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Bionutrient Potentiality of *Parthenium hysterophorus* and its Utility as Green Manure in Rice Ecosystem

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Abstract : The present investigation was carried out to determine the nutrient composition of *Parthenium hysterophorus* L. and its utility as a green manure in rice. The results indicated that the weed is a good source of nitrogen (2.54%), phosphorous (0.44%), potassium (1.23%), zinc(13.9 ppm), manganese (161.2 ppm), iron (528.3 ppm) and copper (9.0 ppm). The nutrient composition of different habitats was correlated to nutrient composition of *Parthenium* and found significantly positive relationship with respect to nitrogen (r = 0.74) and potassium (r = 0.73) but no such strong relationship was observed with respect to other nutrients. The utility of the weed as a green manure in rice was investigated for four seasons in a field experimentation which consisted of 18 treatment combinations with six organic source as main plots and three levels of inorganic nutrients as subplots. It was found that incorporation of *Parthenium* alone @ 5 t ha^{-1} resulted in 16.1% higher rice productivity or *Parthenium* @ 2.5 t ha^{-1} in combination with other organic sources, the yield advantage varied viz., *Glyricidia* (11.4%), farmyard manure (20.2%), poultry manure (9.1%), vermicompost (10.9%). *Parthenium* @ 2.5 t ha^{-1} with farmyard manure @ 6 t ha^{-1} recorded significantly higher yield (4346 kg ha^{-1}) compared to no organic manure application (3616 kg ha^{-1}). Among soil properties, pH and electrical conductivity were not affected by different treatments but organic carbon, availability of major nutrients and microflora (total bacteria and phosphorous solubilizing bacteria) were significantly improved by the application of *Parthenium* alone or in combination with other organics. The results of this study suggest that *Parthenium hysterophorus* has a better utility as a green manure in rice ecosystems.

Introduction

Parthenium hysterophorus L., an obnoxious weed is considered to be one of the worst weeds for agriculture, environment and human health in the world. It is a herbacious erect and annual plant belonging to family Asteracae (Compositae) which normally grows to a height of about 1 to 1.5 m and has a wide range of ecological adaptation. It grows on any type of soils in different habitats and also in crop fields. The plant is an extremely prolific seed producer with up to 25 000 seeds per plant (Navie *et al.* 1996). It is estimated to produce 200 000 seeds per m^2 in abandoned fields (Joshi, 1991). Prolific seeding habit of this weed plant, non-dormancy and extreme light weight of its seeds armed with pappus are some of the characteristics which help its extensive spread and establishment. *Parthenium* has been regarded as a beneficial plant too and has many medicinal and insecticidal properties. The aggressive characteristics of the plant for faster establishment in any type of environment makes it a good potential candidate for the possibility of utilization as a green leaf manure and also as a compost for crop plants. The effective control of *Parthenium* is a major menace especially in irrigated ecosystems and hence alternate use of it as a green manure in rice ecosystems is more feasible from all fronts. Although the dreaded weed is considered as a nuisance in both agricultural and non-agricultural environments, the possible utility would become a boon especially in *Parthenium* infested areas.

Rice is cultivated both as irrigated and rainfed crop and in traditional rice growing areas sustaining the system could be possible with the application of organic manures and also by incorporation of green manures. Green manures can accumulate nitrogen either from biological nitrogen fixation and / or from the sequestration of native soil or added nitrogenous fertilizer. After considering various losses, the economy of nitrogen through green manure ranged from 38 kg ha^{-1} to 136 kg ha^{-1} (Palaniappan and Siddeswaran, 2001). The manurial value of *Parthenium hysterophorus* has been reported and nutrient composition was the richest source of potassium and was the next best with respect to nitrogen among various weed species studied (Palaniappan and Siddeswaran, 2001). However, what is not known is that whether the composition of nutrients has any relation with the habitat in which weeds are growing and also what is the extent of micronutrients present in this weed. Very few field investigations have been conducted on the utility of weeds as green manure in different crop ecosystems. The present study is carried out with an aim to assess the bionutrient potentiality of *Parthenium hysterophorus* and its utility as a green manure alone or in combination with other organic sources on rice productivity and also on different soil biological properties.

Material and Methods

Parthenium samples from infested areas were collected from different habitats viz., irrigated, rainfed and also waste lands in both black and red soils for assessing nutrient composition. The samples of above ground parts were collected from plants which were in vegetative or in early flowering stage and infested in an area of minimum of 4-5 m^2. The soil samples were also collected from top 30 cm layer from which the weed samples were collected. Eight such habitats were used for the purpose of collection of weed and soil samples for assessing the nutrient status before the first season of the experimentation. The *Parthenium* samples were air-dried in the shade, powdered, packed in polythene bags and used for different nutrients analysis. However, bulk samples so collected in every season were chopped into small pieces of 15-20 cm long and immediately used for green manuring as per the treatments. The soil samples of different habitats were air-dried, crushed and sieved through 2 mm and used for analysis of different nutrients.

Field experiments were carried out at Agricultural Research Station, Siruguppa, Karnataka during kharif and summer seasons of 2000-01 and 2001-02. The experiments was laid out in a split plot design with three replications on vertisols. The soil at the experimental site had more clay (63%) with initial values of pH 8.1, electrical conductivity (EC) 0.34 dsm^{-1}, organic carbon (OC) 0.49 % and 155 kg, 22 kg and 323 kg of available N, P and K, respectively. The same site with fixed plots were used for all four seasons of experimentation. The treatments consisted of 18 combinations with six organic source as main plots (viz, *Parthenium* alone @ 5 t ha^{-1} and combination of *Parthenium* @ 2.5 t ha^{-1} with *Glyricidia* @ 2.5 t ha^{-1}, farmyard manure @ 6 t ha^{-1}, poultry manure @ 1 t ha^{-1}, vermicompost @ 1 t ha^{-1} and without any organic manure) and three levels of inorganic nutrients as subplots (viz., 50, 75 and 100 percent of recommended dose). A fertilizer dose of 150:75:75 NPK kg ha^{-1} was used as a recommended level in the current study. Green manure treatments (i.e., *Parthenium and Glyricidia*) were incorporated 15 days prior to transplanting while other organic sources (i.e., farm yard manure, poultry manure and vermicompost) were applied 2 days before transplanting the rice seedlings. Rice variety BPT-5204 and Early sona were used in kharif and summer seasons, respectively and seedlings of 25-30 day old were planted at 20 X 10 cm spacing during all seasons. A basal dose of 50% N and a full dose of P and K as per the treatments were applied at the time of transplanting and the remaining 50% N was applied in two equal splits at 30 days intervals. All need based plant protection measures and agronomic management practices were followed during the experimentation period. The rice yield from a net plot area of 30 m^2 in each treatment was used to calculate yield in kgs on hectare basis. At the end of fourth season's experimentation period, soil samples were collected from each treatment plots for further soil, nutrient and microflora analysis.

The soil pH and electrical conductivity were measured in a 1 : 5 soil : water (w/v) with the help of digital pH and conductivity meter, respectively. The soil organic carbon, available nitrogen, available phosphorus, available potassium (ammonium acetate extract, pH 7.0) and available micronutrients (using an atomic absorption spectrophotometer) were measured as described by Allen (1989). For plant analysis, nitrogen (modified Kjeldhal's), phosphorus (molybdo-phosphoric acid yellow color in HNO_3 system), potassium concentration (diacid digested samples in flame photometer) and available micronutrients with diethylene-triaminepentaacetic acid (DTPA) using an atomic absorption spectrophotometer were used. The concentration of different nutrients in *Parthenium* from all the eight habitats is averaged and expressed as in table 1. The total bacteria and phosphorous solubilizing bacteria populations from different treatments after the harvest of rice at the end of the fourth season of experimentation were enumerated by serial dilution plate technique using the protocols as in Parkinson *et al.* (1971).

Statistical significance of experimental treatments was determined by subjecting the data to ANOVA and least significant differences were calculated at the 5% level. Data on nutrient composition of *Parthenium* and habitat were analyzed using linear regression functions and linear correlation coefficients (r-value) are presented. The significance of r-value was tested at 5% level.

Results and Discussion

The composition of *Parthenium* weed with respect to major nutrients in the present investigation was estimated as 2.55%, 0.44% and 1.23% of nitrogen, phosphorous and potassium, respectively (Table 1). The estimations are mean values of eight different habitats which encompassed black and red soils, irrigated and rainfed ecosystems with weeds in vegetative and flowering stages at the time of collection. The values estimated in the current investigation are relatively lower compared to the reported composition of *Parthenium* viz., 2.68%, 0.68% and 1.45% of NPK (Palaniappan and Siddeswaran, 2001). In addition, the present study indicated that the weed also contains substantial amounts micronutrients such as zinc (13.9 ppm), manganese (161.2 ppm), iron (528.3 ppm) and copper (9.0 ppm) for which no reported information is available in the literature to compare. *Parthenium* has been reported to contain water soluble phenolics and sesquiterpene lactone parthenin (Batish *et al.,* 2002). More studies have concentrated on the role of allelopathic effects (Evans, 1997) than green manurial value of *Parthenium*.

The nutrient status of different habitats from which the weed was collected indicated varying correlation to nutrient composition of *Parthenium* weed (Table 1). A significant positive relationship was observed (Fig.1) with respect to nitrogen (r = 0.74) and potassium (r = 0.73). It is to be noted that both nitrogen and potassium are major nutrients and especially the relationship of nitrogen has to be seen with greater implications as the main purpose of green manuring whether it is *Parthenium* or any other plant species is to harness the nitrogen for the benefit of crops. Considerable variation in different phenotypic characteristics with respect to soil quality has been observed in *Parthenium hysterophorus* (Annapurna and Singh, 2003). Hence, varying nutrient acquiring capability of *Parthenium* could be possible in habitats depending on their native

Table 1. Nutrient composition of *Parthenium* samples and correlation between nutrient contents of weed samples and habitat from which it is collected

Name of nutrient	Mean nutrient content	Correlation co-efficient (r) value
Nitrogen	2.55 % (0.07)	0.74*
Phosphorous	0.44 % (0.06)	0.27
Potassium	1.23 % (0.07)	0.73*
Zinc	13.9 ppm (0.47)	- 0.28
Manganese	161.2 ppm (1.18)	- 0.09
Iron	528.3 ppm (2.53)	- 0.14
Copper	8.0 ppm (0.29)	- 0.20

Figures in the paranthesis indicate the standard error of means

* indicates r-value is significant at p = 0.05

Table 2. Grain yield of rice as influenced by application of *Parthenium* and other sources of organics and inorganic levels of nutrients (pooled over four seasons)

Treatments		Grain yield (kg/ha)
Organics		
Parthenium @ 5 t ha^{-1}		4198
Parthenium @ 2.5 t ha^{-1} + *Glyricidia* @ 2.5 t ha^{-1}		4030
Parthenium @ 2.5 t ha^{-1} + Farm yard manure @ 6 t ha^{-1}		4346
Parthenium @ 2.5 t ha^{-1} + Poultry manure @ 1 t ha^{-1}		3945
Parthenium @ 2.5 t ha^{-1} + Vermicompost @ 1 t ha^{-1}		4009
No organic manure		3616
	LSD (0.05)	113
Inorganics		
75-37.5-37.5 NPK kg ha^{-1}		3407
112.5-56.25-56.25 NPK kg ha^{-1}		4033
150-75-75 NPK kg ha^{-1}		4634
	LSD (0.05)	72

N = Nitrogen; P = Phosphorus; K = Potassium; LSD = Least significant difference

fertility status. The relationship with respect to phosphorous composition and its status in habitat was positive but not that pronouncing like in nitrogen and potassium. The lack of stronger relationship could be partly due to varying degree of phosphorous fixation in different soils. The relationship between micronutrient composition of the weed and its habitat indicated negative but none of the r-values were statistically significant. However, more investigations over wider ecosystems and geographical regions are needed not only on the nutrients studied in the present investigation but also on other nutrients which have not been studied to draw definite conclusions with regard to bionutrient potentiality of the weed and also its relation to native fertility of the different habitats.

The utility of *Parthenium* as a green manure was investigated for four seasons on rice and the pooled data over four seasons with respect to rice productivity are presented in table-2. Among the organic sources, application of *Parthenium* @ 2.5 t ha^{-1} + FYM @ 6 t ha^{-1} recorded significantly the highest grain yield of 4346 kg ha^{-1}. This was an additional 730 kg ha^{-1} grain yield advantage (i.e., 20.2% percent higher) over no organic manures. The application of

Parthenium alone @ 5 t ha^{-1} recorded 4198 kg ha^{-1} which accounts for 16.1% yield advantage (i.e., 582 kg ha^{-1}) compared to no organic manure application. Application of *Parthenium* @ 2.5 t ha^{-1} with other organics combinations also resulted in substantial yield advantage of rice. For instance, an advantage of 9.1%, 10.9% and 11.4% when *Parthenium* @ 2.5 t ha^{-1} was applied with poultry manure @ 1 t ha^{-1}, vermicompost @ 1 t ha^{-1}, and *Glyricidia* @ 2.5 t ha^{-1}, respectively. The results thus suggest that *Parthenium* either alone or in combination with other organic sources has a better utility as a green manure and helps in improving the rice productivity. Among the inorganic levels, application of 150:75:75 NPK kg ha^{-1} has produced maximum grain yield (4634 kg ha^{-1}) as compared to other two levels. The yield decreased by 18.4 % and 36.0% percent when inorganic level was reduced by 75% and 50%, respectively. The interaction effects between organic sources and inorganic levels were found to be non significant.

The effect of conventional green manures on rice yield has been reviewed by Becker *et al.* (1995) and found that the yield advantage from the green manuring practice ranged from as low as 6% with soybean to a high of 115% with *Sesbania aculeata*. The magnitudes of yield advantage noted in the current study are on the lower side when compared to conventional green manure legumes. Moreover, the extent of yield advantage due to green manuring depends on several factors such as soil fertility level, quantity if biomass added and its quality, time of incorporation, decomposition and nitrogen release pattern and inorganic fertilizer added to the crop (Palaniappan and Siddeswaran, 2001). Further, it is not just the yield improvement but impact on soil properties due to green manuring or application of organic sources is important to judge the benefits that could be accrued from such sources. Another point to be noted is that incorporation of a wasteland weed like *Parthenium* has several other advantages like not loosing a land, season or other resources which would be needed to grow other conventional green manures. Among soil biological properties, pH and electrical conductivity (EC) were not affected but soil organic carbon, availability of major nutrients and microflora were significantly influenced by the application of *Parthenium* alone or in combination with other organic sources (Table 3). The results about pH and EC in the present study are in contrast to the observations of Batish *et al.* (2002) who reported significant reduction in soil pH and an increased EC of soils amended with *Parthenium* residues. While no such significant reduction in soil pH was observed in the present investigation but numerically lower values of pH were recorded in all organic residue treatments. This may be because of the difference in the soil environments under which the experiments have been conducted as the present study is in rice ecosystems under field conditions while the study of Batish *et al.* (2002) was on arable soils under laboratory conditions. The continuous water standing in rice ecosystems may have diluted the phenolics from *Parthenium* residues to reduce the impact on soil properties like pH and EC. Soil organic carbon content increased substantially at the end of four seasons of continuous application of organic sources. Application of *Parthenium* @ 2.5 t ha^{-1} + FYM @ 6 t ha^{-1} recorded significantly the highest organic carbon content of 0.75% (i.e., 33.9% percent higher) over no organic manures. While the application of *Parthenium* alone @ 5 t ha^{-1} recorded an organic carbon content of 0.72% which accounts for 28.6% improvement compared to no organic manure application. Application of *Parthenium* @ 2.5 t ha^{-1} with other organics combinations also resulted in substantial improvements in soil organic carbon. For instance, an improvement of 12.5%, 16.1% and 26.8% higher soil organic carbon content when *Parthenium* @ 2.5 t ha^{-1} was applied with *Glyricidia* @ 2.5 t ha^{-1}, poultry manure @ 1 t ha^{-1} and vermicompost @ 1 t ha^{-1}, respectively. The results from the current study suggest that continuous incorporation of *Parthenium* alone or in combination with other organic sources helps

Table 3. Soil biological properties as influenced by application of *Parthenium* and other sources of organics and inorganic levels of nutrients

Treatments	EC (d sm^{-1})	pH	OC (%)	TB (No./g of soil x 10^4)	PSB (No./g of soil x 10^4)	Availability of nutrients ($kg\ ha^{-1}$) N	P	K
Organics								
Parthenium @ 5 t ha^{-1}	0.30	7.60	0.72	7.00	7.33	250.5	31.7	322.7
Parthenium @ 2.5 t ha^{-1} + *Glyricidia* @ 2.5 t ha^{-1}	0.31	7.80	0.63	6.67	5.66	265.3	40.4	325.7
Parthenium @ 2.5 t ha^{-1} + Farm yard manure @ 6 t ha^{-1}	0.26	7.85	0.75	10.33	9.33	240.2	28.9	311.5
Parthenium @ 2.5 t ha^{-1} + Poultry manure @ 1 t ha^{-1}	0.26	7.84	0.65	3.66	4.66	263.9	39.3	293.6
Parthenium @ 2.5 t ha^{-1} + Vermicompost @ 1 t ha^{-1}	0.29	7.75	0.71	8.33	8.66	252.4	34.1	288.8
No organic manure	0.26	7.92	0.56	2.66	3.33	218.4	28.7	226.1
LSD (0.05)	NS	NS	0.014	1.57	0.13	9.65	2.58	13.12
Inorganics								
75-37.5-37.5 NPK kg ha^{-1}	0.29	7.82	0.64	7.00	5.83	216.5	27.7	268.9
112.5-56.25-56.25 NPK kg ha^{-1}	0.28	7.79	0.68	6.17	6.67	251.1	34.8	294.6
150-75-75 NPK kg ha^{-1}	0.28	7.76	0.69	6.17	7.00	277.8	39.1	320.5
LSD (0.05)	NS	NS	0.012	NS	0.81	7.91	2.29	13.43

EC = Electrical conductivity ; OC = Organic carbon ; TB = Total bacteria ; PSB = Phosphorous solubilizing bacteria; N = Nitrogen; P = Phosphorus; K = Potassium; LSD = Least significant difference; NS = not significant at p = 0.05

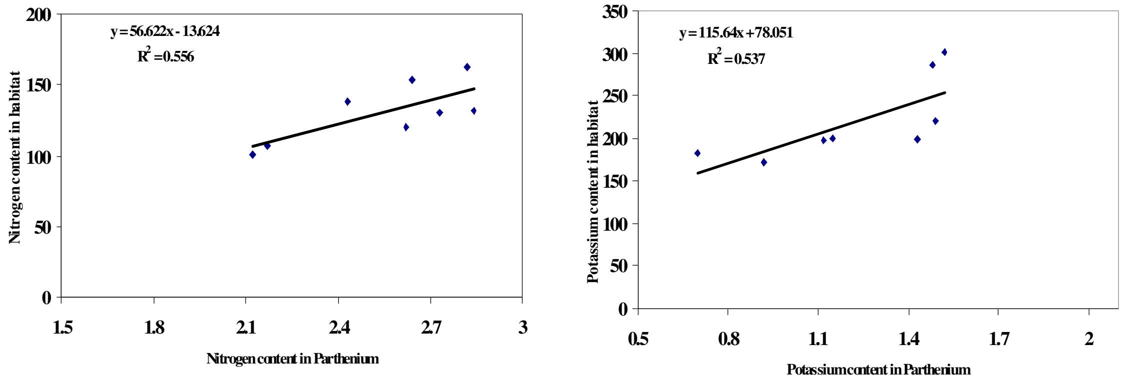

Fig 1. Relationship between nitrogen (A) and potassium (B) contents of parthenium and habitat r vaule is signficant at P= 0.05

in improving the organic carbon content of soils. Improved soil organic carbon content in rice-based cropping systems involving green manure (*Sesbania rostrata*) with application of different organics like poultry manure, farmyard manure and *Azolla* has also been observed by Ramesh and Chandrasekaran (2004). The magnitude of increase in organic carbon content noted in the current investigation is par below the reported increase of organic carbon content of 118% in soils amended with *Parthenium* residues under laboratory conditions (Batish *et al.,* 2002). Nevertheless the observed improvements in organic carbon content levels due to incorporation of *Parthenium* as a green manure in the current study are comparable enough with improvements that could be possible with the conventional green manures thus signifying the utility of the dreaded weed in rice ecosystems.

The availability of major nutrients indicated significant improvement of all major nutrients as influenced by incorporation of *Parthenium* alone or in combination with other organics and inorganic nutrient levels. As it is evident from the data (Table 3), only availability of phosphorus in *Parthenium* with farmyard manure application did not show much improvement when compared to no manure application. The availability of all three major nutrients was maximum viz., 21.5%, 40.8% and 44.1% higher with respect to N, P and K, respectively in *Parthenium* with *Glyricida* incorporation compared to no manure application. While the extent of availability was lower in *Parthenium* with farm yard manure incorporation for N (10.0%) and P (0.7%) and in *Parthenium* with vermicompost incorporation for K (27.7%) compared to control. The differential advantages from the organic sources may be related to their nutrient composition as *Glyricidia* is known for its better NPK composition compared to farm yard manure and vermicompost. The increase in inorganic levels of nutrients significantly improved the availability of all three major nutrients. Batish *et al.* (2002) reported significant alterations in the availability of major as well as micronutrients and also amounts of phenolics from *Parthenium* amended soils. It is also reported that phenolic compounds may alter the accumulation and availability of nutrients in soil (Facelli and Pickett, 1991; Appel, 1993). The present study indicates that *Parthenium* incorporation alone or in combination not only influences soil properties and nutrient availability but also improves microflora in the soils substantially (Table 3). All organic source combinations resulted in significantly higher total bacteria population and also phosphorus solubilizing bacteria in the soil compared to no organic manures. *Parthenium* amended soils are known to produce significantly higher amount of phenolics and amount of phenolics was directly proportional to the amount of *Parthenium* residues added to the soils (Batish *et al.* 2002). It is generally known that phenolics so released by the organics upon entering a complex and heterogeneous soil environment, may be toxified, detoxified, chemically transformed or may serve as a source of carbon for the microbes (Blum and Shafer, 1988). Further, improvement in microflora population was substantial in application of *Parthenium* alone thus ruling out the possibility of improvement due to combined application of other organics with *Parthenium*. This synergistic effect of improved microflora might have reflected in overall improvement in the availability of major nutrients also. Hence, the improvement in microflora of soils due to organic residues specifically with *Parthenium* has to be seen with its additional cascading benefits in mineralization processes and the overall role to sustain soil health. In conclusion, *Parthenium* is a good source of different nutrients needed for crop production and it could be used as an alternate green manure in rice ecosystems. Incorporation of *Parthenium* alone or in combination with other organic sources helps to improve productivity and soil biological properties in rice ecosystem.

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