parents 2 and 3 mainly contributed for the increase in yield.

The important yield components viz. number of roots (Fig. 1 b), length of root (Fig. 1 c) and mean weight of root (Fig 1e,) also exhibit overdominance. The proportion of dominant genes was higher in arrays 4 and 1 for number of roots, in 3 for length of root and in 1, 2 and 6 for mean weight of root. The parents 2 and 6 ; 5,4 and 6 and 5 respectively possessed most of the recessive genes with regard to these characters. However, the standardised deviation graphs showed that the recessive genes in array 6 for number of roots and length of root were positive while the dominant genes in arrays 1 and 6 for mean weight of root functioned in the negative direction (Fig. 2e). Of all the yield components, only girth of root showed partial dominance (Fig. 1d). For this traits, the proportion of dominant genes is maximum in array 3 and they are positive in nature (Fig.2d).

The study on standardised deviations showed that the parent 3 possessed dominant genes having positive effects for all the traits.

Combining ability analysis in cassava (Easwari Amma *et al.*, 1995) also revealed P3 as the best general combiner for root yield. The parents 5 and 2 had higher proportion of genes having positive effects irrespective of whether they are dominant or recessive in nature. In general, the parents 5, 3 and 2 are better than the other inbred lines.

The present study revealed the predominance of non-additive gene action emphasizing the role of overdominance in the expression of yield and its components in cassava. Therefore, crop improvement in cassava through a hybrid breeding programme to exploit heterosis would be a paying prospective. With respect to the choice of parents inclusion of inbred parents P2, P3 and P5 appears to be beneficial.

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BIOMASS PRODUCTION AND NITROGEN ACCUMULATION OF VELVET BEANS, SUNNHEMP AND PILLIPESARA AS INFLUENCED BY PLANT DENSITY AND PHOSPHORUS APPLICATION

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ABSTRACT

Field experiments were conducted at Tamil Nadu Agricultural University during the NEM season of 1993-94 and SWM season of 1994 to study the effect of different spacings and phosphorus application on biomass production and nitrogen (N) accumulation of three green manure crops, pillipesara, sunnhemp and velvet beans. Velvet beans produced the highest biomass of 27.6 t/ha in the SWM season followed by Sunnhemp and pillipesara. Biomass production and N accumulation were higher at closer spacing (30x20cm). Application of 50 kg P_2O_5/ha significantly increased the growth of all the three crops. Interaction between spacing and P levels was significant and highest biomass (10.0, 11.2 and 35.9 t/ha for pillipesara, sunnhemp and velvet beans respectively) was achieved in the treatment combination of 50 kg P_2O_5/ha and closer spacing (30 x 20 cm). Velvet beans and sunnhemp produced higher biomass in SWM season (27.6 and 10.1 t/ha) while NEM season was more favourable for pillipesara (8.5 t/ha).

KEY WORDS : Velvet beans, sunnhemp, pillipesara, biomass, N accumulation

Green manuring is a cheap alternative to the use of fertilizer N. The effectiveness of green manure is related to its biomass production and ability to accumulate higher amounts of N within a short period of time. Moreover effective stand establishment is important for maximising yield of crops. Ability for leguminous plants to utilize applied P is rather strong. Also velet beans, an important forage legume, has not yet been evaluated for its green manurial value. Hence this study was taken up to evaluate three green manure crops for their biomass production and N accumulation under varying plant densities and phosphorus levels.

MATERIALS AND METHODS

Field experiments were conducted at the Tamil Nadu Agricultural University, Coimbatore (11° N and 77° E) on three green manure crops *viz.*, pillipesara (*phaseolus trilobus*). Sunnhemp (*Crotolaria juncea*) and velvet beans (*Stizolobium deeringianum*) during the north-east monsoon season (NEM) of 1993-94 and south-west monsoon season (SWM) of 1994 under irrigated condition. Soil of the experimental field was clay loam with pH 7.5, EC 0.2 dS/m, low in available N (236.4 kg N/ha), medium in available P (14.7 kg/ha) and high in available K (616.5 kg/ha). The experiment was laid out in a split plot design with three replications.

The treatments consisted of three green manure species and three levels of spacing (30x20 cm, 45x20 cm and 60x20 cm) as main plot treatments and three levels of phosphorus (0,25 and 50 kg P_2O_5/ha) as subplot treatments. Statistical analysis was performed for each crop separately by following the method for simple single factor split plot design. The seeds were treated with peat-based cowpea type rhizobial culture before sowing. A common dose of 10 kg N/ha was applied to all the plots in the form of urea (46 per cent N). Potassium fertilization was not done. The population was maintained as per the treatments.

RESULTS AND DISCUSSION

Performance of green manures in biomass and N accumulation

In the present study, among the green manures tested, velvet beans produced the maximum biomass of 27.6 t/ha in 60 days in SWM season followed by Sunnhemp (10.1 t/ha) and pillipesara (8.5 t/ha) (Table 1). Velvet beans accumulated higher biomass due to its inherent vigorous growth habit, trailing nature, production of more vines, larger and thicker leaflets, hard stem and well developed root system and better canopy development. Pillipesara produced the least biomass due to short stature of crop, production of less number of primary branches, smaller leaves and its slow growth especially in the initial stages. Velvet beans accumulated more nitrogen (255 kg N/ha) in 60 days compared to other two crops. The N accumulation is a function of dry matter accumulated and N concentration in dry matter. The N content in velvet beans and pillipesara was the same but due to better growth habit and higher dry matter production, velvet beans accumulated more nitrogen (Table 1).

Effect of plant density

Accommodation of more plants per unit area increased the fresh biomass production appreciably in all the three crops. In all the three crops, higher plant population at 1.67 lakh plants/ha recorded more biomass than 1.11 and 0.83 lakh plants/ha in both the season. Increased plant density led to earlier canopy coverage, better crop stand and thus higher biomass accumulation. This could be attributed to more number of plants per unit area, production of more number of leaves and enhanced plant height compared to lower population levels (Table 2). Similar findings were obtained in *Sesbania rostrata* (Halepyati and Sheelavantar, 1991). Increase in number of plants per unit area lead to effective utilization of available space, light, CO_2, water and nutrients. So a greater amount of available resources was harnessed, thereby increased the biomass and N accumulation of green manures. High density recorded higher N accumulation compared to low and medium densities. The results are in line with those obtained by St Macary *et al.* (1985).

Effect of phosphorus application

Enhancing the level of P application to 50 kg/ha significantly increased the fresh biomass and N accumulation at all stages of growth in all the three crops in both seasons of study. This is

Table 1. Fresh biomass production (t/ha) and N accumulation of green manures at 60 DAS

Treatment	BMP (t/ha)						DMP (t/ha)						Nitrogen accumulation (kg/ha)					
	Pillipesara		Sunnhemp		Velvet beans		Pillipesara		Sunnhemp		Velvet beans		Pillipesara		Sunnhemp		Velvet beans	
	SWM	NEM	SWM	NEM	SWM	NEM	SWM	NEM	SWM	NEM	SWM	NEM	SWM	NEM	SWM	NEM	SWM	NEM
S_1	5.4	8.5	10.1	8 9	27.6	20.5	1.3	1.9	1.75	1.78	8.93	5.39	44.3	62.3	57.5	65.2	240.0	238.7
S_2	4.4	5 6	9.1	7.8	20.3	14.9	1.2	1.4	1.67	1.65	7.54	4.73	39.6	53.3	55.2	63.9	239.8	193.8
S_3	4 0	4.7	7.7	6.1	14.7	10.9	1.1	1.2	1.56	1.44	4.97	4.27	33.8	51.4	53.8	59.9	185.3	196.4
SEd	0.33	0.18	0.33	0.26	1.18	1.08	0.03	0.04	0.04	0.01	0.20	0.11	1.72	1.21	1.61	1.29	5.84	3.14
CD	0 92	0 50	0.91	0.72	3.28	2.99	0.07	0.11	0.11	0.04	0.56	0.30	4.77	3.37	4.46	3.59	16.20	8.71
P_0	3 6	4 9	7.3	6.6	15.5	13.3	1.0	1.4	1.47	1.52	5.82	4.23	34.1	45.0	47.8	57.9	180.1	172.0
P_1	4.6	6.2	9.2	7.2	21.5	14.9	1.2	1.5	1.71	1.61	7.29	4.87	40.3	53.2	57.1	63.8	229.4	219.1
P_2	5 5	7 6	10.2	9.1	25.8	18.2	1.4	1.7	1.81	1.74	8.32	5.53	43.5	68.7	61.6	67.3	255.8	238.1
SEd	0.19	0 17	0.19	0 28	0 72	0.67	0.04	0.03	0.02	0.02	0.32	0.09	1.41	2.07	0.96	1.14	7.01	4.90
CD	0.40	0.37	0.41	0.61	1.58	1.45	0.08	0.06	0.05	0.04	0.70	0.21	3.07	4.50	2.08	2.48	15.27	10.68

S_1 - 30 x 20 cm ; S_2 - 45 x 20 cm ; S_3 - 60 x 20 cm ; P_0 : 0 kg P_2O_5/ha ; P_1 : 25 kg P_2O_5/ha ; P_2 : 50 kg P_2O_5/ha

Table 2. Effect of plant density and phosphorus on plant height of green manures at different stages

Treat-ment	Pillipesara						Sunnhemp						Velvet beans					
	SWM			NEM			SWM			NEM			SWM			NEM		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
S_1	23.4	41.0	54.9	24.2	43.8	64.2	60.2	112.2	153.7	57.8	90.7	130.6	38.1	62.2	83.0	30.9	57.8	75.9
S_2	22.3	34.8	47.7	22.2	41.4	62.4	55.5	102.9	151.7	54.7	87.6	126.3	36.8	58.7	74.7	28.6	56.2	74.8
S_3	19.4	32.4	44.0	20.3	35.8	55.3	52.5	96.0	146.4	51.9	81.5	121.5	36.0	57.4	77.6	27.21	54.6	72.9
SEd	0.38	0.39	0.62	0.82	0.73	0.08	0.49	0.48	0.72	0.58	0.57	0.47	0.43	0.42	0.25	0.29	0.40	0.32
CD at 5%	1.06	1.09	1.72	2.24	2.01	0.22	1.38	1.34	1.99	1.61	1.58	1.30	1.20	1.17	0.69	0.82	1.11	0.88
P_0	19.6	33.7	46.7	20.6	37.2	57.7	53.19	100.8	147.5	53.3	82.6	125.1	35.5	58.0	78.3	27.3	54.8	71.8
P_1	21.1	36.3	48.2	22.3	40.2	60.7	56.4	103.9	150.2	54.9	85.8	127.2	36.9	59.0	79.9	28.3	55.7	74.3
P_2	24.3	38.2	51.8	23.7	43.6	63.5	58.5	106.5	153.8	56.1	91.3	130.0	38.5	61.2	82.1	31.1	58.2	77.6
SEd	0.52	0.48	0.41	0.90	0.63	0.31	0.55	0.35	0.62	0.37	0.89	0.36	0.30	0.47	0.29	0.32	0.43	0.37
CD at 5%	1.13	1.04	0.88	1.97	1.37	0.69	1.19	0.76	1.34	0.81	1.93	0.79	0.66	1.02	0.63	0.70	0.94	0.80

Table 3. Interaction effect of spacing and P levels on biomass production (t/ha) 60 DAS

Spacing	CROP											
	Pillipesara(NEM)				Sunnhemp (NEM)				Velvet beans(SWM)			
	P_0	P_1	P_2	Mean	P_0	P_1	P_2	Mean	P_0	P_1	P_2	Mean
S_1	7.2	8.4	10.0	8.5	7.4	8.2	11.2	8.9	18.1	29.1	35.9	27.6
S_2	4.1	5.5	7.3	5.6	7.0	7.3	9.3	7.8	15.9	20.7	24.4	20.3
S_3	3.6	4.8	5.5	4.7	5.4	6.3	6.7	6.1	12.3	14.7	17.0	14.7
Mean	4.9	6.2	7.6		6.6	7.2	9.1		15.5	21.5	25.8	
	S	P	Pat S	Sat P	S	P	Pat S	Sat P	S	P	Pat S	Sat P
SEd	0.18	0.17	0.29	0.29	0.26	0.28	0.48	0.47	1.18	0.72	1.56	1.25
CD (5%)	0.50	0.37	0.64	0.72	0.72	0.61	1.05	1.11	3.28	1.58	3.94	2.73

attributed to better root development, rapid and vigorous start and improved plant metabolism and higher N content due to application of P. Application of P to leguminous green manure crops has been shown to stimulate N fixation, increase biomass production and N and P content of plants (Sanyasi Raju, 1952 ; Chen, 1988). P application increased the Nitrogen accumulation in velvet beans at 60 DAS by 42 and 38 per cent during SWM and NEM seasons respectively. Similar effect was also observed in Sunnhemp and pillipesara. Higher N accumulation due to application of P has been observed earlier (Anon., 1987 ; Balasubramani and Kannaiyan, 1991).

Effect of season

Weather parameters played an important role in the biomass production of green manure crops. Both sunnhemp and velvet beans accumulated more biomass during SWM season. Longer the day length during vegetative phase greater is the biomass production. During short day season, vegetative growth is retarded by early flowering and growth is very much restricted. Thus biomass and N yield were poor during NEM season. Pillipesara performed better in the NEM season.

Interaction effect of spacing and P level on growth

Crop production system abounds in interactions between nutrients and other inputs. In this study the interaction between spacing and P levels was significant for the three crops at 60 DAS and highest biomass was achieved in the treatment combination of 50 kg P_2O_5/ha and closer spacing (30x20 cm) (Table 3). Higher plant density of green manure crops could be gainfully adopted if it is accompanied by adequate P application. Application of 50 kg P_2O_5/ha itself would create a better nutritional environment. But the combination of higher plant density and P level was more beneficial than their individual effects.

Thus it can be concluded that in terms of biomass production and N accumulation velvet beans performed the best followed by sunnhemp and pillipesara. Higher the plant density, higher is the biomass production irrespective of crops and season. The spacing recommended for higher biomass production and N accumulation is 30 x 20 cm. Application of 50 kg P_2O_5/ha significantly increased the growth of all the three crops. The treatment combination of closer spacing (30 x 20 cm) and 50 kg P_2O_5/ha accumulated higher biomass and nitrogen.

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