_2, F_2W_0, F_2W_2 and F_2W_3, being statistically similar, were statistically superior to rest of the combinations (Table 3).

Soil organic C (%), pH, available N, P_2O_5 and K_2O (kg/ha) at harvest of sesamum in 2013

Significantly higher soil organic C (0.55%), soil available N (240.87 kg/ha) and K_2O

(114.22 kg/ha) was recorded with application of F_2 compared to F_0. In case of soil available P_2O_5 (29.16 kg/ha), F_2 was the best. Application of F_1 and F_2 were no different from each other in respect of soil organic C, available N and K_2O (Table 2).

In case of soil available N and P_2O_5, no weed management treatment could be better than W_0 that recorded 232.58 kg/ha soil available N of and 27.0 9 kg/ha soil available P_2O_5. In case of K_2O, W_2 and W_3 (104.30 kg/ha and 101.33 kg/ha, respectively) resulted similarly with W_0 (103.45 kg/ha) (Table 2).

At the same level of F_0, both W_0 and W_1 being statistically similar in case of P_2O_5 and W_1 in case of K_2O were significantly better than the rest of the treatments. Now, at the same level of F_1, it was found that W_0 in case of soil available P_2O_5 was significantly superior. In case of soil available K_2O, W_0, W_2 and W_3, were *at par*, W_1 being the inferior amongst all. At the level of F_2, in respect of soil available P_2O_5, W_0 and W_3 were statistically *at par*, both being superior to the rest. In case of soil available K_2O, W_2 and W_3, being no different from each other, proved to be significantly superior to the rest of the treatments.

At the same or different level of non-herbicidal weed management in maize, F_2W_0, F_2W_2 and F_2W_3 were statistically *at par* but these were significantly superior in respect of available P_2O_5. On the other hand, F_1W_2, F_2W_0, F_2W_2 and F_2W_3, statistically similar themselves, recorded significantly more soil available K_2O than the rest of the treatment combinations (Table 3).

Soil organic C (%), pH, available N, P_2O_5 and K_2O (kg/ha) before sowing of maize during 2014

Application of F_2 resulted in significantly more soil organic C (0.55%) than F_0. In case of soil available N (241.72 kg/ha and 229.25 kg/ha in case of F_2 and F_1, respectively) and K_2O (115.68 and 106.89 kg/ha in case of F_2 and F_1, respectively), F_2 and F_1 being *at par* were significantly superior to F_0. On the other hand, in respect of soil available P_2O_5, F_2 (30.36 kg/ha) was significantly superior to F_0 and F_1 (Table 4).

No other treatments of weed management could be significantly better than W_0 which recorded the highest soil available N (233.21 kg/ha) and soil available P_2O_5 (28.15 kg/ha). In case of soil available K_2O, W_2 (106.03 kg/ha) and W_3 (102.63 kg/ha) were *at par* with W_0 (104.40 kg/ha) (Table 4).

At the same level of F_0 treatment, W_0 and W_1, being *at par*, recorded significantly higher soil available P_2O_5 than W_2 and W_3 whereas in case of soil available K_2O, W_1 was significantly better than the rest of the treatments. At the same or different level of F_1, no weed treatment could be better than W_0 in respect of soil available P_2O_5 whereas, W_2 and W_3 could be *at par* with W_0 in case of soil available K_2O were significantly superior to W_1. In case of same level of F_2, it was noted that W_0 and W_3, both being similar, recorded significantly higher soil available P_2O_5. In case of soil available K_2O, W_2 and W_3, both being statistically similar were significantly better than the rest. The data further showed that at the same or different level of weed management in maize, F_2W_0, F_2W_2 and F_2W_3, statistically being similar, were significantly better in respect of soil available P_2O_5 whereas, F_1W_2, F_2W_0, F_2W_2 and F_2W_3, no different from each other, recorded significantly more K_2O than rest of the combinations (Table 3).

Soil organic C (%), pH, available N, P_2O_5 and K_2O (kg/ha) at harvest of maize in 2014

It was evident that application of F_2 resulted in significantly more soil organic C (0.56%), available N (189.98 kg/ha), P_2O_5 (27.39

kg/ha) and K_2O (74.54 kg/ha) than other treatments. On the other hand, F_2 resulted in significantly lower soil pH (5.14) compared with either F_0 or F_1 (Table 4).

It was observed that W_0 treatment recorded significantly more soil available N (193.48 kg/ha, Fig. 4.3), P_2O_5 (25.92kg/ha, Fig. 4.5) and K_2O (70.86kg/ha) than rest of the treatments (Table 4).

At the same level of F_0 fertility, W_1 resulted in significantly more soil available N, P_2O_5 and K_2O. Now, at the same level of F_1, it was clear that W_0 in case of soil available N, P_2O_5 and W_0, W_2, both being *at par*, in case of soil available K_2O were significantly superior to other treatments. At the same level of F_2, W_0 for N, P_2O_5; W_0, W_2 and W_3, all statistically similar for K_2O, were significantly superior to rest of the treatments. At the same or different level of non-herbicidal weed management (W), F_2W_0 in case of soil available N and P_2O_5 and F_1W_0, F_2W_0, F_2W_2 and F_2W_3, all being statistically *at par* for K_2O were significantly better than the respective other combinations (Table 5).

Soil organic C (%), pH, available N, P_2O_5 and K_2O (kg/ha) before sowing of sesamum in 2014

Application of F_2 recorded more soil organic C (0.57%), available N (197.74 kg/ha), P_2O_5 (29.44 kg/ha) and K_2O (85.58 kg/ha) before sowing of sesamum while the next best treatment was F_1 application. F_2 also registered lower soil pH (5.12) while in case of F_0 higher soil pH (5.26) was recorded. Further it was noticed that F_1 and F_2 were statistically similar in respect of soil organic C, pH, available N and K_2O (Table 4).

Effect of weed management on available N, P_2O_5 and K_2O in soil before sowing of sesamum in 2014 was found to be significant. The data revealed that barring W_2 which was *at par* with W_0 but was significantly superior to rest of the treatments in respect of soil available K_2O (76.27 kg/ha); no weed management treatments could be significantly better than W_0 in respect of soil available N (196.57 kg/ha) and P_2O_5 (26.90 kg/ha) (Table 4).

The data reflected that at the same level of F_0 in respect of fertility management in maize, W_1 resulted in significantly more soil available N, P_2O_5 and K_2O than others. At the same level of F_1 application in maize, W_0 in case of soil available N and P_2O_5 and W_0 and W_2, statistically *at par* in case of soil available K_2O were significantly superior to the respective other treatments. At the same level of F_2, W_0 for soil available N and P_2O_5 was superior to other treatments. In case of soil available K_2O, W_2 and W_3, being statistically no different were significantly superior to the rest. On the other hand, at the same or different level of non-herbicidal weed management (W) of maize, no other treatment combination was better than F_2W_0 in case of soil available N and P_2O_5; F_2W_0, F_2W_2 and F_2W_3, all being statistically *at par* were significantly better than the rest of the treatment combinations in respect of soil available K_2O (Table 5).

Soil organic C (%), pH, available N, P_2O_5 and K_2O (kg/ha) at harvest of sesamum in 2014

The perusal of the data reflected that the application of F_2 resulted in significantly the highest soil organic C (0.57%), available N (171.63 kg/ha), P_2O_5 (27.35 kg/ha) and K_2O (68.65 kg/ha). F_1 was the second best in this regard (Table 6).

It was observed as compared with W_0 which registered the significantly higher values of soil available N and P_2O_5 (172.56 kg/ha N and

24.50 kg/ha P_2O_5), other weed management treatments were inferior barring W_2 which was significantly superior to all other treatments in respect of soil available K_2O (60.585 kg/ha) (Table 6).

The data revealed that at the same level of treatment, F_0, W_1 resulted in significantly more soil available N, P_2O_5 and K_2O than W_0, W_2 and W_3. In the same level of F_1, it was noted that W_0 for soil available N and P_2O_5; W_0 and W_2, statistically *at par* themselves for soil available K_2O, were significantly better than the respective other treatments. At the same level of F_2 treatment, W_0 for N and P_2O_5 and W_2 and W_3, statistically no different from each other for K_2O, were significantly superior than the respective other treatments. On the other hand, at the same or different level of weed management (W) in maize, F_2W_0 in case of soil available N and P_2O_5; F_2W_2 and F_2W_3, being statistically similar for soil available K_2O proved to be significantly superior to rest of the treatment combinations (Table 6).

From the above described findings in respect of soil pH, organic C and available N, P_2O_5 and K_2O, it could be known that throughout the period of the experiment, fertility management could influence the status of soil organic C and availability of N, P_2O_5 and K_2O in soil.

Soil pH decreased significantly over the period of the study due to enriched compost application in maize compared to no application control. This may be attributed to decomposition and nitrification processes during which various acids were produced (Kalhapure *et al.*, 2013). Soils become acidic because of warm temperature and high rainfall due to which basic cations are leached from the soil profile leaving behind more stable materials rich in Fe and Al oxides (Salim *et al.*, 2015)

By comparing soil organic C from soil analysis prior to beginning of the experiment with the data in this regard from analysis during the period of the experiment at different stages, it appeared that fertility management in maize with enriched compost could maintain a significantly higher level of soil organic C. The utility of organic manure application in maintaining soil organic C status is an established fact (Diacono and Montemurro, 2010).

Non-herbicidal weed management did not show any effect on soil pH and soil organic C which may be attributed to the fact that the experimental period was not sufficient enough to observe significant influence in these aspects. Perhaps, long-term experiments may show significant effect in this regard. In general, due to non-herbicidal weed management during maize, organic C had increased whereas the soil pH decreased as compared to initial values at the end of the experiment.

By comparing the data obtained from soil analysis prior to the experiment with the data obtained from later soil analysis at different stages, it may be seen that availability of soil N, P_2O_5 and K_2O gradually decreased over the period of the experiment. On the other hand, due to either enriched compost application or non-herbicidal weed management in maize during both the years of the experiment, soil available N, P_2O_5 and K_2O varied significantly. Significantly more available N, P_2O_5 and K_2O recorded due to enriched compost application in the previous season meant that organic nutrition could sustain availability of these major nutrients in soil.

Table.1 Effect of weed and fertility management and their interaction on grain yield (kg/ha) of maize and seed yield (kg/ha) of sesamum

Treatment	Maize		Sesamum	
	2013	**2014**	**2013**	**2014**
F				
F_0	380.18	314.31	445.06	226.92
F_1	1779.74	1681.83	556.28	353.91
F_2	2322.33	2178.29	589.08	402.78
SEm (±)	17.602	16.414	9.823	6.105
CD (P=0.05)	69.113	64.450	38.570	23.970
W				
W_0	1050.43	944.64	541.71	339.42
W_1	3014.59	2849.24	529.02	334.53
W_2	917.44	854.06	531.17	313.96
W_3	993.88	917.96	518.67	323.56
SEm (±)	25.640	17.627	10.290	7.637
CD (P=0.05)	76.179	52.371	NS	NS
F X W	**	**	NS	**
CV (%)	4.08	4.09	6.42	6.45
	5.15	3.80	5.82	6.99

	Year (Maize)								Year (Sesamum)			
	2013				**2014**				**2014**			
	W_0^*	**W_1**	**W_2**	**W_3**	**W_0^***	**W_1**	**W_2**	**W_3**	**W_0^***	**W_1**	**W_2**	**W_3**
F_0	226.63	851.83	219.80	222.46	173.63	747.32	168.55	167.73	227.97	312.67	191.57	175.47
F_1	1303.78	3468.14	1104.97	1242.08	1210.54	3293.16	1043.88	1179.74	328.87	385.97	324.53	376.28
F_2	1620.88	4723.81	1427.54	1517.11	1449.75	4507.24	1349.75	1406.42	461.43	304.97	425.77	418.93
	SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)	
D_1	44.409		131.947		30.530		90.710		13.228		39.304	
D_2	37.716		132.665		32.269		100.732		12.472		47.371	

F- Fertility management, W- Weed management F_0 – Control, F_1 – 2.5 t/ha Enriched Compost, F_2 – 5.0 t/ha Enriched Compost; W_0 - Weedy check, W_1 - Hand hoeing and earthing up at 20 and 50 DAS, W_2 - *In situ* cowpea mulching upto 50 DAS, W_3 - *In situ* blackgram mulching upto 50 DAS
D_1 Difference of two W means at the same level of F; D_2 Difference of two F means at the same or different level of W

Table.2 Effect of weed and fertility management on soil organic C (%), pH, available N (kg/ha), P_2O_5 (kg/ha) and K_2O (kg/ha) at harvest of maize 2013, before sowing of sesamum 2013 and after harvest of sesamum 2013

	C	pH	N	P_2O_5	K_2O	C	pH	N	P_2O_5	K_2O	C	pH	N	P_2O_5	K_2O
F	**After harvest of maize 2013**					**Before sowing of sesamum 2013**					**After harvest of sesamum 2013**				
F_0	0.51	5.30	230.37	25.06	102.86	0.51	5.29	232.70	26.10	107.12	0.51	5.29	191.36	21.84	83.09
F_1	0.53	5.24	248.12	26.83	113.53	0.53	5.21	254.20	28.56	126.14	0.54	5.23	228.58	24.06	105.83
F_2	0.54	5.19	258.49	31.22	118.00	0.54	5.17	265.50	33.64	132.75	0.55	5.20	240.87	29.16	114.22
SEm (±)	0.006	0.019	4.938	0.423	2.150	0.005	0.020	4.958	0.435	2.070	0.007	0.023	5.261	0.365	2.441
CD (P=0.05)	0.023	0.074	19.391	1.663	8.442	0.020	0.078	19.468	1.707	8.129	0.028	NS	20.656	1.433	9.584
W															
W_0	0.53	5.24	261.89	30.53	121.64	0.52	5.22	264.57	31.80	125.43	0.53	5.24	232.58	27.09	103.45
W_1	0.52	5.24	248.80	25.97	108.01	0.53	5.22	251.51	27.30	116.93	0.53	5.25	220.02	23.00	95.09
W_2	0.53	5.24	237.39	26.66	108.90	0.53	5.22	245.64	29.22	125.22	0.54	5.25	215.43	24.81	104.30
W_3	0.54	5.25	234.55	27.66	107.31	0.54	5.23	241.49	29.41	120.42	0.54	5.24	213.07	25.18	101.33
SEm (±)	0.005	0.021	3.291	0.407	1.282	0.007	0.025	3.311	0.404	1.286	0.006	0.017	3.926	0.419	1.374
CD (P=0.05)	NS	NS	9.777	1.210	3.808	NS	NS	9.838	1.199	3.821	NS	NS	11.666	1.245	4.081
F X W	NS	NS	NS	**	**	NS	NS	NS	**	**	NS	NS	S	**	**
CV (%)	3.82	1.24	6.96	5.29	6.68	3.39	1.31	6.85	5.12	5.88	4.58	1.53	8.27	5.05	8.37
	2.75	1.18	4.02	4.41	3.45	3.76	1.45	3.96	4.11	3.16	3.37	1.00	5.35	5.02	4.08

F- Fertility management, W- Weed management F_0 – Control, F_1 – 2.5 t/ha Enriched Compost, F_2 – 5.0 t/ha Enriched Compost; W_0 - Weedy check, W_1 - Hand hoeing and earthing up at 20 and 50 DAS, W_2 - *In situ* cowpea mulching upto 50 DAS, W_3 - *In situ* blackgram mulching upto 50 DAS
NS Non-significant; ** Significant

Table.3 Effect of interaction of weed and fertility management on soil available P_2O_5 (kg/ha) and K_2 (kg/ha) after harvest of maize 2013, before sowing of sesamum 2013, after harvest of sesamum 2013 and before sowing of maize 2014

Treatment	After harvest of maize 2013								Before sowing of sesamum 2013							
	P_2O_5				K_2O				P_2O_5				K_2O			
	W_0*	W_1	W_2	W_3	W_0*	W_1	W_2	W_3	W_0*	W_1	W_2	W_3	W_0*	W_1	W_2	W_3
F_0	25.61	27.55	23.62	23.45	106.07	120.63	94.21	90.55	26.42	28.38	25.06	24.52	108.77	124.12	100.10	95.48
F_1	30.69	25.47	25.12	26.05	127.50	102.00	115.69	108.92	31.73	26.62	27.94	27.97	131.17	112.36	135.81	125.21
F_2	35.30	24.88	31.23	33.47	131.34	101.40	116.81	122.45	37.26	26.89	34.65	35.75	136.35	114.31	139.75	140.57
	SEm (±)		CD (P = 0.05)		SEm (±)		CD (P = 0.05)		SEm (±)		CD (P = 0.05)		SEm (±)		CD (P = 0.05)	
D_1	0.705		2.096		2.220		6.596		0.699		2.077		2.228		6.618	
D_2	0.814		2.439		3.886		10.100		0.830		2.457		3.755		9.929	
Treatment	**After harvest of sesamum 2013**								**Before sowing of maize 2014**							
	P_2O_5				K_2O				P_2O_5				K_2O			
	W_0*	W_1	W_2	W_3	W_0*	W_1	W_2	W_3	W_0*	W_1	W_2	W_3	W_0*	W_1	W_2	W_3
F_0	22.26	23.77	20.87	20.45	86.36	96.67	76.90	72.42	23.12	24.65	21.81	21.37	87.19	97.45	78.98	73.54
F_1	26.69	22.21	23.48	23.85	109.36	92.51	113.88	107.58	27.80	23.54	24.79	25.14	110.46	93.54	114.96	108.59
F_2	32.32	23.00	30.08	31.25	114.65	96.10	122.13	123.99	33.53	24.20	31.31	32.41	115.55	97.26	124.16	125.75
	SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)	
D_1	0.726		2.156		2.379		7.068		0.726		2.157		2.380		7.073	
D_2	0.729		2.334		4.392		11.271		0.733		2.671		4.402		11.625	

F- Fertility management, W- Weed management F_0 – Control, F_1 – 2.5 t/ha Enriched Compost, F_2 – 5.0 t/ha Enriched Compost; W_0 - Weedy check, W_1 - Hand hoeing and earthing up at 20 and 50 DAS, W_2 - *In situ* cowpea mulching upto 50 DAS, W_3 - *In situ* blackgram mulching upto 50 DAS

D_1 Difference of two W means at the same level of F; D_2 Difference of two F means at the same or different level of W

Table.4 Effect of weed and fertility management on soil organic C (%), pH, available N (kg/ha), P_2O_5 (kg/ha) and K_2O (kg/ha) before sowing of maize 2014, after harvest of maize 2014 and before sowing of sesamum 2014

	C	pH	N	P_2O_5	K_2O	C	pH	N	P_2O_5	K_2O	C	pH	N	P_2O_5	K_2O
F	**Before sowing of maize 2014**					**After harvest of maize 2014**					**Before sowing of sesamum 2014**				
F_0	0.51	5.29	191.76	22.74	84.29	0.50	5.27	133.91	15.04	45.82	0.50	5.26	137.23	15.85	52.59
F_1	0.54	5.24	229.25	25.32	106.89	0.55	5.17	173.77	19.12	65.15	0.55	5.15	180.58	20.62	74.41
F_2	0.55	5.21	241.72	30.36	115.68	0.56	5.14	189.98	27.39	74.54	0.57	5.12	197.74	29.44	85.58
SEm (±)	0.005	0.023	4.679	0.368	2.447	0.006	0.020	3.706	0.377	1.559	0.008	0.025	4.955	0.406	1.936
CD (P=0.05)	0.021	NS	18.372	1.444	9.606	0.023	0.078	14.550	1.479	6.122	0.031	0.096	19.457	1.592	7.600
W															
W_0	0.53	5.25	233.21	28.15	104.40	0.53	5.19	193.48	25.92	70.86	0.54	5.18	196.57	26.90	74.17
W_1	0.53	5.25	220.62	24.13	96.08	0.54	5.19	167.89	16.31	58.93	0.54	5.17	171.04	17.38	65.40
W_2	0.53	5.25	216.05	25.97	106.03	0.54	5.20	154.85	19.68	62.12	0.54	5.19	165.41	21.88	76.27
W_3	0.54	5.24	213.75	26.31	102.63	0.55	5.19	147.33	20.16	55.44	0.55	5.18	154.40	21.73	67.60
SEm (±)	0.005	0.018	3.936	0.419	1.374	0.006	0.019	3.099	0.491	1.308	0.006	0.018	3.240	0.492	1.891
CD (P=0.05)	NS	NS	11.695	1.246	4.083	NS	NS	9.207	1.459	3.885	NS	NS	9.628	1.462	5.619
F X W	NS	NS	NS	**	**	NS	NS	**	**	**	NS	NS	**	**	**
CV (%)	3.49	1.49	7.34	4.87	8.29	3.72	1.33	7.74	6.36	8.73	5.06	1.64	9.99	6.39	9.46
	3.02	1.05	5.34	4.81	4.03	3.15	1.12	5.60	7.18	6.34	3.21	1.04	5.66	6.72	8.00

F- Fertility management, W- Weed management F_0 – Control, F_1 – 2.5 t/ha Enriched Compost, F_2 – 5.0 t/ha Enriched Compost; W_0 - Weedy check, W_1 - Hand hoeing and earthing up at 20 and 50 DAS, W_2 - *In situ* cowpea mulching upto 50 DAS, W_3 - *In situ* blackgram mulching upto 50 DAS
NS Non-significant; ** Significant

Table.5 Effect of interaction of weed and fertility management on soil available N (kg/ha), P_2O_5 (kg/ha) and K_2O (kg/ha) after harvest of maize 2014 and before sowing of sesamum 2014

Treatment	After harvest of maize 2014											
	N				P_2O_5				K_2O			
	W_0^*	W_1	W_2	W_3	W_0^*	W_1	W_2	W_3	W_0^*	W_1	W_2	W_3
F_0	145.53	163.88	116.92	109.34	16.00	19.69	12.44	12.02	50.91	73.93	32.01	26.42
F_1	203.37	168.59	167.05	156.07	24.98	15.58	17.73	18.18	77.43	53.00	71.09	59.10
F_2	231.54	171.21	180.58	176.58	36.78	13.67	28.85	30.26	84.24	49.86	83.25	80.81
	SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)	
D_1	5.367		15.947		2.379		7.068		0.851		2.527	
D_2	6.957		19.868		4.392		11.271		0.779		2.915	
Treatment	Before sowing of sesamum 2014											
	N				P_2O_5				K_2O			
	W_0^*	W_1	W_2	W_3	W_0^*	W_1	W_2	W_3	W_0^*	W_1	W_2	W_3
F_0	147.75	166.10	122.19	112.90	16.59	20.31	13.49	13.01	53.17	76.88	44.40	35.93
F_1	206.54	171.94	179.36	164.50	25.81	16.50	20.20	19.97	80.59	59.98	85.30	71.76
F_2	235.41	175.09	194.68	185.78	38.30	15.32	31.93	32.21	88.75	59.33	99.13	95.12
	SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)		SEm (±)		CD (P=0.05)	
D_1	5.613		16.676		2.379		7.068		0.852		2.533	
D_2	9.030		25.905		4.392		11.271		0.822		3.001	

F- Fertility management, W- Weed management F_0 – Control, F_1 – 2.5 t/ha Enriched Compost, F_2 – 5.0 t/ha Enriched Compost; W_0 - Weedy check, W_1 - Hand hoeing and earthing up at 20 and 50 DAS, W_2 - *In situ* cowpea mulching upto 50 DAS, W_3 - *In situ* blackgram mulching upto 50 DAS
D_1 Difference of two W means at the same level of F; D_2 Difference of two F means at the same or different level of W

Table.6 Effect of weed and fertility management and their interaction on soil organic C (%), pH, available N (kg/ha), P_2O_5 (kg/ha) and K_2O (kg/ha) at harvest of sesamum, 2014

Treatment	C	pH	N	P_2O_5	K_2O
	2014				
F					
F_0	0.50	5.27	116.39	13.22	38.44
F_1	0.56	5.18	156.94	18.53	58.36
F_2	0.57	5.15	171.63	27.35	68.65
SEm (±)	0.007	0.029	4.265	0.364	1.230
CD (P=0.05)	0.028	NS	16.747	1.430	4.829
W					
W_0	0.54	5.20	172.56	24.50	57.54
W_1	0.55	5.19	147.51	15.07	49.68
W_2	0.55	5.20	142.19	19.78	60.58
W_3	0.55	5.20	131.03	19.45	52.80
SEm (±)	0.008	0.018	2.657	0.484	1.414
CD (P=0.05)	NS	NS	7.893	1.437	4.202
F X W	NS	NS	**	**	**
CV (%)	4.53	1.91	9.96	6.40	7.72
	4.30	1.03	5.37	7.37	7.69

	Year											
	2014											
	N				P_2O_5				K_2O			
	W_0^*	**W_1**	**W_2**	**W_3**	**W_0^***	**W_1**	**W_2**	**W_3**	**W_0^***	**W_1**	**W_2**	**W_3**
F_0	127.08	142.43	102.91	93.16	14.01	17.28	10.96	10.64	38.86	60.91	30.80	23.21
F_1	183.16	147.51	156.56	140.53	23.68	14.00	18.63	17.80	63.69	43.17	70.53	56.05
F_2	207.43	152.58	167.11	159.39	35.80	13.95	29.74	29.93	70.06	44.96	80.42	79.14
	SEm (±)		CD (P=0.05)		SEm (±)		CD(P=0.05)		SEm (±)		CD(P=0.05%)	
D_1	4.601		13.672		0.838		2.489		2.450		7.278	
D_2	7.737		20.319		0.757		2.927		2.457		7.875	

F- Fertility management, W- Weed management F_0 – Control, F_1 – 2.5 t/ha Enriched Compost, F_2 – 5.0 t/ha Enriched Compost; W_0 - Weedy check, W_1 - Hand hoeing and earthing up at 20 and 50 DAS, W_2 - *In situ* cowpea mulching upto 50 DAS, W_3 - *In situ* blackgram mulching upto 50 DAS

D_1 Difference of two W means at the same level of F; D_2 Difference of two F means at the same or different level of W

NS Non-significant; ** Significant

It was obvious to note that during the subsequent crop sesamum, unweeded control plot showed significantly more available N, P_2O_5 and K_2O as it is easily understandable that due to non-herbicidal weed management *i.e.* hand hoeing and earthing up at 20 and 50 days, *in situ* cowpea or blackgram mulching upto 50 days during the preceding crop maize, the crop and weeds besides the live mulches absorbed these major nutrients substantially resulting in lesser soil available N, P_2O_5 and K_2O compared to absorption mainly by weeds only in case of weedy check. Significant interaction between fertility and weed management in this respect highlighted this aspect.

Compared to the initial soil fertility status, it was observed that soil available N, P_2O_5 and K_2O decreased at the end of the field experiment (after harvest of sesamum, 2014). This may be due to the uptake of nutrients by the maize crop, sesamum crop, weeds, *in situ* cowpea or blackgram live mulching, leaching loss, volatilization loss, fixation in the soil and also due to the slow release of nutrients from enriched compost even though large quantity of enriched compost @ 2.5 or 5.0 t/ha were applied during the maize crop season in 2013 and 2014. Diacono and Montemurro (2009) on reviewing the experiment conducted by Hartl *et al.,* (2003) and Eghball *et al.,* (2004) concluded that compost application on long-term basis for several years may result in residual effects in respect of soil properties and crop production since only a fraction of the N and other nutrients becomes available to plants in the first year after application. Eghball and Power (1999) in a four year study found that the estimated N availability was 40% for manure and 15% for compost in the first year and was 18% for manure and 8% for compost in the second year after application. Curless *et al.,* (2005) found that an apparent availability of manurial N from 10% to 40%, with an overall average across all 3 years and all parameters of 28.6% for the lower rate and 24.6% for the high rate and P availability ranged from 20% to 90% with an overall average across all 3 years of 55.4% for the low and 50.5% for the high manure rates. Diacono and Montemurro (2009) reviewed the work of Hartl *et al.,* (2003) and stated that soil available potassium (K) content increased on average by 26%, as compared with control, in 5-year compost treatments derived from organic household wastes and yard trimmings.

In conclusions, application of enriched compost resulted in significantly better yield and higher soil fertility level under rainfed maize-sesamum cropping sequence. Hand hoeing and earthing up at 20 and 50 days significantly increased the yield of maize as well as maintain higher soil fertility level of the sequence however no carry over effect was observed in the yield sesamum.

Since the present investigation was carried out during 2013 and 2014 only, experiments are needed to be conducted for more number of years to derive concrete information on long term benefits covering every aspect of management including weed and fertility management from organically managed cropping sequence like maize-sesamum under rainfed situation.

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