Weed growth and nutrient uptake in organically managed rice and maize as affected by nitrogen management and live mulching with cowpea

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ABSTRACT
Field investigations were conducted during 2015 and 2016 kharif seasons at the experimental farm of ICAR, Nagaland Centre, Medziphema to study weed growth and nutrient uptake in organically managed rice and maize as affected by N management and live mulching with cowpea. The experiment was laid out in factorial RBD with two kharif crops viz., rice (C1) and maize (C2), two organic N management viz., vermicompost @ 2 t/ha (N1) and vermicompost @ 2.7 t/ha (N2) and two mulches viz., control (No mulching) (L1) and live mulching with cowpea (L2). The dominant weed species observed were Cynodon dactylon, Digitaria setigera, Ageratum conyzoides, Amaranthus viridis, Cyperus iria and Cyperus rotundus. Weed density, dry weight and NPK uptake was found to be significantly lower in maize compared to rice during both years. Weed growth and NPK uptake was also found to be significantly higher with application of vermicompost @ 2.7 t/ha (N2) compared to 2 t/ha (N1) whereas, significantly lower weed growth as well as NPK uptake was also recorded with cowpea live mulch (L2) as compared to no mulching (L1). Cowpea live mulch (L2) with application of vermicompost @ 2 t/ha (N1) was found to record significantly lower NPK uptake by weeds in both crops. Yield and yield attributes of rice and maize were observed to be higher under cowpea live mulch with application of vermicompost @ 2.7 t/ha (N2).

Key words: Live mulch, Maize, Nitrogen, NPK uptake, Organic, Rice, Weed growth.

INTRODUCTION
Cropping system in the North East Region of India is predominantly rice and maize based under low-input low-risk and low yield condition. The production of food grains in NE region is 5.97 million tonnes and the requirement is 7.6 million tonnes and the requirement would be 15.24 million tonnes by 2021 (Sharma and Datta, 2006). 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. In the present scenario, the intensification of cropping systems and high input agriculture in order to meet the food grain requirements of the ever-increasing population had led to resource degradation and reducing production and productivity of these systems leading to major interest and work for popularization of organic farming systems worldwide. Organic agriculture is one among the broad-spectrum production methods that is supportive of the environment (Ramesh et al, 2008). Socio-economic and ecologically sustainable development concept of organic systems can be attributed to the fact that on one hand application and efficient management of local resources viz., local seed varieties, manure, etc. leads to cost effectiveness while, on the other hand the market for organic products at local seed varieties, manure, etc. leads to cost effectiveness systems can be attributed to the fact that on one hand broad-spectrum production methods that is supportive of the environment and opportunities for income generation. The concept of organic agriculture opens up new ways of achieving sustainable development and has therefore developed dynamically over the past decade (Willer and Yussefi, 2006). Farming in the North East hill region is regarded as organic by default as the application of fertilizers and pesticides is meager in this part compared to the other parts of the country. With increasing awareness and availability of resources organic systems are slowly gaining momentum in the North East. The weed problems and management strategies under organic systems are different from conventional systems and the primary weed control strategies for organic systems are cultural, mechanical and biological methods such as crop rotation, competitive cultivars, cover crops, mulching, N management, soil solarization, use of cultivating tools like hoes, harrows, etc. and use of pathogens and natural enemies and these management practices are focused on prevention rather than complete elimination of weed species. Hence, the present investigation was conducted to study the weed growth and NPK uptake in organic rice and maize in an attempt to estimate the level of weed growth under these systems and the degree of weed control achieved under these systems under rainfed conditions of North East India.
MATERIALS AND METHODS

The present investigation was conducted during the *kharif* seasons of 2015 and 2016 at the experimental farm of ICAR, Nagaland Centre, Medziphema to study weed growth and nutrient uptake in organically managed upland rice and maize as affected by N management and live mulching with cowpea. The soil of the experimental field was sandy loam in texture with pH 4.84, organic carbon (0.47%), N (147.39 kg ha⁻¹), P₂O₅ (19.04 kg ha⁻¹) and K₂O (170.02 kg ha⁻¹). The experiment was laid out in factorial RBD with two *kharif* crops *viz.*, rice (C₁) and maize (C₂), two organic N management viz., vermicompost @ 2 t/ha (N₁) and vermicompost @ 2.7 t/ha (N₂) and two mulches viz., control (No mulching) (L₁) and live mulching with cowpea (L₂). Upland rice variety Inglonkiri and composite maize variety 'RCM-76' were used for the present investigation. The experimental plot was ploughed thoroughly with tractor drawn disc plough and disc harrow followed by laddering to obtain fine tilth and a levelled bed. Rice was sown in lines 20 cm apart at a depth of 3 cm using a seed rate of 75 kg ha⁻¹ whereas, maize was also sown in lines at a depth of 3-4 cm maintaining a spacing of 60 cm x 20 cm with a seed rate of 22.5 kg ha⁻¹. Cowpea was sown in between the rows of rice and maize at a depth of 5 cm maintaining one row of cowpea in between rice rows and two rows of cowpea in between maize rows. The cowpea live mulch was allowed to grow up to 50 days and thereafter it was cut at ground level and left on the ground within the rows. Weed density and dry weight data was recorded at 30 and 60 DAS (days after sowing) and at harvest using a quadrant of 0.25 m² size which was placed twice randomly in each individual plot and average values were recorded for each plot. Nutrient uptake by weeds recorded at 60 DAS and at harvest was analysed with Micro Kjeldhal method (Jackson, 1973) for nitrogen, Vanadomolybdate yellow colour (colorimetric) method (Jackson, 1973) for phosphorous and Potassium-Flame photometer method (Jackson, 1973) for potassium. Total NPK uptake by weeds was calculated using the formula, Nutrient uptake = Percent of nutrient concentration x Biomass (kg ha⁻¹). Yield data on rice and maize was also recorded from each plot however, since the yield and yield attributes of rice and maize was statistically impossible to analyze together, the average data were worked out to have an average assessment of yield performance by each crop under the different management practices.

RESULTS AND DISCUSSION

Weed flora: Rice and maize both being *kharif* crops were infested by diverse weed flora. The weed flora of both rice and maize consisted of grasses, sedges and broadleaved weeds. During both years, the dominant weed species observed were *Cynodon dactylon*, *Digitaria setigera* and *Elesine indica* among grasses; *Ageratum conyzoides*, *Amaranthus viridis*, *Eleusine indica* and *Mimosa pudica* among broadleaf weeds and *Cyperus iria* and *Cyperus rotundus* among sedges.

Weed growth: Weed density and dry weight recorded at 30 and 60 DAS and harvest were found to be significantly lower in maize (C₂) than in rice (C₁) during both the years of experiment (Table 1 and 2). This may be attributed to the fact

| Table 1: Effect of crop, organic nitrogen management and live mulching on weed density (No. m⁻²). |
|-----------------------------------------------|----------|----------|----------|----------|----------|----------|
| Treatment                                      | Weed density (No. m⁻²) |
|                                               | 30 DAS    | 60 DAS    | Harvest  |
|                                               | 2015      | 2016      | 2015      | 2016      | 2015      | 2016      |
| Crop (C)                                       |           |           |           |           |           |           |
| C₁-Rice                                       | 19.28     | 19.06     | 21.68     | 21.00     | 26.89     | 26.50     |
| (374.93)                                      | (363.12)  | (473.39)  | (448.06)  | (696.54)  | (712.99)  |
| C₂-Maize                                      | 17.91     | 17.63     | 19.93     | 19.11     | 23.92     | 23.21     |
| (322.41)                                      | (312.49)  | (399.15)  | (373.82)  | (538.58)  | (538.71)  |
| Organic N management (N)                      |           |           |           |           |           |           |
| N₁-75% N as vermicompost                      | 17.90     | 17.59     | 19.94     | 19.12     | 23.91     | 23.20     |
| (322.51)                                      | (311.37)  | (399.91)  | (374.58)  | (504.89)  | (538.79)  |
| N₂-100% N as vermicompost                     | 19.28     | 19.10     | 21.67     | 20.99     | 26.89     | 26.50     |
| (374.82)                                      | (364.24)  | (472.63)  | (447.30)  | (730.22)  | (712.93)  |
| Live mulching (L)                             |           |           |           |           |           |           |
| L₁-Control (No mulching)                      | 20.00     | 19.80     | 22.20     | 21.54     | 29.50     | 27.95     |
| (401.56)                                      | (396.01)  | (495.46)  | (470.13)  | (771.17)  | (775.15)  |
| L₂-Live mulching with cowpea                  | 17.18     | 16.89     | 19.40     | 18.57     | 21.31     | 21.75     |
| (295.77)                                      | (285.60)  | (377.08)  | (351.75)  | (463.95)  | (476.56)  |
| SEM(±)                                        | 0.15      | 0.24      | 0.50      | 0.20      | 0.25      | 0.50      |
| CD (P=0.05)                                   | 0.66      | 0.48      | 1.52      | 0.43      | 0.78      | 1.07      |
| Interactions-CxN, CxL, NxL, CxNxL              | NS        | NS        | NS        | NS        | NS        | NS        |
| CV (%)                                        | 4.10      | 2.99      | 8.37      | 2.49      | 3.53      | 4.95      |

Figures in parenthesis represent original values.
that maize being a C4 plant and being a taller and stronger stunted crop might have been more competitive with the weeds resulting in reduced weed growth and dry matter accumulation. Higher leaf area associated with maize may also be attributed for lower weed crop. Zystro et al. (2012) also reported that plant height and early season leaf area correlated with both weed suppressive ability and crop tolerance in sweet corn. Characteristics commonly identified to make crops more competitive include rapid germination, early above ground growth, rapid leaf area and canopy establishment, large leaf area development and duration, high tillering capacity and greater plant height (Lemerle et al., 2001). Organic nitrogen management also recorded significant variations on weed growth during both years (Table 1 and 2). At all the stages of observations significantly higher weed density and weed dry weight was recorded with application of vermicompost @ 2.7 t/ha (N2) as compared to application of vermicompost @ 2 t/ha (N1). This may be due increase in the availability of nutrients in the soil with application of higher doses of vermicompost resulting in higher weed growth and dry matter accumulation in case of the treatment N2. Arif et al., (2011) also reported that application of 8 t ha⁻¹ organic manure produced higher number of weeds, greater weed fresh and dry biomass in maize as compared with the application of 4 and 6 t ha⁻¹. Significantly higher weed density and weed dry weight in rice with application of 100 % RDF through organic manure was also reported by Borah et al., (2015). Live mulching.

Table 2: Effect of crop, organic nitrogen management and live mulching on weed dry weight (g m⁻²).

| Treatment                  | Weed dry weight (g m⁻²) |
|----------------------------|------------------------|
|                            | 30 DAS | 60 DAS | Harvest |
|                            | 2015   | 2016   | 2015   | 2016   | 2015 | 2016 |
| Crop (C)                   |        |        |        |        |      |      |
| C1-Rice                    | 16.33  | 15.94  | 17.97  | 17.55  | 20.17 | 19.66 |
|                            | (266.74) | (254.08) | (324.91) | (309.91) | (409.33) | (389.37) |
| C2-Maize                   | 15.88  | 15.57  | 16.86  | 16.39  | 19.47  | 18.94 |
|                            | (252.32) | (240.91) | (287.10) | (272.10) | (380.92) | (360.99) |
| Organic N management (N)   |        |        |        |        |      |      |
| N1-75% N as vermicompost  | 15.90  | 15.58  | 16.86  | 16.40  | 19.47  | 18.95 |
|                            | (252.88) | (240.98) | (286.63) | (271.63) | (380.48) | (360.47) |
| N2-100% N as vermicompost | 16.31  | 15.93  | 17.97  | 17.54  | 20.17  | 19.66 |
|                            | (266.18) | (254.01) | (325.38) | (310.38) | (409.81) | (389.79) |
| Live mulching (L)          |        |        |        |        |      |      |
| L1-Control (No mulching)   | 16.65  | 16.35  | 18.93  | 18.52  | 21.30  | 20.83 |
|                            | (277.06) | (266.87) | (358.57) | (343.57) | (454.31) | (434.31) |
| L2-Live mulching with cowpea| 15.56  | 15.17  | 15.90  | 15.42  | 18.33  | 17.78 |
|                            | (242.00) | (228.12) | (253.44) | (238.44) | (335.99) | (315.89) |
| SEm(±)                     | 0.11   | 0.31   | 0.10   | 0.11   | 0.12   | 0.11 |
| CD (P=0.05)                | 0.34   | 0.67   | 0.32   | 0.33   | 0.37   | 0.35 |
| Interactions-CxN, CxL, NxL, CxNxL | NS     | NS     | NS     | NS     | NS     | NS   |
| CV (%)                     | 2.47   | 4.87   | 2.13   | 2.26   | 2.16   | 2.11 |

Figures in parenthesis represent original values.

Table 3: Effect of crop, organic nitrogen management and live mulching on NPK (kg ha⁻¹) uptake by weeds at 60 DAS.

| Treatment                  | Nutrient uptake (kg ha⁻¹) |
|----------------------------|--------------------------|
|                            | N  | 2016 | P₂O₅| 2016 | K₂O | 2015 | 2016 |
| Crop (C)                   |    |      |     |      |     |      |      |
| C1-Rice                    | 36.33 | 35.63 | 8.39 | 7.56 | 39.94 | 38.74 |
| C2-Maize                   | 29.92 | 29.18 | 7.15 | 6.46 | 35.12 | 33.89 |
| Organic N management (N)   |    |      |     |      |     |      |      |
| N1-75% N as vermicompost  | 29.92 | 29.11 | 7.15 | 6.45 | 35.09 | 33.94 |
| N2-100% N as vermicompost | 36.33 | 35.71 | 8.39 | 7.57 | 39.97 | 38.69 |
| Live mulching (L)          |    |      |     |      |     |      |      |
| L1-Control (No mulching)   | 41.01 | 40.33 | 9.40 | 8.49 | 45.89 | 44.48 |
| L2-Live mulching with cowpea| 25.24 | 24.49 | 6.14 | 5.53 | 29.17 | 28.15 |
| SEm (±)                    | 0.33  | 0.30  | 0.11 | 0.10 | 0.53  | 0.49 |
| CD (P=0.05)                | 1.05  | 0.96  | 0.50 | 0.48 | 2.41  | 2.20 |
Table 4: Effect of crop, organic nitrogen management and live mulching on NPK uptake by weeds at harvest.

| Treatment | Nutrient uptake (kg ha⁻¹) |
|-----------|---------------------------|
|           | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Crop (C)  |       |       |       |       |       |       |
| C₁-Rice   | 46.14 | 45.40 | 11.34 | 9.42  | 50.89 | 48.64 |
| C₂-Maize  | 40.28 | 39.49 | 10.14 | 8.25  | 45.96 | 44.18 |
| Organic N management (N) |       |       |       |       |       |       |
| N₁-75% N as vermicompost | 40.37 | 39.60 | 10.15 | 8.24  | 45.84 | 44.10 |
| N₂-100% N as vermicompost | 46.05 | 42.29 | 11.34 | 9.43  | 51.01 | 48.72 |
| Live mulching (L) |       |       |       |       |       |       |
| L₁-Control (No mulching) | 52.28 | 51.47 | 12.73 | 10.46 | 58.18 | 55.95 |
| L₂-Live mulching with cowpea | 34.13 | 33.42 | 8.76  | 7.21  | 38.67 | 36.86 |
| SEm (±)   | 0.48  | 0.40  | 0.14  | 0.22  | 1.38  | 1.13  |
| CD (P=0.05) | 1.54  | 1.28  | 0.65  | 0.70  | 4.39  | 4.19  |

Table 5: Interaction effects of crop, organic N management and live mulching on nitrogen uptake (kg ha⁻¹) by weeds.

| Treatment Combinations | Nitrogen uptake (kg ha⁻¹) |
|------------------------|---------------------------|
|                        | 60 DAS | Harvest |
|                        | 2015 | 2016 | 2015 | 2016 |
| C₂N₁                  | 33.78 | 32.67 | 43.85 | 43.06 |
| C₂N₂                  | 38.89 | 38.60 | 48.42 | 47.74 |
| C₂N₃                  | 26.06 | 25.54 | 36.88 | 36.15 |
| C₂N₄                  | 33.77 | 32.83 | 43.68 | 42.83 |
| SEm (±)               | 0.46  | 0.43  | 0.68  | 0.57  |
| CD (P=0.05)           | 1.49  | 1.36  | 2.18  | 1.83  |
| C₁L₁                  | 42.65 | 42.14 | 54.50 | 53.72 |
| C₁L₂                  | 30.02 | 29.13 | 37.77 | 37.08 |
| C₁L₃                  | 39.37 | 38.52 | 50.06 | 49.19 |
| C₁L₄                  | 20.46 | 19.85 | 30.49 | 29.79 |
| SEm (±)               | 0.46  | 0.43  | 0.68  | 0.57  |
| CD (P=0.05)           | 1.49  | 1.36  | 2.18  | 1.83  |
| C₃N₁                  | 38.19 | 37.36 | 48.89 | 48.03 |
| C₃N₂                  | 21.65 | 20.85 | 31.84 | 31.18 |
| C₃N₃                  | 43.83 | 43.29 | 55.67 | 54.88 |
| C₃N₄                  | 28.82 | 28.13 | 36.42 | 35.69 |
| SEm (±)               | 0.46  | 0.43  | 0.68  | 0.57  |
| CD (P=0.05)           | 1.49  | 1.36  | 2.18  | 1.83  |
| C₄N₁                  | 39.30 | 38.29 | NS    | NS    |
| C₄N₂                  | 28.26 | 27.05 | NS    | NS    |
| C₄N₃                  | 46.00 | 45.99 | NS    | NS    |
| C₄N₄                  | 31.78 | 31.21 | NS    | NS    |
| SEm (±)               | 37.09 | 36.43 | NS    | NS    |
| CD (P=0.05)           | 15.04 | 14.65 | NS    | NS    |
| C₅N₁                  | 41.66 | 40.60 | NS    | NS    |
| C₅N₂                  | 25.89 | 25.05 | NS    | NS    |
| SEm (±)               | 0.66  | 0.60  | NS    | NS    |
| CD (P=0.05)           | 2.11  | 1.93  | NS    | NS    |

NS- Non Significant
C₁ - Rice, C₂-Maize.
N₁ - 75% N as vermicompost, N₂-100% N as vermicompost,
L₁-Control (No mulching), L₂-Live mulching with cowpea

with cowpea (L₂) was also found to significantly reduce weed density and dry weight during both the years at all the stages of observation compared with control plots (L₁) (Table-1 and 2). Reduced weed growth observed under cowpea live mulching may be attributed to early growth of the crop and ground cover which may have resulted in physical interference on weed seed germination and seedling growth and competition for light, water, and nutrients. Jamshidi et al. (2013) and Talenneigi and Ghadiri (2012) also reported that cowpea live mulching greatly reduced the density and dry weight of the weeds.

**NPK uptake by weeds**: Significant variations were observed in NPK uptake by weeds as affected by crop, organic N management and live mulching (Table-3 and 4). The uptake of NPK by weeds at 60 DAS and at harvest was found to be significantly lower in maize (C₁) as compared to takeup by weeds in rice (C₂) during both the years which may be attributed to significantly lower weed growth viz., weed density and dry weight as recorded in maize ultimately leading to lower nutrient uptake by weeds whereas, rice crop was found to record higher weed growth which may have resulted in increased NPK uptake by weeds. Hassan and Upasani (2015) also reported NPK removal of 29.88 kg ha⁻¹, 4.87 kg ha⁻¹ and 41.47 kg ha⁻¹ respectively by weeds in weedy rice field. During both years, application of vermicompost @ 2.7 t/ha (N₂) resulted in significantly higher NPK uptake by weeds at both stages of observations compared to vermicompost @ 2 t/ha (N₁) which recorded significantly lower nutrient uptake by weeds. This may be attributed to the fact that higher application of nutrients to the soil, as in case of the treatment N₂ may have resulted in higher availability and uptake of nutrients by weeds moreover, higher weed density and dry matter was also recorded under the treatment (N₂). Borah et al. (2015) also reported increasing weed infestation with increasing dose of FYM application and the highest weed infestation, both weed density and weed dry weight, was noticed in crop with 100% RDN through FYM. Live mulching with cowpea (L₂)
was also found to record significantly lower NPK uptake by weeds as compared to control treatment (L₀) during both years. This may be due to effective suppression of weed by live mulching resulting in reduced weed density, dry weight, as observed, and lower nutrient uptake by weeds. Anitha et al. (2012) also reported that dual cropping of cowpea with dry seeded rice resulted in a weed suppression by 69-75% whereas, Mishra et al. (1995) concluded that cowpea live mulching in maize significantly reduced weed density and dry weight. Increased ground cover due to addition of cover crop under the treatment L₂ may have resulted in reduced weed growth leading to lower NPK uptake by weeds. Uchino et al. (2009) also reported that weed suppression by sowing cover crops was associated with the increase of VCR (Vegetation Cover Ratio) of main crops plus cover crops at the early growth stage of main crops.

Interaction effects on N uptake by weeds: Interaction effects of crops, organic N management and mulching on N uptake were also found to record significant variations (Table-5). During both the years, the interactions C⁻¹N⁻¹L₀ and N⁻¹L₀ were found to record significantly lower N uptake in weeds at both 60 DAS and at harvest compared to all other treatment combinations which registered significantly more N uptake in weeds. The interaction C⁻¹N⁻¹L₂ was also found to record significantly lower N uptake by weeds at 60 DAS during both years. Significantly lower uptake of N by weeds as observed under these interactions may be attributed to significantly reduced weed growth and lower NPK uptake as recorded under the treatments of C₀, N₀ and L₀. Significantly lower NPK uptake recorded by each of the interacting factors C₀, N₀ and L₀ may also have resulted in complementary effect on their interactions.

Yield and yield attributes of rice and maize: In the present investigation data on yield and yield attributes of rice and maize was not analyzed for significant differences, as it was statistically impossible to compare the yield of rice and maize however, yield data was recorded from each plot and average values were worked out for yield performance by each crop under the different management practices (Table 6). During both years both rice and maize crop recorded higher yield and yield attributes viz., grains per panicle/cob, test weight, seed yield and stover yield and harvest Index under the management practice involving organic N management through application of 2.7 t/ha of vermicompost (N₁) with cowpea live mulching (L₁) which was followed by the management practice involving application of 2 t/ha vermicompost (N₀) along with cowpea live mulching (L₀). In the presence of cowpea live mulching up to 50 DAS the yield performance of both rice and maize crop was high with application of vermicompost @ 2.7 t/ha however, the effect was more pronounced in case of maize crop.

CONCLUSION

From the observations of the investigation it may be concluded that organic nitrogen management and live mulching in rice and maize results in significant variations in weed growth and NPK uptake by weeds under organic systems. The weed density, dry weight and NPK uptake in organically managed systems tends to increase with increased dosage of organic manure. In this experiment increasing the dose of nitrogen, applied through vermicompost, from 2 to 2.7 t/ha resulted in increased weed growth and NPK uptake due to higher availability of nutrients as was the case for both rice and maize. Nature of the crop in such systems also dictates the level of weed growth and NPK uptake whereas; larger/taller statured plants with higher foliage area like maize due to ground coverage advantage may have better weed suppression ability resulting in reduced weed growth and NPK uptake on the other hand, smaller statured crops like rice may not perform as well in comparison. Use of alternative/indirect weed management strategies under organic systems like live mulching also has significant impact on weed growth and NPK uptake. The use of cowpea live mulch was found to significantly reduce weed density, dry weight and NPK uptake by weeds in both rice and maize however, the effect was more pronounced in case of maize. Yield and yield attributes of rice and maize were also observed to be higher under cowpea live mulch with application of 2.7 t/ha of vermicompost however, the effect was more pronounced in case of maize.
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