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Effect of organic nutrient sources on nutrient uptake, yield, and protein content of horse gram (*Macrotyloma uniflorum*) in upland soil of Jharkhand

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ABSTRACT

A field experiment was conducted in the Western Section of Research Farm of Birsa Agricultural University, Kanke, Ranchi, during the late kharif season of 2023 to study the evaluation of different organic nutrient sources on nutrient uptake, yield, and protein content of horse gram (Macrotyloma uniflorum) in upland soil of Jharkhand. The experiment was laid out in a Randomized Block Design (RBD) with three replications, and the variety used was Birsa Kulthi-1. The treatment consists of100% N through FYM (T_1),100% N through Vermicompost (T_2),100% N through Karanj Cake (T_3), 50% N through FYM+50% N through VC (T_4),50% N through FYM+50% N through KC(T_5),50% N through KC+50% N through VC (T_6), 1/3 N through FYM+1/3 N through VC+1/3 N through KC(T_7), 50% N through FYM (T_8), 50%N through VC (T_9), 50% N through KC (T_{10}) and Control (T_{11}). Application of 50% N through FYM+50% N through VC (T_4) resulted in the highest seed yield (770.53 kg/ha), stover yield (1781.40kg/ha), and harvest index (30.18%). Protein content was non-significant; however, numerically higher protein content (24.23%) was obtained with 50% N through FYM + 50% N through VC (T4), which also resulted in a significantly higher protein yield (186.94 kg/ha).The nitrogen uptake in seed (29.95 kg/ha), nitrogen uptake in stover (24.94 kg/ha), total nitrogen uptake (54.89 kg/ha), phosphorus uptake in seed (2.82 kg/ha), phosphorus uptake in stover (4.10 kg/ha), total phosphorus uptake (7.28 kg/ha), potassium uptake in seed (4.21 kg/ha), potassium uptake by stover (23.19 kg/ha) and total potassium uptake (27.40 kg/ha) respectively was higher with application of T_4 (50% N through FYM+50% N through VC).

Keywords: *Horse gram, Farm yard manure, Vermicompost, Karanj cake, Nutrient uptake, Protein content.*

INTRODUCTION

Pulses play a crucial role in India's agricultural sector by contributing to food security and soil fertility enhancement. Horse gram (*Macrotyloma uniflorum*) is an important pulse crop, particularly suited for rainfed and marginal upland soils due to its drought tolerance and adaptability. It is widely cultivated in India, primarily in Karnataka, Odisha, Chhattisgarh, and Jharkhand, and is often referred to as the "poor man's pulse" due to its affordability. It is an annual herb that grows to a height of 30–40 cm, with trifoliate leaves, yellow flowers, and small seeds ranging from brown to black [12].

In India, horse gram accounts for 0.33% of total food seed production [18], covering 5.07 lakh hectares, with an average yield of 516 kg/ha [1]. Karnataka leads in area and production, followed by Odisha and Chhattisgarh, while Bihar records the highest yield (959 kg/ha). In Jharkhand, horse gram is cultivated on 0.25 lakh hectares, producing 0.195 lakh tons, with an average yield of 780 kg/ha [21].

Horse gram is nutritionally rich, containing 51.9–60.9% carbohydrates, 17.9–25.3% protein, and 0.70–2.06% fat, along with essential minerals such as calcium (287 mg), phosphorus (311 mg), and iron (6.77 mg) [2]. Dehulled seeds have higher carbohydrate and protein content, making them a valuable protein source. It is also rich in essential amino acids, including arginine (6–7.1%), tyrosine (6.68%), and lysine (7.64%), though deficient in cystine and tryptophan. Additionally, it provides thiamine (0.4 mg), riboflavin (0.2 mg), and niacin (1.5 mg), contributing to its high nutritional value. However, its protein quality is influenced by nutrient availability, as proper nutrient uptake plays a vital role in amino acid composition and overall seed quality. Besides its nutritional importance, horse gram has medicinal benefits, aiding in kidney stone treatment, diabetes management, and cholesterol reduction due to its antioxidant and therapeutic properties [8].

In Jharkhand, horse gram is cultivated on nutrient-deficient upland soils, where conventional farming practices and imbalanced nutrient management often result in low productivity. The availability and uptake of essential nutrients like nitrogen, phosphorus, and potassium significantly impact plant metabolism, influencing seed protein content and overall crop quality. The key challenge in improving horse gram yield and quality is ensuring adequate nutrient availability while maintaining soil health.

Using too many chemical fertilizers over time has damaged the soil and harmed the environment. Organic inputs like farmyard manure, vermicompost, and karanj cake not only give plants the nutrients they need but also help improve the soil's structure, support healthy microbes, and keep the soil moist for longer.

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Studies have shown that organic amendments improve growth, yield, and nutrient efficiency in pulses like soybean [16], cowpea, and horse gram [9].

Considering the importance of organic farming in upland soil fertility restoration, this study was undertaken to evaluate the effects of different organic nutrient sources on yield, nutrient uptake, and protein content of horse gram in the upland soils of Jharkhand. The findings from this research will contribute to developing efficient, eco-friendly nutrient management strategies for sustainable horse gram cultivation.

MATERIALS AND METHODS

The present study was carried out in the Western Section of Research Farm of Birsa Agricultural University, Kanke, Ranchi (23°317'N, 85°19'E, 625 m above mean sea- level) during the late*kharif*seasons of 2023. The climate of the site is sub-humid with hot summer and cold winter. The mean monthly maximum temperature and pan-evaporation were recorded as highest in April during the year, whereas the mean monthly minimum temperature was the lowest in December. An average amount of 50.8 mm of rainfall was received during the cropping period. Initial status of soil (0–15 cm) of experimental field was sandy loam (62.5 % sand, 21.6 % silt and 15.9 % clay) in nature, low in organic carbon (0.41%) and available nitrogen (232.57 kg N/ha), medium in available phosphorus (34.62 kg P/ha), available potassium (181.21 kg Kg/ ha) and neutral in soil reaction (pH 6.30). The experiment was laid out in a Randomized Block Design (RBD) with 3 replications. The treatment consists of 100% N through FYM (T_1),100% N through Vermicompost (T_2),100% N through Karanj Cake (T_3), 50% N through FYM+50% N through VC (T_4),50% N through FYM+50% N through KC(T_5),50% N through KC+50% N through VC (T_6), 1/3 N through FYM+1/3 N through VC+1/3 N through KC(T_7), 50% N through FYM (T_8), 50%N through VC (T_9), 50% through KC (T_{10}) and Control (T_{11}). Horse gram variety "Birsa kulthi-1" was seeded using 25 kg of seed per hectare, with 30cm between each row and 10cm between each plant in a row. The recommended dose of nitrogen (20 kg/ha) was applied through different sources of organic nutrients, such as FYM, vermicompost, and Karanj cake. Seed and stover yield were recorded after manual threshing and converted to kg/ha. The samples were then dried, processed, and analyzed in a laboratory for protein, nitrogen (N), phosphorus (P), and potassium (K) content to determine nutrient uptake. Protein content in horse gram seed was calculated by multiplying the per cent nitrogen content in a seed by a factor of 6.25. Nitrogen content in plant samples was measured using the Kjeldahl method [6] phosphorus was estimated using the spectrophotometric method [22] and potassium content was determined with a Flame photometer[22]. The nitrogen content in both seed and stover was then multiplied by their respective yields to determine N-uptake. The data for various characteristics were analyzed using analysis of variance (ANOVA) following the method outlined by [4]. The significance of the results was tested at a 5% probability level. When the F-values were found to be significant, critical difference (CD) values were calculated to compare the treatment means.

RESULTS AND DISCUSSION

Yield

Application of 50% N through FYM+50% N through VC recorded the highest seed yield (770.53 kg/ha), stover yield (1781.40 kg/ha), biological yield (2551.93 kg/ha) and harvest index (30.18 %) followed by100% N through VC and 1/3 N through FYM+1/3 N through VC+1/3 N through KC. The increased yield was likely due to the rapid release of nitrogen and the steady supply of nutrients from both FYM and vermicompost, which met the needs of the crop during critical growth stages. Additionally, FYM acted as a nutrient reservoir, gradually releasing nutrients as it decomposed, thereby improving various yield components and leading to higher seed yield (Table1).[15] and [3] found that higher seed yields in organic management are due to better nutrient availability, improved photosynthate production, and efficient translocation, enhancing yield traits and seed production.

As per the harvest index was concerned, there was no significant difference between various treatments under test. Application of 50% N through FYM+50% N through VC recorded the highest harvest index and lowest with control. The present result was in accordance with the findings of [10]and [20].

Nutrient content

An analysis of the data (Table 2) revealed that the application of different sources of organic manure was not significant for the nitrogen, phosphorus, and potassium content in both the seed and stover. However, maximum nitrogen content in seed and stover was registered in treatment with 50% N through FYM and 50% N through VC (3.88 and 1.40% respectively), and the lowest nitrogen content was observed in the control.

For phosphorus**,** the highest content in seed and stover (0.395 and 0.247% respectively) was observed in the treatment with 100% N through vermicompost, while the lowest phosphorus content was again found in the control.

When it comes to potassium, the treatment that applied 50% N through FYM + 50% N through VC (0.55 and 1.30 % respectively) recorded the highest potassium content in both seed and stover.

This improvement in nutrient content in seed and stover might be becauseFYM and vermicomposts release nutrients slowly and steadily during decomposition, making them more available to plants over time. *Rhizobium species* help fix atmospheric nitrogen, while AM fungi improve phosphorus absorption and expand the root surface area for better nutrient accumulation. Together, these practices create a more fertile soil environment, boost microbial activity, and lead to higher nutrient accumulation in both seeds and stover[11].

Nutrient uptake

The uptake of any nutrient by seed or stover is determined by the yield and nutrient content of the seed and stover. A significant increase in either the yield or the nutrient content leads to a significant rise in nutrient uptake. Examination of data (Table 3) revealed that the uptake of nitrogen, phosphorus, and potassium in seed and stover as well as total uptake was significantly influenced by the applied treatments.

The highest nitrogen uptake was recorded with the application of 50% N through FYM and 50% N through vermicompost, which resulted in 29.95 kg/ha by seed, 24.94 kg/ha by stover, and a a total uptake of 54.89 kg/ha; however, it was statistically similar with 100% N through vermicompost and 1/3 N through FYM + 1/3 N through vermicompost + 1/3 N through karanj cake.

The highest phosphorus uptake was recorded with the application of 50% N through FYM + 50% N through VC, with 2.97 kg/ha in seed, 4.31 kg/ha in stover, and a total of 7.28 kg/ha and it was statistically at par with 100% N through

Vermicompost and 1/3 N through FYM + 1/3 N through VC + 1/3 N through KC.

The treatment with 50% nitrogen through FYM and 50% nitrogen through VC resulted in the highest potassium uptake, with 4.21 kg/ha in seed, 23.19 kg/ha in stover, and a total of 27.40 kg/ha; this treatment showed significantly higher potassium uptake compared to the other treatments, although the potassium uptake in stover and total uptake was statistically similar to the treatment with 100% nitrogen through Vermicompost. Increased nutrient uptake with combined application of organic manures might be due to a consistent supply of nutrients and reduced rate of loss of releasing nutrients during the process of decomposition of organic manure and also due to improved root growth and its functional activity which helped in greater extraction of nutrients [18].

Mineralization of organic sources in addition to soil provided ample opportunity for plants to uptake these elements in addition to fixation that normally takes place. Vermicompost reduced the loss of nutrients through leaching and made it available to plants, which created a balancing effect on the supply of nitrogen, phosphorus, and potassium. This observation is consistent with past studies by[5].

Protein content

An examination of the data (Table 4) revealed that different sources of organic manure had no significant effect on protein content in seed and stover. However, 50% N through FYM + 50% N through VC resulted in the highest protein content (24.23%) and significantly higher protein yield (186.94 kg/ha), which was on par with 100% N through vermicompost (169.01 kg/ha). Seed and nitrogen a key component of protein, play a crucial role in yield improvement. The increased availability of phosphorus is essential for certain co-enzymes in protein synthesis, and nitrogen under these treatments enhanced uptake, cell enlargement, and division, ultimately improving photosynthesis and carbohydrate translocation to the sink, leading to higher yield attributes and yield. These findings align with those of [6]. The beneficial effects of FYM addition are also related to improvement in soil physical properties, which in turn helps in better nutrient absorption by plants. The results were partially in agreement with the findings of [13].

Table 1: Effect of different sources of organic nutrients on yield of horse gram

Tr. No.	Treatment details	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest Index (%)
T_1	100% N through FYM	624.73	1520.35	2145.09	29.18
T_2	100% N through Vermicompost	713.95	1660.84	2374.79	30.06
T_3	100% N through Karanj Cake	616.44	1476.38	2092.82	29.53
T_4	50% N through FYM+50% N through VC	770.53	1781.40	2551.93	30.18
T_5	50% N through FYM+50% N through KC	642.07	1530.31	2172.38	29.58
T_6	50% N through KC+50% N through VC	630.35	1515.45	2145.80	29.41
T_7	1/3 N through FYM+1/3 N through VC+1/3 through KC	701.69	1660.48	2362.18	29.69
T_8	50% N through FYM	550.56	1372.10	1922.66	28.70
T_9	50%N through VC	558.04	1375.21	1933.25	28.91
T_{10}	50%N through KC	513.11	1284.91	1798.01	28.65
T_{11}	Control	392.88	985.57	1378.45	28.53
S.Em±		29.76	73.42	97.46	1.20
CD (p=0.05)		87.81	216.60	287.52	NS
CV%		8.45	8.65	8.11	7.13

Table 2: Effect of different sources of organic nutrients on NPK content (%) by horse gram

Tr. No.	Treatment details	N content (%)		P content (%)		K content (%)	
		Seed	Stover	Seed	Stover	Seed	Stover
T_1	100% N through FYM	3.52	1.36	0.374	0.234	0.52	1.28
T_2	100% N through Vermicompost	3.78	1.39	0.395	0.247	0.53	1.29
T_3	100% N through Karanj Cake	3.60	1.33	0.353	0.218	0.51	1.21
T_4	50% N through FYM+50% N through VC	3.88	1.40	0.385	0.242	0.55	1.30
T_5	50% N through FYM+50% N through KC	3.75	1.37	0.363	0.229	0.50	1.23
T_6	50% N through KC+50% N through VC	3.71	1.35	0.375	0.238	0.52	1.22
T_7	1/3 N through FYM+1/3 N through VC+1/3 through KC	3.70	1.38	0.364	0.230	0.50	1.26
T_8	50% N through FYM	3.54	1.20	0.350	0.209	0.51	1.21
T_9	50%N through VC	3.60	1.23	0.365	0.218	0.52	1.19
T_{10}	50%N through KC	3.51	1.18	0.345	0.214	0.50	1.16
T_{11}	Control	3.48	1.13	0.339	0.208	0.49	1.13
S.Em±		0.14	0.05	0.01	0.009	0.01	0.04
CD (p=0.05)		NS	NS	NS	NS	NS	NS
CV%		6.68	6.69	6.46	7.19	5.28	5.82

Table 3:Effect of different sources of organic nutrients on NPK uptake (kg/ha) by horse Gram

Tr. No.	Treatment details	Seed uptake (kg/ha)			Stover uptake (kg/ha)			Total uptake (kg/ha)		
		N	P	K	N	P	K	N	P	K
T_1	100% N through FYM	21.91	2.33	3.23	20.65	3.38	18.96	42.56	5.71	22.19
T_2	100% N through Vermicompost	27.11	2.82	3.75	23.03	4.10	20.93	50.15	6.92	24.68
T_3	100% N through Karanj Cake	22.24	2.18	2.71	19.70	2.97	17.84	41.94	5.15	20.56
T_4	50% N through FYM+50% N through VC	29.95	2.97	4.21	24.94	4.31	23.19	54.89	7.28	27.40
T_5	50% N through FYM+50% N through KC	24.16	2.33	3.17	20.95	3.27	18.42	45.11	5.60	21.58
T_6	50% N through KC+50% N Through VC	23.43	2.38	3.01	20.36	3.58	17.95	43.79	5.96	20.96
T_7	1/3 N through FYM+1/3 N through VC+1/3 through KC	26.03	2.56	3.51	22.81	3.99	20.59	48.84	6.54	24.10
T_8	50% N through FYM	19.48	1.93	2.56	17.27	2.49	15.60	36.75	4.43	18.16
T_9	50%N through VC	20.06	2.03	2.54	17.45	2.62	15.17	37.52	4.65	17.71
T_{10}	50%N through KC	18.05	1.77	2.17	15.75	2.20	13.43	33.80	3.98	15.60
T_{11}	Control	13.65	1.33	1.62	11.55	1.66	9.52	25.20	2.99	11.14
S.Em±		1.36	0.12	0.14	1.08	0.17	0.85	2.44	0.25	1.03
CD (p=0.05)		4.01	0.35	0.42	3.18	0.51	2.50	7.21	0.75	3.03
CV (%)		10.52	9.30	8.34	9.59	9.57	8.45	10.11	8.21	8.75

Table 4: Effect of different sources of organic nutrients on protein content and yield of horse gram

Tr. No.	Treatment details	Protein content (%)	Protein yield (kg/ha)
T_1	100% N through FYM	21.98	136.93
T_2	100% N through Vermicompost	23.63	169.01
T_3	100% N through Karanj Cake	22.47	139.00
T_4	50% N through FYM+50% N through VC	24.23	186.94
T_5	50% N through FYM+50% N through KC	23.44	151.00
T_6	50% N through KC+50% N through VC	23.19	146.20
T_7	1/3 N through FYM+1/3 N through VC+1/3 through KC	23.12	162.69
T_8	50% N through FYM	22.1	121.72
T_9	50%N through VC	22.48	125.43
T_{10}	50%N through KC	21.92	112.80
T_{11}	Control	21.75	85.37
S.Em±		0.50	7.50
CD (p=0.05)		1.49	22.14
CV (%)		3.72	9.3

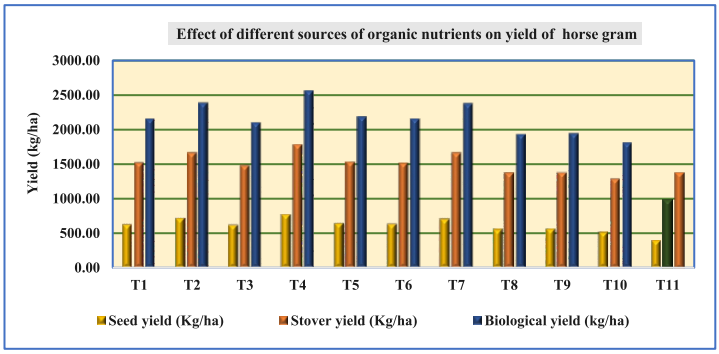

Figure 1: Evaluation of different organic nutrient sources on seed yield, stover yield and biological yield of horse gram

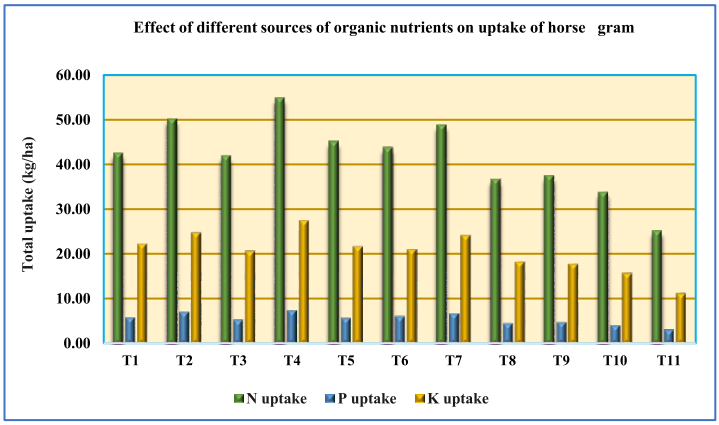

Figure 2: Evaluation of different organic nutrient sources on NPK uptake by horse gram

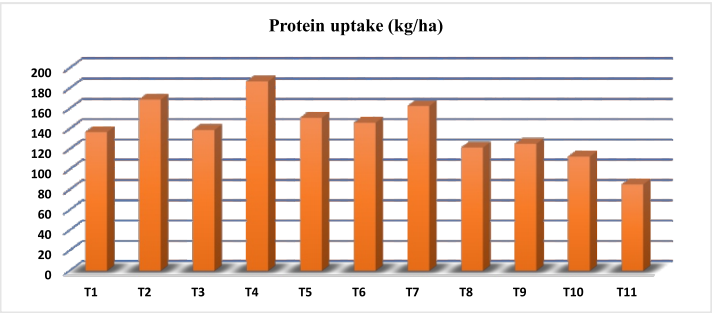

Figure 3: Evaluation of different organic nutrient sources on protein uptake by horse gram

CONCLUSION

Based on one year of experimentation, it may be concluded that the application of 50% nitrogen through farmyard manure (FYM) and 50% N through vermicompost is the most effective combination of organic sources for improving yield, nutrient content, and uptake as well as protein content. This treatment resulted in notably higher yield (770.53), total uptake of nitrogen (54.89 kg/ha), phosphorus (7.28 kg/ha), and potassium (27.40 kg/ha), as well as increased protein content (24.23 %) and uptake (186.94).

Conflict of Interest: No conflict of interest amongst the authors.

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