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# Soil Fertility Status and Nutrient Uptake Pattern in Fodder Maize and Ricebean Intercropping at Varying Nutrient Levels

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***Abstract***: Sustaining soil fertility and enhancing fodder production on smallholder farms is a great challenge in the trans-gangetic plain (North-Western zone of Haryana state). Therefore, the present investigation on the effect of nutrient management practices on fodder maize and ricebean intercropping under irrigated conditions was conducted during the rainy season of 2019 at the ICAR-NDRI, Karnal. The experiment was laid out in a randomised block design with 14 treatments. The higher value of total fresh fodder (45.25 t $ha^{-1}$) and dry matter yield (10.93 t $ha^{-1}$) in maize + ricebean intercropping system in a 1:1 row ratio with 100% RDF and Plant growth promoting rhizobacteria (PGPR). The composition of macronutrient (N, P, K) and micronutrient (Zn, Cu, Fe, and Mn) content along with uptake significantly improved under sole treatments, but it is comparable with 1:1 and 2:1 ratios receiving RDF + PGPR. The maximum total uptake was recorded in Maize + Ricebean (1:1) + 100% RDF + PGPR. Soil parameters such as pH, EC, organic carbon, available P and K content were not affected significantly. But significantly higher available N was in the sole ricebean plot and some intercropped plots receiving 100% RDF in both 1:1 and 2:1 ratio. The treatment of maize + ricebean (1:1) + 100% RDF + PGPR treatment enriched green and dry fodder yields with the fulfilment of qualitative fodder production along with maintaining the soil fertility.

***Keywords***: Fodder maize, Ricebean, Intercropping, Nutrient content, Uptake

Maize (*Zea mays* L.) is the most important *kharif* fodder, which is grown over 0.9 Mha in various parts of the country. Globally, maize is grown in an area of about 150 Mha with a production of 1134 MT as a grain purpose. It is grown on 9.5 Mha in India, with a production of 28.7 MT in 2019-20 (Anonymous 2020). It can be grown in both temperate and tropical regions, from mean sea- level up to an altitude of 3000 m. Due to its high yielding potential, along with good quality fodder and an absence of anti-nutritional factors, it is considered the most preferable fodder crop among farmers (Arya et al 2015). It is also an excellent fodder crop for silage making due to its low protein content and the presence of more water-soluble carbohydrates. This makes it less resistant to pH change in the silage making process. Because of its photo-insensitive nature, this crop can grow all year long. Basically, maize is a photosynthetically $C_4$ type plant which is capable of utilizing water efficiently and can also be grown in an area receiving an annual rainfall of 50 cm, but an optimum rainfall of 120-150 cm is necessary for a higher yield. Maize is a highly nutrient-exhaustive crop and demands more nutrients from the soil (Ciampitti and Vyn 2014). Further, to sustain the productivity of maize, proper nutrient management practices like applying fertilizers, manure and biofertilizers including PGPR, along with suitable intercropping with legumes and crop rotation, help to maintain soil fertility to some extent. Ricebean [*Vigna umbellate* (Thub.)] is one of the underutilized leguminous fodder crops which is grown in western, northern and eastern India in an area of around 20,000 ha (Katoch 2013). It is a neglected crop grown under diverse climatic conditions, from tropical to temperate, without the addition of any inputs. It can be grown as an intercrop in different cereal based cropping systems like maize, sorghum, bajra etc. Ricebean has an erect to semi erect growth habit. Some varieties have a twining growth habit, which makes them most suitable to grow along with maize. Due to intensive cultivation year after year without the addition of proper organic matter to the soil, the organic carbon content of the soil is depleted. The majority of our Indian soils are low in available nitrogen, low to medium in phosphorus and medium to high in available potash, which results in a negative soil nutrient balance (Kumar et al 2018). In addition to macro nutrient deficiency, there is another problem of micro nutrient deficiency due to intensive cultivation with the use of straight and high-analysis fertilizers (Singh 2008). An adequate supply of nutrients from both organic and inorganic sources in combination with biofertilizer and PGPR is very important to fulfil the nutrient demand of fodder crops. Fodder production through scientific crop rotation, cropping systems/intercropping with cereals and legumes helps in enhancing the total productivity as well as improving the quality of fodder along with maintaining soil nutrient status in a sustainable manner. The present study was, therefore, designed to find out the nutrient management practices for maximization of green fodder yield, nutrient content and nutrient uptake in fodder maize and ricebean intercropping under irrigated conditions.

## MATERIAL AND METHODS

**Site details**: Agronomic experiment was performed at ICAR-NDRI, Karnal during rainy season of 2019. Geographically, the experimental site situated at 29°45' N latitude, 76°58' E longitude and at an altitude of 245 m above mean sea level (MSL).

**Soil status**: The soil of experimental site was neutral in pH (7.24), clay loam in texture, medium in organic carbon (0.62%), low in available N (147.4 kg $ha^{-1}$) and medium in available P (24.5 kg $ha^{-1}$) and K (251.2 kg $ha^{-1}$).

**Treatment details**: The experiment was laid out in Randomized Block Design with 14 treatments (Table 1). For sole crops their respective recommended dose of fertilizer was applied whereas, in intercropping we consider the demand of only main crop (maize) and fertilizer varied as per the treatments (100%, 75% and 50% RDF). The maize seeds were treated with PGPR inoculums by diluting 50 ml of PGPR solution in 1 liter of water and seeds were soaked overnight, dried in the shade before sowing in the field. The fodder maize (Cultivar J-1006) and Ricebean (Sikkim local) were sown with seed rate of 45 and 35 kg/ha during 1st week of August by giving spacing of 30 × 10 cm for sole crop of maize and ricebean. The intercropped maize geometry was modified by giving spacing of 45 × 7.5 cm to introduce ricebean. For accommodating component crops in intercropping treatments additive series was used.

**Forage analysis**: To estimate the nutrients (macro and micro), plant samples collected at harvest were oven dried (65–70°C), grinded, and passed through a sieve (pore size of 2 mm). The nitrogen content in plant samples of maize was estimated by a modified Micro Kjeldahl method (Piper 1966). Phosphorus and potassium contents were determined in the Di-acid extracts after digesting the plant material with Di-acid mixture of 9:4 ($HNO_3$: $HClO_4$) (Piper 1966). The phosphorus content in the plant sample was determined by the Vanado-molybdo phosphoric yellow colour method using a spectrophotometer (Jackson 1973) and potassium content was determined using a flame photometer (Piper 1966). After digestion on the hot plate, the plant samples were analyzed for micronutrient content using an Atomic Absorption Spectrophotometer (Lindsay and Norvell 1978).

**Statistical analysis**: All the data recorded were processed in Microsoft excel 2010 and analyzed with ANOVA at 5% level of significance.

## RESULTS AND DISCUSSION

**Forage yield (GFY & DMY):** Dry matter and green fodder yield were significantly influenced by different nutrient

**Table 1.** Effect of nutrient management practices on green fodder and dry matter yield in fodder maize + ricebean intercropping

| Treatments | Green fodder yield ( t $ha^{-1}$) | | | Dry matter yield (t $ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | M | R | Total | M | R | Total |
| $T_1$- Maize + RDF | 34.17 | - | 34.17 | 8.51 | - | 8.51 |
| $T_2$- Ricebean + RDF | - | 15.17 | 15.17 | - | 3.57 | 3.57 |
| $T_3$- M + R (1:1) + RDF | 31.07 | 13.02 | 44.08 | 7.50 | 3.01 | 10.51 |
| $T_4$- M + R (1:1) + 50% RDF | 26.40 | 10.10 | 36.50 | 5.84 | 2.06 | 7.90 |
| $T_5$- M + R (1:1) + 50% RDF + PGPR | 27.62 | 10.05 | 37.67 | 6.22 | 2.15 | 8.37 |
| $T_6$- M + R (1:1) + 75% RDF | 30.17 | 12.00 | 42.17 | 6.87 | 2.74 | 9.61 |
| $T_7$- M + R (1:1) + 75% RDF + PGPR | 29.67 | 12.52 | 42.00 | 6.81 | 2.88 | 9.69 |
| $T_8$- M + R (1:1) + 100% RDF + PGPR | 32.00 | 13.25 | 45.25 | 7.85 | 3.07 | 10.92 |
| $T_9$- M + R (2:1) + RDF | 32.08 | 8.25 | 40.33 | 7.78 | 1.10 | 8.88 |
| $T_{10}$- M + R (2:1) + 50% RDF | 27.00 | 7.33 | 34.33 | 5.95 | 1.67 | 7.62 |
| $T_{11}$- M + R (2:1) + 50% RDF + PGPR | 27.83 | 7.17 | 35.00 | 6.34 | 1.64 | 7.98 |
| $T_{12}$- M + R (2:1) + 75% RDF | 31.15 | 7.48 | 38.63 | 7.41 | 1.74 | 9.15 |
| $T_{13}$- M + R (2:1) + 75% RDF + PGPR | 31.20 | 7.47 | 38.67 | 7.51 | 1.72 | 9.23 |
| $T_{14}$- M + R (2:1) + 100% RDF + PGPR | 31.92 | 8.58 | 40.50 | 7.95 | 1.99 | 9.94 |
| CD (p=0.05) | 3.92 | 1.82 | 4.11 | 1.09 | 0.40 | 1.12 |

— Maize; R- Ricebean; RDF- Recommended dose of fertilizer; PGPR- Plant growth promoting rhizobacteria management practices (Table 1). Intercropping of maize with ricebean in a 1:1 ratio with RDF + PGPR records higher green fodder (45.25 t $ha^{-1}$) and dry matter yield (10.93 t $ha^{-1}$) in comparison to sole maize and ricebean. Further, the contribution of both the crop was less than 100% in comparison with the sole crop (100%). This is due to the partition of available resources among both the crops under intercropped cultivation. However, the relative yield was found to be superior in intercropped conditions, especially by sowing maize and ricebean in a 1:1 ratio with RDF and PGPR this may be due to an increase in the photosynthetic area leading to more uptake of nutrients, which in turn increases biomass production. The extra yield contribution from ricebean in the 1:1 additive series eventually increases the fodder yield. Further increases in fertilizer dose has a positive effect on other growth attributes which are directly correlated with green fodder yield. The results are in tune with Zaman and Malik (2000) and Kheroar and Patra (2013).

**Macro nutrient content and uptake:** The higher N, P and K content was recorded in the sole maize treatment (1.43% N, 0.3% P and 0.9% K) (Table 2). In ricebean, only N content showed a significant difference among various nutrient management practices. Higher N content in ricebean forage was analyzed in sole ricebean + RDF (3.03% N). In P and K content, no significant influence was observed among various nutrient management practices. In terms of total N, P and K uptake per plot basis was significantly higher under intercropped condition with Maize + Ricebean (1:1) + 100% RDF + PGPR ie., 199 kg N $ha^{-1}$, 35.30 kg P $ha^{-1}$, 116.09 kg K $ha^{-1}$) respectively. Significantly higher N, P, and K content and uptake was in treatments that received full doses of fertilizer. This might be due to a higher uptake of nutrients. Even in some of the treatments under intercropped situations where they had received 100% RDF, also recorded higher values of N, P and K content and uptake. This might be due to no competition for available nutrients and also some nitrogen fixed by the ricebean crop, helping the component crops to overcome their nitrogen shortage. However, as fertilizer dose decreases, the nutrient content of both maize and ricebean decreases, but the difference is not huge because of increased nodule numbers, which increase the N-fixing ability of ricebean. Sharma and Gupta (2002) also observed the same trend in pearl millet and cluster bean intercropping.

**Micronutrient content and uptake**: There were significant differences among the different treatments and higher zinc (44.5 ppm), iron (429 ppm), manganese (41.73 ppm) and copper content (15.47 ppm) was in maize with 100% RDF in comparison with other treatments (Table 3). Nutrient management has significant influence on minerals viz. Zn content and no significant difference was found in Fe, Mn and Cu content in ricebean plants on a dry weight basis. However, Zn (57.7 ppm), Fe (487 ppm), Mn (84.2 ppm) and Cu (22.5 ppm) content was higher in ricebean monoculture. Even though higher micronutrient content was in both sole maize and ricebean plots, higher uptake of Zn (508.85 g $ha^{-1}$), Fe (4586.92 g $ha^{-1}$), Mn (572.80 g $ha^{-1}$) and Cu (185.93 g $ha^{-1}$) was

**Table 2.** Effect of nutrient management on macronutrient content and uptake pattern in fodder maize + ricebean intercropping

| Treatments | N content (%) | | P content (%) | | K content (%) | | Total uptake (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | R | M | R | M | R | N | P | K |
| $T_1$ | 1.43 | - | 0.30 | - | 0.90 | - | 121.84 | 25.35 | 76.44 |
| $T_2$ | - | 3.03 | - | 0.48 | - | 1.65 | 107.88 | 16.93 | 58.94 |
| $T_3$ | 1.40 | 2.89 | 0.28 | 0.41 | 0.87 | 1.53 | 192.07 | 33.43 | 111.43 |
| $T_4$ | 1.22 | 2.72 | 0.23 | 0.38 | 0.71 | 1.34 | 127.32 | 21.43 | 69.08 |
| $T_5$ | 1.27 | 2.74 | 0.25 | 0.38 | 0.71 | 1.41 | 137.76 | 23.79 | 74.81 |
| $T_6$ | 1.34 | 2.81 | 0.26 | 0.39 | 0.76 | 1.47 | 169.16 | 28.72 | 92.34 |
| $T_7$ | 1.37 | 2.81 | 0.26 | 0.40 | 0.79 | 1.48 | 173.75 | 29.42 | 95.39 |
| $T_8$ | 1.40 | 2.90 | 0.29 | 0.41 | 0.88 | 1.53 | 199.00 | 35.30 | 116.09 |
| $T_9$ | 1.41 | 2.92 | 0.29 | 0.42 | 0.88 | 1.58 | 165.57 | 30.80 | 98.39 |
| $T_{10}$ | 1.28 | 2.77 | 0.25 | 0.39 | 0.75 | 1.41 | 122.20 | 21.34 | 67.97 |
| $T_{11}$ | 1.29 | 2.77 | 0.26 | 0.39 | 0.75 | 1.46 | 126.86 | 22.97 | 71.34 |
| $T_{12}$ | 1.38 | 2.85 | 0.27 | 0.40 | 0.83 | 1.48 | 152.59 | 27.04 | 87.18 |
| $T_{13}$ | 1.39 | 2.87 | 0.27 | 0.40 | 0.87 | 1.50 | 153.70 | 27.28 | 91.28 |
| $T_{14}$ | 1.41 | 2.92 | 0.29 | 0.44 | 0.90 | 1.65 | 170.45 | 31.94 | 103.95 |
| CD (p=0.05) | 0.13 | 0.16 | 0.03 | NS | 0.08 | NS | 23.21 | 5.11 | 12.61 |

See Table1 for treatment details

observed in intercropped conditions, i.e., sowing maize and ricebean in a 1:1 ratio with application of 100% RDF and PGPR. This might be due to the higher photosynthetic area available to harness sunlight, which led to an increase in the biomass yield and uptake of nutrients under an additive series of intercropping. Higher micronutrient concentration in both maize and ricebean was recorded under sole crop conditions than intercropping because the sole crop experienced zero competition from intercrop for available resources, which made the plant grow healthier than in intercropped conditions. The results are to the tune of Surve et al (2012).

**Soil chemical properties**: The soil analyses result indicated that there was no substantial change in the chemical properties of soil like pH, EC and organic carbon content (Table 4). However, higher pH was in Maize + Ricebean (2:1) + 75% RDF + PGPR (7.42). In EC initial soil status was high but after completion of experiment its value was little lowered. However, higher value of EC was noticed in Maize + Ricebean (2:1) + 50% RDF (0.225 ds/m). Even in soil organic carbon content there was slight decreased after completion of experiment but not in significant amount. Higher organic carbon recorded in sole ricebean plot (0.62) this might be due to higher root biomass and higher nodulation in sole ricebean plot. The result of organic carbon was in line with observation made by Girijesh et al (2017). Further the experiment was carried over for short period of time and those properties changes over long period of time with similar practices (Ranpariya et al 2017).

There was a significant change only in soil available N content, but there was no variation observed in soil P or K content before and after the completion of the experiment (Table 4). The higher value of available N was recognized in the sole ricebean + RDF plot (150.73 kg $ha^{-1}$), but was statistically at par with $T_3$, $T_8$, $T_9$, and $T_{14}$ treatments. The lower N was analyzed in the sole maize plot (130.33 kg $ha^{-1}$). The higher value of available N in the sole ricebean plot might be due to higher atmospheric nitrogen fixation by the ricebean crop compared to sole maize. Hirpa (2014) also observed the same trend in maize and haricot bean. There was no significant variation in both available P and K content by various nutrient management practices, but a higher value of both P and K was under intercropped conditions. The highest available P was recorded in the maize + ricebean (1:1) + 100% RDF plot (26.68 kg $ha^{-1}$) and the lowest value was in the sole maize plot (23.29 kg $ha^{-1}$). In available K, a higher value was recorded in the sole ricebean plot (244.37 kg $ha^{-1}$) and a lower value was in the sole maize plot (221 kg $ha^{-1}$). The lower values of P and K in pure maize may be due to the exhaustive nature of maize for available nutrients. Dahmardeh et al (2010) and Patel et al (2017) observed the same trend in various legume and cereal based intercropping. The micronutrient content, especially Zn and Fe, varied significantly among the different treatments, with no significant variation in Mn and Cu content. The Zn and Fe content were initially high but slightly decreased after the completion of the experiment. The greater value of Zn (0.99

**Table 3.** Effect of nutrient management on micronutrient content in fodder maize + ricebean intercropping

| Treatments | Zn content (ppm) | | Fe content (ppm) | | Mn content (ppm) | | Cu content (ppm) | | Total uptake (g $ha^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | R | M | R | M | R | M | R | Zn | Fe | Mn | Cu |
| $T_1$ | 44.5 | - | 429 | - | 41.73 | - | 15.47 | - | 367.25 | 3648.95 | 355.48 | 131.51 |
| $T_2$ | - | 57.7 | - | 484 | - | 84.20 | - | 22.50 | 200.38 | 1690.23 | 299.95 | 80.09 |
| $T_3$ | 43.2 | 55.3 | 410 | 450 | 39.75 | 83.00 | 15.27 | 22.33 | 505.72 | 4457.90 | 548.32 | 182.16 |
| $T_4$ | 38.5 | 50.7 | 373 | 404 | 36.30 | 81.30 | 13.50 | 21.24 | 329.52 | 3013.26 | 380.16 | 122.88 |
| $T_5$ | 38.2 | 50.0 | 380 | 430 | 36.33 | 81.20 | 13.58 | 21.33 | 346.53 | 3308.22 | 399.35 | 130.22 |
| $T_6$ | 41.2 | 53.8 | 408 | 436 | 39.30 | 82.00 | 14.27 | 21.67 | 430.82 | 3994.66 | 494.34 | 157.35 |
| $T_7$ | 40.7 | 53.0 | 385 | 435 | 40.21 | 82.30 | 14.43 | 21.47 | 430.24 | 3882.68 | 509.64 | 160.20 |
| $T_8$ | 43.0 | 56.3 | 415 | 470 | 40.65 | 82.70 | 15.00 | 22.17 | 508.85 | 4586.92 | 572.80 | 185.93 |
| $T_9$ | 42.5 | 55.7 | 425 | 450 | 41.43 | 83.20 | 15.17 | 22.00 | 437.63 | 4167.53 | 482.40 | 159.98 |
| $T_{10}$ | 40.2 | 52.3 | 382 | 417 | 34.50 | 80.70 | 13.53 | 21.03 | 326.39 | 2964.66 | 339.99 | 115.42 |
| $T_{11}$ | 40.2 | 53.2 | 378 | 423 | 36.23 | 81.00 | 13.87 | 21.43 | 342.51 | 3085.18 | 362.53 | 122.79 |
| $T_{12}$ | 41.0 | 53.0 | 403 | 436 | 38.33 | 81.70 | 14.50 | 21.60 | 396.43 | 3737.46 | 425.40 | 145.16 |
| $T_{13}$ | 41.9 | 54.4 | 406 | 437 | 37.00 | 81.80 | 14.93 | 21.83 | 408.40 | 3802.08 | 418.96 | 149.65 |
| $T_{14}$ | 43.7 | 56.0 | 434 | 471 | 41.21 | 83.80 | 15.37 | 22.37 | 458.27 | 4407.46 | 493.24 | 166.53 |
| CD (p=0.05) | 3.67 | 4.39 | 40.78 | NS | 4.67 | NS | 1.21 | NS | 61.66 | 490.53 | 64.21 | 21.64 |

See Table1 for treatment details

**Table 4**. Effect of nutrient management on soil chemical properties after harvest of fodder maize + ricebean intercropping

| Treatments | Chemical properties | | | Available soil nutrient | | | Micro nutrient status (ppm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $pH_2$ | $EC_2$ (ds/m) | OC (%) | N | P | K | Zn | Fe | Mn | Cu |
| Initial status | 7.24 | 0.227 | 0.62 | 147.40 | 25.70 | 251.20 | 0.99 | 9.67 | 9.54 | 0.86 |
| $T_1$ | 7.37 | 0.220 | 0.56 | 130.33 | 21.29 | 221.00 | 0.69 | 8.47 | 8.45 | 0.77 |
| $T_2$ | 7.30 | 0.218 | 0.62 | 150.73 | 22.69 | 244.37 | 0.72 | 7.85 | 9.71 | 0.81 |
| $T_3$ | 7.32 | 0.219 | 0.61 | 146.53 | 24.68 | 240.43 | 0.95 | 9.53 | 9.29 | 0.91 |
| $T_4$ | 7.20 | 0.210 | 0.57 | 130.48 | 21.48 | 225.43 | 0.75 | 7.36 | 8.50 | 0.85 |
| $T_5$ | 7.38 | 0.222 | 0.60 | 140.12 | 23.85 | 235.17 | 0.79 | 8.45 | 9.16 | 0.83 |
| $T_6$ | 7.29 | 0.213 | 0.58 | 132.65 | 23.43 | 228.63 | 0.88 | 8.18 | 8.66 | 0.88 |
| $T_7$ | 7.23 | 0.211 | 0.59 | 135.24 | 23.95 | 232.33 | 0.70 | 7.54 | 9.07 | 0.85 |
| $T_8$ | 7.13 | 0.206 | 0.60 | 146.95 | 24.64 | 246.03 | 0.74 | 7.62 | 9.33 | 0.83 |
| $T_9$ | 7.31 | 0.219 | 0.59 | 143.08 | 24.55 | 238.63 | 0.92 | 9.04 | 9.23 | 0.84 |
| $T_{10}$ | 7.41 | 0.225 | 0.57 | 133.59 | 24.43 | 229.80 | 0.97 | 9.09 | 8.52 | 0.87 |
| $T_{11}$ | 7.28 | 0.212 | 0.58 | 131.32 | 22.40 | 226.03 | 0.93 | 7.62 | 8.64 | 0.82 |
| $T_{12}$ | 7.36 | 0.219 | 0.58 | 139.91 | 23.68 | 236.00 | 0.99 | 9.46 | 8.68 | 0.83 |
| $T_{13}$ | 7.42 | 0.224 | 0.60 | 137.20 | 23.77 | 233.33 | 0.80 | 9.18 | 9.11 | 0.89 |
| $T_{14}$ | 7.41 | 0.223 | 0.61 | 148.96 | 24.60 | 243.47 | 0.74 | 9.05 | 9.21 | 0.91 |
| CD (p=0.05) | NS | NS | NS | 9.59 | NS | NS | 0.10 | 0.85 | NS | NS |

See Table1 for treatment details

ppm) was analyzed in the maize + ricebean (2:1) + 75% RDF treatment and the lower value of Zn was noticed in the sole maize plot. In Fe, the maximum was recorded in maize + ricebean (1:1) + RDF (9.53 ppm) and a lower value in maize + ricebean (1:1) + 50% RDF treatment (7.36 ppm). Although Mn and Cu content showed no significant difference among various treatments, a higher value of Mn was in sole ricebean + RDF (9.71 ppm) whereas, in Cu, a higher value was in maize + ricebean (1:1) + RDF plot and maize + ricebean (2:1) + 100% RDF + PGPR (0.91 ppm) respectively.

## CONCLUSION

Among the different nutrient management practices, combined application of 100% RDF and PGPR in maize + ricebean (1:1) intercropping significantly increased fodder yield, macro and micro-nutrient content with grater uptake, which eventually indicated the fulfilment of qualitative fodder production and was found to be advantageous to the growers along with improving the soil fertility.

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