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Utilization of congress grass (*Parthenium hysterophorus* L.) for soil fertility enhancement and improved productivity of potential crop sequences in West Bengal

AK Dolai, MK Bhowmick, P Ghosh and RK Ghosh

Abstract
The invasive alien weed *Parthenium hysterophorus* L. is posing serious threat to agriculture as well as public health in India. Management of this pernicious weed is possible through utilization as compost, green manure or mulch that helps to improve soil health and crop productivity. Keeping this background in view, a field experiment was conducted during 2008-09 and 2009-10 at Bidhan Chandra Krishi Viswavidyalaya (BCKV), West Bengal to utilize *Parthenium* either as green manure or as mulch in potential crop sequences of new alluvial zone of West Bengal. Three levels of nutrients *viz.* recommended dose of NPK + green manuring of *Parthenium* @ 5 t ha^{-1} (N_1), recommended dose of NPK + mulching of *Parthenium* @ 5 t ha^{-1} and its subsequent incorporation (N_2) and only recommended dose of NPK (N_3) were applied in three different crop sequences *viz.* Black gram - Transplanted rice - Onion (CS_1); Sesame - Transplanted rice - Chickpea (CS_2) and Okra - Transplanted rice - Rapeseed (CS_3) under medium land situation having irrigation facility. The experiment was conducted in RBD with three replications in a plot size of 5 m x 3 m. The results revealed that application of NPK at recommended dose along with either green manuring or mulching of *Parthenium* @ 5 t ha^{-1} effectively improved the productivity of all crops grown under crop sequences as well as soil fertility status. The possible reason of increased productivity of crops grown in sequence on addition of *Parthenium* biomass might be due to better availability of plant nutrients, improved soil and plant health. The management of invasive alien weed *Parthenium* may also be done by utilizing the same as compost etc. and this will also create an opportunity of employment generation in the rural & municipal areas of West Bengal.

Keywords: *Parthenium*, green manure, mulch, productivity, soil fertility

Introduction
Congress Grass (*Parthenium hysterophorus* L.) is now a weed of international importance. Its invasion in cultivated fields is causing alarming signals in India. It has already invaded in the crop fields of paddy, wheat, banana etc. at Nadia, West Bengal [1]. *Parthenium* adversely affects crop growth and yield by competing with the crop plants for growth resources. The weed exhibits fast luxuriant vegetative growth and keeps flowering and seeding throughout the year [2]. By this way, it has been continuously invading in new areas including both agricultural and non-agricultural ones. If this noxious weed is, therefore, allowed to grow unchecked, it will obviously pose serious threat to agriculture as well as public health [3]. Toxic exudates of this weed are also appeared to have allelopathic effect on the species at the vicinity and thus this can be utilized as biopesticides. Owing to its potential nutrient content this can also be utilized as a source of organic manure through making compost and in combination with graded levels of fertilizers with a view to reduce the dose of chemical fertilizers on one hand and to improve the soil health on the other [4]. Ghosh *et al.* [5] also reported better management of *Parthenium* through weed utilization as compost (before or after flowering) or green manure (before flowering). In recent years, attempts are also being made to utilize the weeds as mulch for the purpose of crop production and soil reclamation [6]. With this background, a field experiment was conducted to utilize *Parthenium* either as green manure or as mulch before flowering for enhancing soil fertility and crop productivity in three commonly farmers accepted crop sequences Black gram - Transplanted rice (TR) - Onion; Sesame - TR - Chickpea and Okra - TR - Rapeseed in alluvial plains of West Bengal.

Materials and Methods
A field experiment was conducted during 2008-09 and 2009-10 at the Viswavidyalaya 'C-Block' (Incheck) Farm, Kalyani, West Bengal, located at 23.5°N latitude and 89°E longitude with an altitude of 9.75 m above MSL. Three levels of nutrients *viz.* NPK at recommended

dose + green manuring of *Parthenium* @ 5 t ha^{-1} (N_1), NPK at recommended dose + mulching of *Parthenium* and its subsequent incorporation @ 5 t ha^{-1} (N_2) and only NPK at recommended dose (N_3) were applied in three different crop sequences *viz.* Black gram - Transplanted rice - Onion (CS_1); Sesame - Transplanted rice - Chickpea (CS_2) and Okra - Transplanted rice - Rapeseed (CS_3) under medium land situation having irrigation facility. The experiment was conducted in a randomized block design with three replications, having individual plot size of 5 m x 3 m. The experimental soil was a typical Gangetic Alluvium with sandy loam texture, pH 6.8 and initial content of available N 180.72 kg ha^{-1}, available P_2O_5 12.9 kg ha^{-1} and available K_2O 130.2 kg ha^{-1}. Productivity data were recorded along with soil fertility status in terms of available nitrogen, available phosphate and available potash content in soil and subjected to pooled analysis.

Soil analysis

Composite soil samples were collected from the five different places at 0–15 cm depth of the experimental field before sowing and after harvesting of the each crop grown in sequence. Then the samples were dried in shade, pulverized to pass through 0.2 mm sieve and were used for chemical analysis. Mechanical analysis of soil particularly the content of sand, clay and silt was done by International Pipette Method [7]. The pH was determined by using electronic digital pH meter with glass electrode, calomel reference electrode and salt bridge at soil: water ratio of 1:2.5 soil water suspensions, stirred till the reading (at 20^0 C) was recorded [8]. Organic carbon was determined in percentage according to the Volumetric Redox Titration taking 2 g soil using diphenylamine as indicator by Walkley and Black Method [8]. Available nitrogen content in soil was determined in percentage, according to the Modified Macrokjeldahl Distillation Method [8]. Available phosphate in kg ha^{-1} was determined by Olsen's Method [8] and available potash in kg ha^{-1} was determined from 5 g of soil by Flame Photometer Method [8].

Statistical analysis

The statistical analysis for various soil analytical data was determined as per the method described by Gomez and Gomez [9]. The correlation study in all the three cropping seasons with applied NPK in combination with added organic manures was calculated in terms of Rice Equivalent Yield (REY) at 1 and 5% levels of probability.

Results and Discussion

Effect of treatments on rice and rice equivalent yield (t ha^{-1}): The results of the experiment (Table 1) from the average of two-year yield data of three seasons as obtained in three nutrient levels in *pre-kharif*, *kharif* and *rabi* seasons showed that rice equivalent yields in *pre-kharif* were significantly influenced by the treatments. The highest rice equivalent yield was observed in N_1 treatment in all three crop sequences followed by N_2 and the lowest average rice equivalent yield was observed under N_3 treatment. There was significant variation among the treatments. In subsequent *kharif* and *rabi* seasons, trends of rice and rice equivalent yield were almost similar. The studies indicated the better effect of incorporation of *Parthenium* as green manure @ 5 t ha^{-1} with RDF which offered good soil health and recorded significantly higher crop yield as compared to sole application of RDF. Such higher productivity could be obtained under these treatments possibly due to balanced nutrient instead of using NPK only. Similar opinion was also expressed by Chamappagoudar *et al.* [10].

Table 1: Effect of treatments on rice equivalent yield (REY) t ha^{-1} of pooled data of three different crops grown *Pre-kharif* & three different crops grown *rabi* and transplanted paddy grown in *kharif*

Treatment	*Pre-kharif* BG+SE+OK	*Kharif* Transplanted Rice (TR)	*Rabi* RS+ON+CP	Mean
	REY (t ha^{-1})	Rice yield (t ha^{-1})	REY (t ha^{-1})	
N_1CS_1	2.99	5.45	16.21	8.21
N_2CS_1	2.86	5.01	15.42	7.76
N_3CS_1	2.65	4.51	14.71	7.29
N_1CS_2	1.32	5.24	7.19	4.58
N_2CS_2	1.21	4.60	6.29	4.03
N_3CS_2	0.95	4.11	5.86	3.64
N_1CS_3	11.06	3.96	5.44	6.82
N_2CS_3	10.16	3.69	4.88	6.24
N_3CS_3	9.66	3.50	4.60	5.92
CD at 5 %	0.65	0.86	0.90	0.37

Note: N- Nutrient level: N_1 - NPK + Green manuring of *Parthenium* @ 5 t ha^{-1}, N_2 - NPK + *Parthenium* mulching @ 5 t ha^{-1} and its subsequent incorporation and N_3 - Recommended NPK; CS- Crop sequence: CS_1 - Black gram (BG) - Transplanted rice (TR) - Onion (ON); CS_2- Sesame (SE) - Transplanted rice (TR) - Chickpea (CP) and CS_3- Okra (OK) - Transplanted rice (TR) - Rapeseed (RS)

Correlation coefficient between NPK applications and Rice Equivalent Yield (REY): In all three crop sequences during 1st year in *pre-kharif* the initial content of available nitrogen is non-significant in respect of control but the availability of nitrogen in N_1 and N_2 after the harvesting of all three crops showed significant increment over N_3. Again in second year both the initial and final availability of nitrogen in soil under N_1 and N_2 nutrient level characterized significant increment over that of only RDF (control) in all the three crops. Here, due to leguminous crop, rate of availability of nitrogen after harvest is higher than sesame and okra, but due to less mineralization final content of nitrogen is less than the initial of transplanted paddy. During *pre-kharif* due to 50-60% moisture present in soil, N mineralization rate is higher than transplanted paddy results increase in N availability in soil.

The pH of the experimental soil is 6.8; P_2O_5 availability to plants is more as most of the P_2O_5 become available at neutral soil reaction.

The results showed increasing trends of available K_2O in the subsequent crop seasons just like that of available P_2O_5. The indogangetic plain is rich in K_2O containing mineral *i.e.* Illite.

Due to this rich K_2O content of the soil it was increased significantly both the year. Biradar *el al.* [11] reported in the same way.

The correlation study (Table 2.) indicated that, in all the cropping seasons viz. *Pre-kharif*, *Kharif* and *Rabi*, NPK in combination with added organic manures impacted the yield, calculated in terms of Rice Equivalent Yield (REY). Analysis of *Parthenium* plant showed it contains N, P and K % and thus in N_1 and N_2 treatment addition of these nutrients not only increased the total yield but also the nutrient level after two years of completion of this experiment. Moreover, as the source of the nutrients is organic the soil was also benefitted by other macro & micro nutrients. Many research works proved the advantages of using organic manure in addition to inorganic fertilizers for crop yield & soil health advantages.

Table 2: Correlation coefficient between NPK applications and Rice Equivalent Yield (REY)

Correlations	*Pre-kharif REY*	Correlations	*Kharif REY*	Correlations	*Rabi REY*
Pre-kharif *N*	0.862**	*Kharif N*	0.819**	*Rabi N*	0.811**
Pre-kharif *P*	0.782*	*Kharif P*	0.773*	*Rabi P*	0.714*
Pre-kharif *K*	0.660*	*Kharif K*	0.638*	*Rabi K*	0.653*

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Effect of treatments on soil available nitrogen

Available nitrogen (N) content in soil before crop sowing during pre-kharif (Table 3) was found to be the highest (208.40 kg ha^{-1}) when NPK along with GM of *Parthenium* @ 5 t ha^{-1} was applied in okra - TR – rapeseed crop sequence and it was significantly higher than the others excepting the application of similar treatment in black gram - TR - onion crop sequence (207.55 kg ha^{-1}). Available N content in the soil remained statistically at par when application of NPK along with mulching of *Parthenium* and its subsequent incorporation @ 5 t ha^{-1} (N_1) was done in all the three crop sequences taken for the study. Again, in case of the treatments where only NPK was applied (N_3), the data were statistically at par, irrespective of crop sequences. It was, thus, evident that NPK + green manuring of *Parthenium* could enhance more content of available N in the soil and was followed by NPK + *Parthenium* mulching. Almost similar trend was recorded in respect of available soil N status at crop harvest during pre-kharif though the available N content was found to be slightly reduced than that at sowing. In subsequent *kharif* and *rabi* seasons, trends of available N content were almost similar. Although the available N content of the soil decreased after growing a particular crop in a given season possibly due to crop removal or leaching loss, it ultimately increased in a particular crop sequence when *Parthenium* as green manure or mulch was added (Table 1). Kiran Kumar *et al.* [12] reported that use of *Parthenium* as GM at 10 t ha^{-1} + 100% NPK through fertilizers recorded higher residual fertility in terms of nitrogen than traditional manures in pre-kharif aerobic rice.

Table 3: Effect of treatments on available nitrogen (kg ha^{-1}) content of soil (Pooled of two-year data)

Treatment	*Pre-kharif*		*Kharif*		*Rabi*		Overall increase (%)
	Initial	Final	Initial	Final	Initial	Final	
N_1CS_1	206.98	215.36 (3.89)	226.86	225.37 (-0.66)	239.63	238.14 (-0.63)	24.1
N_2CS_1	199.26	205.25 (2.92)	214.66	213.78 (-0.41)	224.63	223.75 (-0.39)	19.2
N_3CS_1	190.39	192.53 (1.11)	197.24	196.38 (-0.44)	201.51	200.65 (-0.43)	9.9
N_1CS_2	207.55	215.57 (3.72)	226.03	225.21 (-0.36)	238.09	237.25 (-0.35)	23.8
N_2CS_2	199.33	203.51 (2.05)	211.82	211.5 (-0.15)	220.62	219.86 (-0.35)	17.8
N_3CS_2	192.49	195.48 (1.53)	201.58	201.34 (-0.12)	207.55	207.32 (-0.11)	12.8
N_1CS_3	208.4	216.69 (3.83)	228.35	226.98 (-0.60)	241.2	239.83 (-0.57)	24.6
N_2CS_3	198.96	203.6 (2.28)	213.32	212.44 (-0.41)	222.59	221.71 (-0.40)	18.5
N_3CS_3	195.31	198.92 (1.81)	206.16	206.13 (-0.01)	213.39	213.36 (-0.01)	15.3
CD(P=0.05)	9.36	8.97	4.02	3.45	7.55	8.64	-

Note-values in the parentheses indicate the percent increase from initial; N: Nutrient level; CS: Crop sequence; Initial: Nutrient content in soil before crop sowing; Final: Nutrient content in soil at crop harvest

Effect of treatments on soil available phosphate

A perusal of data in (Table 4) showed that available P_2O_5 content in soil was in medium range of soil fertility. During *pre-kharif* season application of the treatment NPK + GM of *Parthenium* @ 5 t ha^{-1} in okra - TR – rapeseed crop sequence initially recorded the highest content of available P_2O_5 (18.55 kg ha^{-1}), which was followed by those recorded under application of the same treatment in sesame - TR – chickpea (18.10 kg ha^{-1}) and black gram - TR – onion(16.57 kg ha^{-1}). The crop sequences which received NPK + mulching of *Parthenium* with subsequent incorporation @ 5 t ha^{-1}, the results were statistically at par among themselves. Regardless of crop sequences, the treatments having only NPK application recorded comparatively lower values of available P_2O_5. Thus, better results were recorded under the treatment NPK + GM of *Parhenium*. Next in order was NPK + mulching in respect of initial soil content of available P_2O_5 (Table 2). Similar trends were recorded at the time of crop harvest during *pre-kharif*. Though similar trends were also found in subsequent *kharif* and *rabi* seasons, available P_2O_5 content in soil was increasing in a linear fashion from crop sowing to harvest. The ultimate increase in available P_2O_5 status of soil might be due to addition of weed biomass either as green manure or as mulch which ensured better aeration and improved soil physical condition with increasing microbial activity.

Table 4: Effect of treatments on available phosphate (kg ha^{-1}) content of soil (Pooled of two-year data)

Treatment	*Pre-kharif*		*Kharif*		*Rabi*		Overall increase (%)
	Initial	Final	Initial	Final	Initial	Final	
N_1CS_1	16.57	17.83 (7.07)	18.32	19.57 (6.39)	20.06	21.31 (5.87)	39.5
N_2CS_1	15.51	16.08 (3.54)	16.5	17.07 (3.34)	17.49	18.06 (3.16)	28.6
N_3CS_1	14.41	14.58 (1.17)	14.69	14.86 (1.14)	14.97	15.13 (1.06)	14.7
N_1CS_2	18.1	19.97 (9.36)	20.64	22.51 (8.31)	23.18	25.04 (7.43)	48.5
N_2CS_2	15.93	16.72 (4.72)	17.17	17.96 (4.40)	18.41	19.2 (4.11)	32.8
N_3CS_2	14.51	14.7 (1.29)	14.85	15.04 (1.26)	15.19	15.38 (1.24)	16.1
N_1CS_3	18.55	18.27 (-1.53)	18.89	20.1 (6.02)	20.72	21.94 (5.56)	41.2
N_2CS_3	15.52	15.98 (2.88)	16.39	16.84 (2.67)	17.25	17.71 (2.60)	27.2
N_3CS_3	14.28	14.41 (0.90)	14.44	14.57 (0.89)	14.6	14.73 (0.88)	12.4
CD(P=0.05)	0.81	1.09	1.1	1.01	1.11	1.02	-

Note-values in the parentheses indicate the percent increase from initial; N: Nutrient level; CS: Crop sequence; Initial: Nutrient content in soil before crop sowing; Final: Nutrient content in soil at crop harvest

Effect of treatments on soil available potash

Data in (Table 5) revealed that soil fertility status was medium in respect of available potash (K_2O) content in soil in all the treatments having different nutrient levels and crop sequences. However, from the data on initial soil status during *pre-kharif* season, available K_2O content was the highest (169.17 kg ha^{-1}) in the crop sequence okra – TR - rapeseed that received the application of NPK + GM of *Parthenium* @ 5 t ha^{-1} and was followed by black gram - TR - onion and sesame - TR - chickpea, each having similar nutrient application. Next in order were okra - TR - rapeseed, black gram - TR - onion and sesame - TR - chickpea, each receiving NPK + mulch. The crop sequences having only NPK application recorded similar values of K_2O content, being statistically at par among themselves. Compared with sole application of NPK, combined application of NPK + GM always proved to be the effective and was followed by NPK + mulching. In the same season, final data exhibited the similar trend. Increasing trends of available K_2O were recorded in the subsequent crop seasons (Table 5) like available P_2O_5 (Table 4). Denesh [13] had also similar opinion.

Table 5: Effect of treatments on available potash (kg ha^{-1}) content of soil (Pooled of two-year data)

Treatments	*Pre-kharif*		*Kharif*		*Rabi*		Overall increase (%)
	Initial	Final	Initial	Final	Initial	Final	
N_1CS_1	168.74	186.26 (9.41)	190.12	207.64 (8.44)	211.49	229.02 (7.65)	43.1
N_2CS_1	153.84	164.69 (6.59)	167.68	178.53 (6.08)	181.51	192.36 (5.64)	32.3
N_3CS_1	148.11	153.97 (3.81)	155.96	161.82 (3.62)	163.81	169.67 (3.45)	23.3
N_1CS_2	166.36	183.06 (9.12)	186.64	203.34 (8.21)	206.93	223.63 (7.47)	41.8
N_2CS_2	155.84	166.7 (6.51)	169.29	180.14 (6.02)	182.73	193.59 (5.61)	32.7
N_3CS_2	145.18	150.31 (3.41)	152.09	157.22 (3.26)	159.01	164.13 (3.12)	20.7
N_1CS_3	169.17	187.19 (9.63)	191.07	209.09 (8.62)	212.98	230.99 (7.80)	43.6
N_2CS_3	153.7	163.52 (6.01)	166.11	175.93 (5.58)	178.51	188.34 (5.22)	30.9
N_3CS_3	143.51	149.63 (4.09)	151.33	157.46 (3.89)	159.16	165.28 (3.70)	21.2
CD(P=0.05)	8.23	5.73	7.31	9.44	7.29	6.15	-

Note-values in the parentheses indicate the percent increase from initial; N: Nutrient level; CS: Crop sequence; Initial: Nutrient content in soil before crop sowing; Final: Nutrient content in soil at crop harvest

From the above findings, it might be inferred that the invasive weed *Parthenium hysterophorus* could be well managed by utilizing it in its vegetative stage (before flowering) either as green manure or as mulch. More precisely to say, the application of NPK at recommended dose along with either green manuring or mulching of *Parthenium* @ 5 t ha^{-1} was found to effectively enhance the soil fertility status and productivity in the crop sequences taken for study.

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