INTERCROPPING, PLANT DENSITY AND YIELD COMPONENTS ON PROTEIN AND OIL YIELD OF SOYBEAN

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SUMMARY

The potential for N_2 fixation, protein and soil synthesis, is discussed in light of factors which lead to their variability i.e. (spacement and intercropping).

Nodule biomass at 21 days after planting, flowering and pod hardening phases did not differ significantly between treatments, although it increased in mixtures with increase in population. There was a decrease in nodule biomass at the pod hardening stage and is attributed to high rainfall, low soil temperature and sink strength at this phase.

Plant diversity and population had a great influence on the number of nodules and the pattern of growth. Growth pattern of nodules, root length increased with reduction in plant population. This in turn influenced N_2 fixation.

The oil and protein content was the same for both LD and ND but slightly lower for HD. Protein in monoculture was 44% with a slight decrease at HD (10.93%). Similar trend was true for mixtures but with slightly lower value of (38.25) for high density mixtures.

Monoculture soybeans recorded an average of 18% of oil and 17% for HD. Similarly mixtures recorded 18 - 16% (L-H).

The values recorded in this study for both protein and oil fall with values of (30 - 40%) and (15 - 22%) of those

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recorded in the US. It is concluded that soybean can be used in Kenya as a basis for livestock feed, and oil for food and industrial use.

INTRODUCTION

There are several reasons advanced for intercropping legumes and non legumes. Among these are; legumes may fix atmospheric nitrogen which would be available for non legume because of addition of nitrogen to the soil. The extent to which competition for light, moisture and nutrients in crop mixtures affect N_2fixation, protein and oil synthesis is not known precisely. Wahua and Miller (1978) reported little influence on soybean seed per cent protein and oil insoybean intercropped with dwarf sorghum, although he noted that adverse environmenta conditions in mixtures reduced protein synthesis and vegetative growth in intercropped grasses. Most tall cereals shade associated legumes and shading has been shown to reduce soybean photosynthesis (Johnson et al 1969) and consequently N_2 fixation (Mann and Jaworski 1970).

Influence of row width and plant density on soybean (Glycine Max (L) Merr) yield in monoculture have been studied extensively (Herbert and Litchfield, 1982). Seed yield increase when row spacing is narrowed from the traditional wide spacing of 90 to 102 cm to row width of 25cm or less in U.S. has been reported by Pendleton and Hartning (1973); Cooper (1977). Taylor (1980) noted that varying the intensity of competition associated with differing row spacing and plant density changed plant morphology and reproductive potential. Similarly plants at higher densities were taller, had fewer branches and lodged more than low densities (Weber et al, 1966).

About 17 per cent of the total energy stored by the soybean plant is used for oil synthesis and only 12 per cent for protein synthesis (Howel, 1962). Thus under a situation of low energy supply, oil content should be more affected than protein. Furthermore efficient use of Rhizobium - dependent symbiotic N_2 fixation and the N_2 so gained, are vital to the economics of seed protein and oil production and assume increased importance where, as in Kenya, grain legumes are used for improving soil nitrogen fertility with cereal combinations. Improvement of the potential for N_2 fixation, protein and oil synthesis depends on understanding the factors which lead to their variability and control. Thus, the purpose of the work reported here was to investigate the influence of intercropping and density on nitrogen fixation, yield components, seed yield and seed so oil, and protein percentages.

MATERIALS AND METHODS

The experiment was conducted on the botanical garden of the University of Nairobi during the 1982 short rains. The soils of the site are described as humic nitosol (FAO, UNESCO 1974). Some of the characteristics of the soil are given in Table L. Only single superphosphate at the rate of 45Kg/ha.

Sorghum (Serena Var) and soybean (Bossier Var) were grown in pure stands and two species mixtures at a population ratio of 1:1 at three densities designated as Low density (LD), Normal density (ND) and High density(HD) each with a plant density of 66,666; 83,333; and 111,111 respectively.

The design was a split plot with the density as main plots (8m x 5m) and the cropping system as the subplots (4m x 5m) with four replications. Each subplot was planted with either monoculture and mixed culture of the two crops and was surrounded by 75cm boarder of bare earth.

The cereal seeds were sown 3 - 5 seeds/hole and spaced at 75 cm x 20cm, 60cm x 20cm and 45cm x 20cm. The legume seeds were sown 2-3 per hole at similar spacing. After one week the plants were thinned to two plants per hole for sorghum. All other agronomic practices were kept at the optimum level.

Plant growth and yield attributes were taken at the appropriate time. This included plant height, number of pods, nodule number, internode lenghth, weight of pods, number of branches. At some sensiti stages (Table 2) nodule mass, and light penetration were assessed. Finally grain yield, land equivalent ratio, relative yield of the soybean in mono and mixed culture. Nitrogen fixation was estimated from the colour of the 100 nodules. Red nodules were considered as fixing nitrogen, while green ones were not fixing. Percentage seed protein content was determined from total Kjeldal nitrogen. Oil was Soxhlet extracted using n - Hexane as the solvent for 12 hours. Dehydration with magnessium sulphate and filtration was followed by evaporative removal of the solvent in Vacuo (Water aspirator) from a tared 100ml round-bottomed flask. The contents in the flask were subjected to further evacuation overnight with concomitant heating in warm water to remove last traces of hexane before fianl weight was determined. The refractive indices of the samples were determined using Abbe - refractometer in order to establish the efficiency and purity of the oil extracted using n-hexane.

RESULTS AND DISCUSSIONS

Figure 1 shows light penetration and the canopy structure as influenced by intercropping and plant density. The canopy structure was assessed by determination of plant height. The height of both crops in monoculture and mixed culture, increased with density and then decreased, whereaslilight penetration decreased with increasing plant population in both cropping systems.

The influence of intercropping, plant density on nitrogen fixation, yield and yield components, percentage seed yield of oil and protein is shown in Table 1. The pattern of number of branches in monocrop and mixed soybeans was opposite of each other. In Monocrops, increasing plant population increased the number of branches per plant. Contrarily the lowest number of branches were recorded for beans in mixtures at the highest population. Generally number of defective pods/plant increased with increase in population in both cropping system. The number of defective pods/plant appear to have less influence on the final yield of the soybean (Table 1). Although the highest value of defective pods was recorded in high densities, yield increased with increasing plant population contrary to what would be expected if the parameter was affecting yield. The effect of increasing plant density has been variable. Dominguez and Hume (1978) reported an increase in yield of early maturing cultivars with increasing plant population. The seed yield advantage of more uniform spacial arrangement of plants achieved with narrow rows has been associated with greater number of pods per plant (Lehman & Lambert, 1960), whereas Weber et al (1966) reported thatt the effects of increasing plant density was to reduce pod number per plant, thereby increasing the seed weight, since increase in population increased number of branches in monocrops, this might counterbalance the increasing defective pods with an increase in plant population. Low recorded number of branches for less dense populations in mixture, and the increase in hyield at higher populations may be attributed to the number of plants per unit area of land. This is exemplified by the pattern of pod weight.

Symbiotic N_2 fixation by legume - Rhizobium association is the end result of complex biochemical, metabolic and physical interactions between the host plant and the microsymbiont. To maximize symbiotic N_2 fixation efficiency in both, symbionts must interact and complement each other. The efficiency of N_2 fixation was assessed by nodule mass at 21 days after planting (DAP), at flowering and at pod hardening It was shown that biomass in moncrop of soybean did not differ significantly between treatments at 21 (DAP) which is a period before the onset of competition among plants. The increase in nodule biomass in the mixture at this stage with increasing plant density may be attributed to overall physical conditions within these treatments. At pod hardening phase, lower nodule biomass was noted (Table 1). This is indicative of the deteriation in the nitrogen fixation due to competition of the pods.

Intactness of nodules per plant was also used to demonstrate the efficiency of the N_2 fixation at the various phases. The growth pattern of the nodules along the entire root length varied wkit with plant population. It increased with reduction in population. Root length was highest in high densities in both cropping systems. This partly explains the results for percentage N_2 fixation (Table 1) measured at the flowering stage. It is apparent from the results presented that the populations and cropping system are not detrimental to N_2 fixation nor does it affect protein or oil synthesis. Although at the highest densities there was a reduction in both constituents, the percentage contents were about the same for low and normal planting density. The values recorded for protein of 38 to 44% computed from total nitrogen and ofor oil 16 to 18% fall within the same values recorded in the U.S.A. (30 - 40) and (15 - 22) respectively. Increasing plant population increased land equivalent ratio and did not affect relative yields of soybean in higher densities. Based on the results presented in this paper, soybean appears promising in Kenya as a basis for protein and oil in human, industrial and livestock feed since yield, protein and oil levels are comparable to those of the crop from parts of the jworld where it is economically important. Furthermore, the fact that these constituents are not affected by intercropping with taller cereal plants augurs well for its promotion amongst small scale farmers who usually have limited space.

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Table 2: Growth characteristics, seed yield, yield components & N_2 fixation

		LD (66,66 Plant/ha)		ND (83,333 Plants/Ha)		HD (111,111 plants/ha)	
		B	B_S	B	B_S	B	B_S
Nodule Mass	21 (DAP)	0.91±0.18	0.61±0.17	1.1±0.206	0.65±0.13	0.56±0.17	0.87±0.075
	At flowering	5.34±0.96	3.72±2.39	5.4±2.155	4.31±2.71	4.97±1.96	5.15±2.05
	Pod hardening phase	2.67±0.48	1.86±1.19	2.69±1.28	2.16±1.36	2.49±0.98	2.58±1.03
Nodule No/Plant		24.5±4.5	20.25±4.2	26.6±4.64	23.0±7.48	27.6±4.14	23.5±2.5
% N_2 Fixation/Plant		83.3±16.9	93.3±9.42	77.5±14.7	100±0	90±14.14	97.5±4.3
Growth Pattern	Root Length (cm)	23.96±3.08	22.42±2.9	22.46±2.4	22.21±3.11	25.5±1.68	21.54±0.7
	Nodule position (cm)	3.59±1.03	3.65±1.19	2.08±0.8	4.34±1.93	14.3±0.26	3.85±1.01
No. of branches/plant		2.0±0.5	2.5±0.35	1.88±0.22	0.38±0.74	3.0±0.35	2.25±0.56
No. of pods/plant		31.5±5.1	31.88±6.82	31.[illegible]5±5.37	35.5±1.8	34.38±4.94	32.38±2.33
No. of defective pods/plant		6.75±1.44	5.38±1.29	6.38±2.68	5.75±0.49	7.39±1.14	6.88±1.92
Weight of pods/plant		13.78±1.38	13.1±2.83	11.49±0.71	15.49±2.38	11.52±2.58	11.81±1.09
Internode length		2.99±0.25	2.70±1.41	2.65±0.16	2.61±0.15	3.86±1.39	3.11±0.16
Relative growth rate $(gwk^{-1} plant^{-1})$		0.315±0.103	0.205±0.112	0.316±0.85	2.67±0.034	0.333±0.062	0.194±0.032
Yields (Kg/Ha)		1045.3±234.1	526.7±212.6	1288±7.48	615.6±71.17	1855.4±103.3	897.3±132.0
Land equivalent ratio (LER)			0.494±0.142		0.479±0.055		0.601±0.112
Relative Yield%			50.39%		47.79%		48.36%
Oil%		18.20±0.13	18.01±0.28	18.24±0.07	18.25±0.20	17.03±0.31	16.64±0.26
Protein %		44.25±0.687	45.43±0.937	44.43±1.5	44.12±0.187	40.93±0.815	38.25±2.72

Table 1: Some characteristics of the site soils (0-15) and refractive indeces of n-hexene oil extract.

pH	C%	N%	P(ppm)	Ca Mg Meg/100G	Mg Meg/100g	K Meg/100g	CEC	CEC	Refractive Index				
								LD Mono	LD Mix	ND Mono	ND Mix	HD Mono	HD Mix
6.0	3.2	0.32	3.1	13.8	0.6	0.3	29.4	1.4745	1.4750	1.4749	1.4752	1.4752	1.4752