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Studies on spacing and nutrient management practices on growth and yield of *Eclipta prostrata* L. and residual soil properties

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ABSTRACT

A field experiment was conducted to study the effect of spacing and nutrient management practices on performance of growth and yield of bhringaraj (*Eclipta prostrata* L.) and the soil properties after harvest at Research-cum-Experimental farm, Department of Forestry, NERIST, Nirjuli, Arunachal Pradesh during 2005-06 and 2006-07 under split plot design with three replications. There were 3 different spacings *viz.,* S_1- 20 x 20 cm, S_2- 25 x 25 cm and S_3- 30 x 30 considered as main factor and six different doses of nutrients *viz.,* $F_0 - N_0P_0K_0$, $F_1 - N_{30}P_{20}K_{10}$, $F_2 - N_{60}P_{40}K_{20}$, $F_3 - N_{90}P_{60}K_{30}$, F_4 – 10 t FYM/ha and $F_5 - N_{60}P_{40}K_{20}$ + 5 t FYM/ha as sub factor. The results indicated that relatively wider spacing *viz.,* 25 x 25 cm and 30 x 30 cm recorded significantly higher growth and reproductive characters along with herb yield. All the spacing treatments remained at par on residual soil P, K and organic carbon though soil N was superior in the closest spacing. All the nutrient management practices showed better performance than control on all the above parameters. Among the nutrient management treatments FYM application either alone or in combination with fertilizer and highest doses of NPK applied treatments were superior to other treatments. Application of organics recorded the highest residual soil parameters.

Key words : *Eclipta prostrata* L., Spacing, Nutrient management, Growth, Yield, Soil properties

INTRODUCTION

"Bhringaraj" botanically known as *Eclipta prostrata* L. false daisy in English, is a very valuable medicinal plant having wide range of uses from pre-vedic era. The whole plant of the parts is used in medicinal industries (Anonymous, 1989). According to Ayurveda philosophy, *Eclipta prostrata* is bitter, hot fattening alternative anathematic and alexipharmic. In scientific studies *Eclipta prostrata* shows good antifungal activities. From the medicinal point of view it is useful in inflammations, hernia, eye diseases, bronchitis, asthma, leucoderma, anemia, heart and skin black and long hair all over India for its hair growth-promoting potential (Kanjilal *et al.*, 1982). The fresh juice of leaves is used for increasing appetite, improving digestion and as a mild bowel regulator. It is popularly used to enhance memory and a general tonic against debility (Gogate, 1982). There are also reports of clinical improvement in the treatment of infective hepatitis (Dixit and Achar, 1979) and snake venom poisoning in Brazil (Melo *et al.*, 1994) as well as septic shock in folk medicine in China (Kobori *et al.*, 2004). Due to high percentage of saponins and tennins in the leaf extract of *Eclipta prostrata*, the herbs can be used as environment friendly and sustainable insecticides to control *Culex qinquifaciatus* mosquito larvae (Khanna and Kannabiran, 2007). At present 80 per cent of the available quantity of medicinal plant used in medicinal industries is actually obtained from the forest areas, while only 10 per cent of the actual quantity available is collected from non-forest areas (Ravishankar *et al.*, 1999). But now, efforts are being made to change the scenario, to obtain 80 per cent medicinal plants from cultivated field and less than 20% from the forest. The major limitation, however, for the cultivation of a wild medicinal plant is lack of standard cultivation packages. Therefore, present investigation was undertaken to standardize the suitable spacing and nutrient management practices for domestication and commercial cultivation of false daisy.

MATERIALS AND METHODS

One field experiment was conducted at Research-cum-Experimental farm, Department of Forestry, North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Arunachal Pradesh for two consecutive years 2005-06 and 2006-07 under split plot design with three replication. The research farm is located at $27^0$08'30" N latitude and $93^0$44' 36" E longitudes with an altitude of 120 meters above the mean sea level. The soil of the experimental site was loamy sand in texture, acidic in reaction (pH 5.64), 1.19 in bulk density, 15.65% moisture content with low initial available soil nitrogen (265.47 kg/ha), Phosphorus (21.56 kg/ha), Potash (97.53 kg/ha) and medium soil organic carbon (0.66%). The climatic condition of Nirjuli, Arunachal Pradesh, as a whole is tropical warm humid where monsoon normally sets in the first week of June, extends up to the end of September and recedes in October. The mean annual maximum and minimum temperature varies between 37^0C and 12^0C, respectively. More than 80% of rainfall occurs during monsoon (June-September) registering about 60-80%

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RH. The total rainfall during the crop growth period was recorded (May to August) 2021.8 mm and 1983.6 mm in 2005 and 2006, respectively. The experiment was laid out with three different spacings *viz.,* S_1- 20 x 20 cm, S_2- 25 x 25 cm and S_3- 30 x 30 cm between row to row and plant to plant, respectively in main plot and six different doses of nutrients *viz.* F_0 – $N_0P_0K_0$, F_1–$N_{30}P_{20}K_{10}$, F_2 – $N_{60}P_{40}K_{20}$, F_3– $N_{90}P_{60}K_{30}$, F_4– 10 t FYM/ha and F_5– $N_{60}P_{40}K_{20}$ + 5 t FYM/ha in sub plot consisting 18 treatment combinations and 54 number of plots. The gross and net plot sizes were 2m x 2m and 1.8 m x 1.8m, respectively with 50 cm gap between two plots and 1 m gap between two replications. The required amount of FYM, urea, SSP and MOP were weighed as per treatments, applied and mixed well in soil. Application of FYM was done 15 days prior to transplanting and urea, SSP and MOP were applied one day before transplanting of seedlings. Half of urea with whole amount of SSP an MOP was applied as basal and remaining half of urea was top dressed at vegetative growth stage. 27 days old seedlings were transplanted at spacing of 20 x 20 cm, 25 x 25 cm and 30 x 30 cm as per treatments on 5th June during both the year. After transplanting of seedlings light watering was done till the seedlings established. Malathion dust was applied surrounding the seedlings against cutworm. Gap filling was done within 7 days after transplanting. Two weeding were done manually, first at 20 DAT and second at 40 DST. Harvesting of crop was done by uprooting the plants from each net plot at 77 DAT during both the years cleaned and dried under sun for a week and yield of whole plant was expressed in q/ha. The randomly selected plants from each treatment were dried at 70^0C temperature, ground, powdered and analyzed for N, P, K and organic carbon content by using standard methods. The data were statistically analyzed and results of the individual years were discussed.

RESULTS AND DISCUSSION

The results obtained from the present investigation are summarized below :

Growth parameters:

The observation on growth revealed that almost all the growth parameters (Table 1 and 2) were gradually increased with increase in plant spacing. The tallest plant height (47.15 and 48.43 cm), highest number of primary branches (47.15 and 48.43), maximum number of leaves/ plant (257.42 and 247.66) highest number of root/plant (77.08 and 77.74) as well as longest root (18.67 and 19.07 cm) was recorded under 30 x 30 cm spacing, respectively in both the years 2005-06 and 2006-07 at maturity stage

Table 1 : Effect of spacing and various sources and rates of nutrients on plant height (cm), number of Primary branches and leaves/plant of *E. prostrata* L.

Treatments	Plant height (cm)		Primary branches		No. of leaves	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Spacing						
S_1- 20 cm x 20 cm	42.26	43.62	15.69	16.69	211.15	214.31
S_2 - 25 cm x 25 cm	46.53	47.97	17.98	18.98	238.39	237.83
S_3 - 30 cm x 30 cm	47.15	48.43	18.62	19.68	257.42	247.66
S.E. (±)	0.567	0.519	0.618	0.616	7.36	4.36
C.D. (P=0.05))	1.573	1.442	1.714	1.710	20.45	12.11
Doses of nutrients						
F_0 – $N_0P_0K_0$	36.88	38.27	12.15	13.17	164.91	153.77
F_1 – $N_{30}P_{20}K_{10}$	44.71	46.04	16.10	17.11	204.58	189.19
F_2 – $N_{60}P_{40}K_{20}$	46.41	47.41	17.30	18.32	253.45	254.10
F_3– $N_{90}P_{60}K_{30}$	47.64	49.27	19.75	20.85	258.35	259.52
F_4– 10 t FYM/ha	48.18	49.48	19.13	20.11	264.79	270.15
F_5– $N_{60}P_{40}K_{20}$ + 5 t FYM/ha	48.06	49.55	20.16	21.13	267.84	272.87
S.E. (±)	0.590	0.538	0.566	0.568	11.23	11.64
C.D. (P=0.05))	1.204	1.100	1.156	1.159	22.93	23.76
Interaction (S x F)						
S.E. (±)	1.021	0.933	1.160	1.157	19.452	20.153
C.D. (P=0.05))	NS	NS	NS	NS	NS	NS

NS-Non significant

Table 2 : Effect of spacing and various sources and rates of nutrients on number of roots, root length (cm) number of flowers/plant of *E. prostrata* L.

Treatments	No of roots		Root length (cm)		No. of flowers	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Spacing						
S_1- 20 cm x 20 cm	69.70	70.36	16.61	16.98	71.97	72.93
S_2 - 25 cm x 25 cm	76.75	77.39	17.94	18.43	78.21	79.84
S_3 - 30 cm x 30 cm	77.08	77.74	18.67	19.07	76.06	77.24
S.E. (±)	1.30	1.30	0.30	0.29	1.45	1.52
C.D. (P=0.05)	3.61	3.60	0.85	0.80	4.01	4.21
Doses of nutrients						
$F_0 – N_0P_0K_0$	62.87	63.49	13.07	13.43	49.56	50.84
$F_1 – N_{30}P_{20}K_{10}$	71.89	72.58	17.21	17.59	63.52	64.23
$F_2 – N_{60}P_{40}K_{20}$	73.37	74.02	17.76	18.00	69.56	71.11
$F_3– N_{90}P_{60}K_{30}$	78.28	78.91	18.95	19.54	85.04	86.82
$F_4–$ 10 t FYM/ha	78.96	79.60	19.47	19.97	90.13	91.84
$F_5– N_{60}P_{40}K_{20}$ + 5 t FYM/ha	81.70	82.38	20.00	20.43	92.07	93.58
S.E. (±)	1.86	2.01	0.58	0.73	3.93	3.85
C.D. (P=0.05)	3.80	4.10	1.19	1.49	8.03	7.85
Interaction (S x F)						
S.E. (±)	3.226	3.478	1.01	1.27	6.81	6.66
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS-Non significant

and they remained at par with 25 x 25 cm spacing, but proved statistically superior to 20 x 20 cm spacing treatment. The superior results of growth in wider spacing might be due to the fact that wider spacing provides more light for photosynthesis and less competition for nutrients, water and space. Maurya (2005) also reported the superior growth characteristics in wider spaced crop cultivation.

Scanning the data it was observed that various sources and rates of nutrient also brought about significant variation on growth characteristics. All the nutrient management practices produced statistically superior growth characteristics to control *i.e.* no nutrient applied treatment indicating better availability and utilization of plant nutrients in nutrient applied plots. Balakumbahan *et al.* (2005) also reported the superior growth and yield characters through nutrient management against control. Integration of $N_{60}P_{40}K_{20}$ + 5 t FYM/ha treatment showed the maximum values of growth characteristics *viz.,* tallest plant height (48.06 and 49.55 cm), maximum number of primary branches (20.16 and 21.13), maximum number of roots/plant (81.70 and 82.38) and root length (20.00 and 20.43 cm) in both the years, respectively, which showed statistically at par with the treatments $N_{90}P_{60}K_{30}$ and 10 t FYM/ha and proved superior to other nutrient applied treatments *viz.,* $N_{30}P_{20}K_{10}$ and $N_{60}P_{40}K_{20.}$ Regarding number of leaves the same treatment $N_{60}P_{40}K_{20}$ + 5 t FYM/ha produced maximum leaf number (267.84 and 272.87) and at par with all the nutrient applied treatments except the lowest doses of NPK *i.e.* $N_{30}P_{20}K_{10}$ treatment. These superior results could be attributed to the fact that after proper decomposition and mineralization, the farmyard manure supplied adequate quantity of available nutrient along with higher doses of fertilizer directly to the plant and also had solubulizing effect on fixed form of nutrients in soil. Such observation was also made by Singh and Ramesh (2002).

Reproductive parameters:

Study of data on number of flowers and heads per plant coinciding flowering and maturity stages (Table 2 and 3) revealed effectivity of spacing 25 x 25 cm which produced maximum number of flowers (78.21 and 79.84) and heads (76.16 and 77.81) in both the years, respectively, though it was statistically at par with spacing 30 x 30 cm but proved statistically superior to the closest spacing 20 x 20 cm. This might be due to superior performance of vegetative characters in wider spacing of bhringaraj cultivation than closer spacing. This result is also in conformity with the findings of Singh and Chauhan (2001).

Production of flowers and heads were statistically higher in all nutrient applied treatments than control. Markedly increased flowers and heads due to

Table 3 : Effect of spacing and various sources and rates of nutrients on number of heads/plant, fresh and dried herb yield (q/ha) of *E. prostrata* L.

Treatments	No of heads/plant		Fresh herb yield (q/ha)		Dried herb yield (q/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Spacing						
S_1- 20 cm x 20 cm	65.72	66.81	182.78	183.80	25.14	24.71
S_2 - 25 cm x 25 cm	76.16	77.81	187.60	188.57	28.37	28.82
S_3 - 30 cm x 30 cm	72.40	73.73	186.22	187.27	28.29	28.67
S.E. (±)	1.54	1.48	1.172	1.187	0.801	0.658
C.D. (P=0.05)	4.28	4.10	3.253	3.294	2.224	1.827
Doses of nutrients						
$F_0 – N_0P_0K_0$	54.75	55.82	148.08	148.91	17.31	17.44
$F_1 – N_{30}P_{20}K_{10}$	65.62	66.71	184.14	185.18	26.84	26.77
$F_2 – N_{60}P_{40}K_{20}$	69.33	70.64	193.47	194.47	27.62	27.51
$F_3– N_{90}P_{60}K_{30}$	77.50	78.85	195.90	197.00	31.25	31.38
F_4– 10 t FYM/ha	79.03	80.70	194.52	195.58	27.65	28.19
$F_5– N_{60}P_{40}K_{20}$ + 5 t FYM/ha	82.35	83.99	197.08	198.13	32.93	33.20
S.E. (±)	3.75	3.99	1.970	1.949	0.886	0.913
C.D. (P=0.05)	7.66	8.16	4.023	3.979	1.809	1.864
Interaction (S x F)						
S.E. (±)	6.50	6.92	3.41	3.38	1.53	1.58
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS-Non significant

incorporation of higher rates of N, P and K either through fertilizer ($N_{90}P_{60}K_{30}$) or integrated with organic manure ($N_{60}P_{40}K_{20}$ + 5 t FYM/ha) or organic manure alone (10t/ha FYM) were statistically at par among these three treatments were recorded superior to other two lower rates of N, P and K *viz.* $N_{60}P_{40}K_{20}$ and $N_{30}P_{20}K_{10}$. Adequate amount of available nutrients through out the plant growth period with out any nutrient stress brought about proper growth and development of plant in respect of plant height, number of branches, number of leaves/plant and thus proved responsible for higher production of number of flowers and heads per plant. The significant effect of nutrient management treatment on number of flower and head has been reported by Kavitha and Vadivel (2006) on *Mucuna pruriens* cultivation.

Fresh and dried herb yield:

The outcome of the investigation (Table 3) revealed that the maximum fresh herb yield of 187.60 and 188.57 q/ha and dried herb yield 28.37 and 28.82 q/ha were recorded due to 25 x 25 cm spacing followed by 30 x 30 cm spacing in both the years 2005-06 and 2006-07, respectively. Though these two treatments were statistically similar but established their significant superiority over closer spacing 20 x 20 cm. The increased fresh and dry herb yield in wider spacing treatments was mainly because of proper vegetative growth and development due to less competition for inputs as well as better availability of resources like solar radiation, light intensity, soil nutrient, and water etc. The increase in yield due to higher spacing was earlier reported by Sarma and Kanjilal (2000) on Patchouli cultivation.

All the nutrient management treatments produced significantly more herb yield than control *i.e.* no nutrient applied treatment indicating better availability and utilization of plant nutrients in nutrient applied plots. Among the nutrient management treatments, application of FYM either alone or in combination with fertilizer and highest doses of fertilizer ($N_{90}P_{60}K_{30}$) applied treatments recorded superior herb yield than lower doses of fertilizer applied treatments. It is well established that nitrogen is a main constituent of chlorophyll and involved in various important metabolic activities like photosynthesis and protein synthesis bringing about increased vegetative growth along with fresh yield production at higher nutrient concentration (Potti and Arora, 1986). Higher doses of phosphorus played key role in root development, energy transformation and many other metabolic processes of plants. Its ample availability at successive growth stages perhaps resulted in greater synthesis and translocation of photosynthates (Tisdale *et al.*, 1995). Adequate availability of photosynthates as well as energy conservation is one well

known factors directly related with higher biomass yield of crop (Hedge and Srinivas, 1989). These might be the possible reasons for superior yield in higher rate of fertilizer applied treatment. On the other hand, increase herb yield under FYM application either alone or in combination with fertilizer might be the fact that addition of organic manure lower downed the soil bulk density, improved soil aggregation and aeration by adding organic amendments and various humic fractions (Kadalli *et al.,* 2000) which increased the soil microbial and enzymatic activity due to combination of farmyard manure with inorganic fertilizer (Mukharjee *et al.*, 2000). Though the treatments $N_{90}P_{60}K_{30}$ and $N_{60}P_{40}K_{20}$ + 5 t FYM/ha were at par on dried herb yield but regarding fresh herb yield the treatments $N_{90}P_{60}K_{30,}$ $N_{60}P_{40}K_{20}$ + 5 t FYM/ha, $N_{60}P_{40}K_{20}$ and 10tha FYM were proved at par which may be due to variation of dry matter production.

Residual soil properties:

Data on residual soil properties (Table 4) revealed that 20 x 20 cm spacing recorded highest available soil N (280.033 and 276.029 kg/ha in both the years, respectively) after harvest of crop. Though it remained statistically similar with 30 x 30 cm spacing but proved superior to 25 x 25 cm spacing. This might be due to more uptake of soil nitrogen by crop under 25 x 25 cm spacing. No significant effect on P, K and soil organic carbon was recorded among the various spacing treatments.

Application of FYM either alone or integrated with NPK showed the highest available nitrogen in soil, which proved superior to other inorganic fertilizer applied treatments. It might be due to the fact that application of organics alone or in combination with fertilizer which after subsequent decomposition resulted in gradual build up in available nitrogen on account of direct addition of nitrogen. Effectivity of soil micro organisms also increased in FYM applied treatments which increased mineralization of organically bound nitrogen to inorganic form (Mathur, 1997). Application of organics also resulted higher availability of P and K over direct addition through inorganic sources, which might be due the fact that organic materials form a cover on sesquioxides, reducing the phosphate fixing capacity of soil and solubilization of insoluble phosphorus fractions resulting into release of more available phosphorus. Higher availability of potash in soil due to organic could be ascribed to addition of potash to the available pool of soil, besides reduction in potash fixation and release of potash due to interaction of organic matter and clay (Sanwal *et al.*, 2007). Application of FYM @ 10 t/ha or integrated treatments recorded the highest soil organic carbon content than only inorganic fertilizer applied treatments. This might be due to addition of more carbonaceous materials in soil through farm yard manure. Kalita and Deka (2001) also reported

Table 4 : Effect of spacing and various sources and rates of nutrients on residual soil properties

Treatments	Available N		Available P_2O_5		Available K_2O		Organic carbon	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Spacing								
S_1- 20 x 20 cm	280.033	276.029	27.639	23.833	80.121	76.131	0.694	0.676
S_2 - 25 x 25 cm	277.892	274.030	27.499	23.473	79.968	75.826	0.689	0.672
S_3 - 30 x 30 cm	279.064	275.591	27.741	23.980	79.156	75.146	0.686	0.671
S.E. (±)	0.362	0.533	0.119	0.192	0.481	0.530	0.005	0.005
C.D. (P=0.05)	1.004	1.480	NS	NS	NS	NS	NS	NS
Doses of nutrient								
$F_0 – N_0P_0K_0$	263.689	259.817	18.690	15.441	74.401	70.444	0.648	0.631
$F_1 – N_{30}P_{20}K_{10}$	277.588	273.833	27.869	23.987	79.024	75.181	0.684	0.668
$F_2 – N_{60}P_{40}K_{20}$	277.879	273.883	28.538	24.683	79.518	75.324	0.679	0.666
$F_3– N_{90}P_{60}K_{30}$	279.252	275.448	28.707	24.592	79.852	75.800	0.683	0.671
F_4– 10 t FYM/ha	288.210	284.474	30.753	26.830	83.023	78.898	0.726	0.706
$F_5– N_{60}P_{40}K_{20}$ + 5 t FYM/ha	287.359	283.844	31.201	27.040	82.670	78.557	0.719	0.698
S.E. (±)	0.829	0.887	0.414	0.518	0.361	0.369	0.004	0.005
C.D. (P=0.05)	1.693	1.810	0.846	1.057	0.738	0.753	0.009	0.009
Interaction (SxF)								
S.E. (±)	1.436	1.535	0.718	0.896	0.626	0.639	0.008	0.008
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

NS-Non significant

the significant increase in organic carbon content of soil due to application of different organic sources of nutrient than chemical fertilizer.

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