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FABA BEAN AND FIELD PEA SEED PROPORTION FOR INTERCROPPING SYSTEM IN HORRO HIGHLANDS OF WESTERN ETHIOPIA

TOLERA ABERA and DABA FEYISA
Oromia Agricultural Research Institute, Bako Agricultural Research Center,
P. O. Box 26, Bako, Western Oromia, Ethiopia

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ABSTRACT

Intercropping of Faba bean (*Vicia fabae*) and field pea (*Pisum sativum*) is an important cropping system in the Horro highlands of Ethiopia, but seed proportions balance is important to intercrop productivity. An experiment was conducted to determine the optimum seed rates on component crop yield and land equivalent ratio. Grain yield of both crops was higher when the relative seeding rate of Faba bean increased, while Faba bean yield was reduced with increase in the seeding rate of field pea. Seed proportions of Faba bean and field pea in the intercrop significantly ($P < 0.05$) affected grain yield of both crops. Intercropping of Faba bean and field pea at 75%: 25 % seed rate proportion gave higher grain yield and better marginal rate of return (1003%). Under intercropping Faba bean seed yield was reduced by 21 to 69% and 10 to 34%, for field pea. A maximum land use efficiency 0.53 or relative yield advantage of 53% was obtained from intercropping 75 Faba bean: 25% field pea. Superior productivity of the Faba bean/field pea was obtained from intercropping system. Growing Faba bean both as a sole crop and intercropping with field pea is a viable option for sustainable productivity in total grain yield and profit to farmers.

Key Words: Cropping system, LER, *Vicia fabae* and *Pisum sativum*

RÉSUMÉ

La culture mixte de haricot Faba (*Vicia fabae*) et petit pois (*Pisum sativum*) est un système cultural important dans les hautes terres Horro de l'Ethiopie, cependant l'équilibre des proportions de semences est aussi important pour la productivité en culture mixte. Une expérimentation avait été menée pour déterminer les taux optimal de semences sur les composant récoltes de culture et la proportion équivalente des terres. Le rendement en grain de ces deux cultures était plus élevé lorsque le taux relatif de semis de haricot Faba avait augmenté, tandis que le rendement de haricots Faba avait été réduite avec l'augmentation du taux de semis de petit pois. Les proportions de semences de haricots Faba et petit pois en association avaient significativement ($P < 0,05$) affecté le rendement en grain de ces deux cultures. La culture mixte de haricot Faba et les pois à une proportion des taux de semences de 75 % : 25 % avait produit un rendement élevé en grains et le meilleur taux marginal de retour (1003 %). En culture mixte le rendement en semences de haricots Faba a diminué de 21 à 69 % et de 10 à 34 % pour les pois. L'exploitation effective maximale de terre 0,53 ou un gain de 53 % en rendement relatif avait été obtenue à partir de la culture mixte de 75 haricot Faba: 25 % petit pois. Une productivité élevée de haricot Faba/petit pois avait été obtenue à partir du système de culture mixte. Produire le haricot Faba aussi bien comme culture unique que culture mixte avec le petit pois est une option viable pour la productivité durable pour un rendement total en grain et le bénéfique pour les agriculteurs.

*Mots Clé*s: Système de culture, LER, *Vicia fabae* et *Pisum sativum*

INTRODUCTION

Faba bean (*Vicia fabae*) and field pea (*pisum sativum*) are important food, cash and break crops in highlands of Ethiopia (Amare and Adamu, 1994). Faba bean and field pea have been commonly grown in association (Asfaw *et al*., 1997). Intercropping system particularly for morphologically different crops offers a potential for increasing productivity (Alemu *et al.*, 1984). In intercropping systems the productivity of component crops is affected by various factors, specifically seed rate proportion and plant pattern. The overall densities and relative proportions of the component crops are important in determining yield and production efficiency of species in the mixture (Willey and Osiru, 1972).

The seed proportion for the maximum yield advantage is rather difficult to predict since the competitive ability of the crops varies with plant population (Baker, 1981). In mixed cropping systems crop competition is controlled by the proportions and spatial arrangement of the crops, and growth habit of each crop species (Tolessa, 1997). Recommendations of seed rate for Faba bean and field pea are available sole cropping (Amare and Adamu, 1994). For mixed system of these crops Amare (1996) reported 75:25% Faba bean and field pea proportion to give higher grain yield and overall production efficiency in the centeral highland of Ethiopia. The study though lacked farmers' practices included as control treatments. Recommendations on optimum plant populations vary depending on the environmental condition where the crop is grown. There are no firm recommendations for optimum seed proportion in Faba bean and field pea intercropping system at Horro highlands. Therefore, the objective of this study was to determine the seed proportion of Faba bean and field pea in intercropping system for optimum grain yield.

MATERIALS AND METHODS

An experiment was conducted at Shambo Testing Site of the Horro highland in western Oromiya in Ethiopia, for three consecutive years (1997- 1999). The area lies between 9°34'N latitude and 37°06'E longitude and at 2400 metres above sea level. The mean annual rainfall is 1,695 mm (NMSA, 2003), having a cool humid climate with the mean minimum, mean maximum, and average air temperatures of 8.15, 15.72, and 11.94° C, respectively. The characteristics of the soil of the experimental area are described in Table 1.

The experiment was laid in randomised complete block design with four replications. The treatments were: 100% Faba bean, 100% field pea, 50% Faba bean and 50% field pea, 75% Faba bean and 25% field pea, 25% Faba bean and 75% field pea; and 6. farmers' local practices (82% Faba bean and 18% field pea). The recommended seed rate used were 200 kg ha^{-1} for Faba bean and 150 kg ha^{-1} for field pea. The varieties used were CS-20-DK and G-22763-2C for Faba bean and field pea, respectively. Both crops were planted simultaneously during 1997, 1998 and 1999 cropping seasons. All cultural practices were done as per the available research recommendation for Faba bean and field pea production.

Diammonium phosphate (DAP) at a rate of 100 kg ha^{-1} was applied at planting. Data were collected on pods $plant^{-1}$, seeds pod^{-1}, and grain yields kg ha^{-1} and analysed using MSTAT-C computer software. Mean separation was done using least significance difference (LSD) procedure at 5% probability level.

Land equivalent ratio (LER), partial budget, marginal rate of return and value to cost ratio analyses were employed to assess biological and economic efficiency of the different proportions. For economic analysis, Faba bean grain was valued at Ethiopian Birr (EB) 286 100 kg^{-1} and field pea grain at EB 350 100 kg^{-1}. The yield was adjusted down by 10 % to reflect actual production conditions (CIMMYT, 1988). The seed costs were EB 3.5 kg^{-1} and EB 4.5 kg^{-1} for Faba bean and field pea, respectively.

RESULTS AND DISCUSSION

Seed rate proportions significantly ($P < 0.05$) affected pods $plant^{-1}$ of Faba bean (Table 2). On the contrary, seed proportion treatment effects were not significant ($P>0.05$) for pods $plant^{-1}$ for field pea and seeds pod^{-1} for both crops (Table 2). The mean pods $plant^{-1}$ for Faba bean ranged from 5.3 to 7.2, and for field pea from 6.8 to 7.2. The seeds pod^{-1} for Faba bean ranged from 2.4 to

2.9 and for field pea from 3.3 to 3.9. Seed rate proportions significantly ($P < 0.05$) affected grain yield of both crops except field pea in 1998 (Table 2).

With increased proportion of field pea in the seed mixture, a decreasing trend in Faba bean yield was observed which might be attributed to climbing growth habit of field pea. Increasing the proportion of Faba bean to 75 % resulted in greater yields for both crops (Table 3). As the proportions of Faba bean seed was further increased, only Faba bean grain yield showed a trend of increment. The productivity of intercropping system was higher than sole crop of each component crop, which is in agreement with Willey (1979).

The combined grain yields across years averaged 669 and 475 kg ha^{-1} for Faba bean and field pea, respectively (Table 3). The mean grain yield of Faba bean yield varied greatly and more with years than did field pea (Table 3). A very low yield of Faba bean in 1997 could be attributed to shortage of rainfall during late flowering to pod setting. When averaged over years, relatively higher grain yield (695 and 491 kg ha^{-1}) of Faba bean and field pea were recorded in 1998 and 1999 cropping season (Table 3). The relatively high Faba bean yield in 1998 could presumably be attributed to the distribution of rainfall during the growing period as reported by Pfeiffer *et al* (2000) stated that amount and distribution of rainfall was the predominant factor influencing yield variability. Cropping season significantly ($P<0.05$) affected all parameters of component crops except seeds pod^{-1} of Faba bean.

Significant effect of seed rate proportions x year interaction was observed for grain yield and partial LER of Faba bean (Table 3 and 4). Interaction effects were not significant for pods $plant^{-1}$ and seeds pod^{-1} for both crops; and grain yield and partial LER for field pea (Table 3 and 4). The differences in grain yield of Faba bean across years could probably be related to rainfall patterns.

The combined grain yield of Faba bean and field pea in intercropping system was greater than field pea monoculture at all proportions (Table 3). Combined yield of the intercrops were negative to 132 kg ha^{-1} for Faba bean and 330 to 670 kg ha^{-1} higher than yield achieved by growing

TABLE 1. Soil characteristics of (Nitisols) of Shambo site

Texture				PH: H_2O	PH: KCl	T N (%)	Ca	Mg	K	Available P (ppm)	O C (%)	CEC (Meq/100)	C/N
Sand%	Silt %	Clay %	Class				Meq/100g soil						
22	36	42	C	5.2	4.0	0.343	2.41	2.14	0.74	3.9	3.272	26.58	10

TABLE 2. Effects of seed rate proportion on some agronomic parameters of faba bean and field pea in intercropping (1997-1999)

Treatment	Number of pods plant^{-1}		Number of seeds pod^{-1}	
	FB	FP	FB	FP
100% FB	7.2	-	2.7	-
100% FP	-	6.8	-	3.5
50% FB: 50% FP	5.6	7.2	2.4	3.5
25% FB: 75% FP	5.3	6.9	2.6	3.3
75% FB: 25% FP	6.6	7.2	2.9	3.9
Farmer practice (82% FB: 18% FP)	7.1	7.0	2.6	3.8
Mean	6.3	7.0	2.7	3.6
LSD (5%)	1.241	Ns	Ns	Ns
CV%	23.72	18.92	20.33	16.89

FB= Faba bean, FP= Field pea, Ns=non significant, Means followed by the same letter do not differ significantly at 5 % probability level in LSD

TABLE 3. Effects of seed rate proportion on grain yield (kg/ha) of faba bean and field pea in intercropping (1997-1999)

Treatment	Grain yield (kg ha^{-1})							
	1997		1998		1999		Mean	
	FB	FP	FB	FP	FB	FP	FB	FP
100% FB	1043	-	1102	-	1067	-	1071	-
100% FP	-	555	-	482	-	560	-	533
50% FB: 50% FP	319	459	420	477	416	501	385	478
25% FB: 75% FP	385	534	334	526	378	552	332	537
75% FB: 25% FP	676	460	770	462	679	490	708	470
Farmer practice (82% FB: 18% FP)	900	334	850	373	797	354	849	354
Mean	645	468	695	464	668	491	669	475
LSD (5%)	59.8	68.8	6.34	Ns	91	77	30.84	34.59
CV (%)	6.03	9.54	6.34	14	8.84	10.17	7.19	11.36

FB= Faba bean, FP= Field pea, Ns=non significant, Means followed by the same letter do not differ significantly at 5 % probability level in LSD.

Faba bean and field pea separately. This agrees with the report of Willey and Osiru (1972) in maize and beans. This indicates that intercropping gave significantly higher combined yield than the monocultures. This might be probably because of the marked difference in morphology of the two crops, an increased utilisation of more light and other environmental resources. Greater than monoculture yield of Faba bean was obtained at proportion of 75% Faba bean: 25% field pea and farmers practice. Rao and Morgado (1984) reported that yield advantage of intercropping may not vary much over a limited range of row arrangements, though the proportional yields may change. Faba bean yield in intercrop the system was lower than the sole stand culture. Grain yield of Faba bean was reduced by 21 to 69% compared to sole yield and 10 to 34% for field pea except at

TABLE 4. Effects of seed rate proportion on partial LER and LER of faba bean and field pea in intercropping system (1997-1999)

Treatments	1997			1998			1999			Mean		
	PLFB	PLFP	LER	PLFB	PLFP	LER	PLFB	PLFP	LER	PLFB	PLFP	LER
100% FB	1.00	-	1.00	1.00	-	1.00	1.00	-	1.00	1.00	-	1.00
100% FP	-	1.00	1.00	-	1.00	1.00	-	1.00	1.00	-	1.00	1.00
50% FB: 50% FP	0.30	0.83	1.13	0.38	1.00	1.38	0.39	0.91	1.30	0.36	0.92	1.27
25% FB: 75% FP	0.27	0.97	1.24	0.30	1.10	1.40	0.35	1.00	1.36	0.31	1.02	1.33
75% FB: 25% FP	0.65	0.83	1.48	0.70	0.96	1.66	0.63	0.88	1.44	0.66	0.89	1.53
Farmer practice (82% FB: 18% FP)	0.86	0.60	1.46	0.77	0.79	1.56	0.74	0.64	1.38	0.79	0.68	1.47
Mean	0.62	0.85	1.26	0.63	0.97	1.40	0.62	0.89	1.30	0.62	0.90	1.32
LSD (5%)	0.06	0.12	0.13	0.06	Ns	0.22	0.086	0.13	0.21	0.029	0.021	0.079

PLFB= Partial LER Faba bean, PLFP= Partial LER Field pea, LER land equivalent ratio, Ns=non significant, Means followed by the same letter do not differ significantly at $LSD_{0.05}$

proportion of 25% Faba bean: 75% field pea (Table 3).

Seed rate proportion significantly ($P<0.05$) affected partial LER of both crops except field pea in 1998 and land equivalent ratio (LER) (Table 4). Faba bean yield was more affected by the varying seed mixtures than was field pea yield (Fig. 1). The partial LER for Faba bean ranged from 0.31 to 0.79 and for field pea from 0.68 to 1.02 indicting that intercropping Faba bean with field pea is complementary to field pea production (Amare, 1996; Stoskops, 1981). The partial LER indicated the superiority of different proportion with Faba bean. This also indicated a great yield advantage of field pea and a moderate yield disadvantage of Faba bean.

Intercropping exhibited higher over all systems productivity than sole cropping of component crops. The LER for intercropping was greater than one for all seed mixtures (Table 4). The over-all land equivalent ratio was the highest (1.53) with 75% Faba bean and 25% field pea mixtures, followed by the 82: 18% mixture. These results agree with findings of Amare (1996). The LER indicated that greater relative yield advantages of 27 to 53% as compared to sole planting of each crop. Higher land use efficiency was from intercropping as compared to monnocropping component crops. Greater LER values were recorded for field pea than Faba bean in all intercropping except farmers' practice. This is in agreement with Amare (1996) who found the dominance of field pea over Faba bean in all mixtures. The results show that this climbing variety of field pea is better suited for intercropping than for sole crop production, while the Faba bean variety is well suited for sole crop production. Therefore, considering biological and land use efficiency intercropping of 75% Faba bean with 25% field pea is agronomically recommended to Horro highlands.

Total costs varied little with treatments but net benefits varied from 914 to 2609 EB ha^{-1} (Table 5). The value to cost ratio varied from 1.19 to 3.76. Intercropping resulted in increased net profit and marginal rate of return with intercropping as than sole crop production (Table 5). The highest net benefit of EB 2,609 ha^{-1} and MRR of 3954 % and value to cost ratio of 3.76 were obtained with 75:25% Faba bean to field pea seed rate

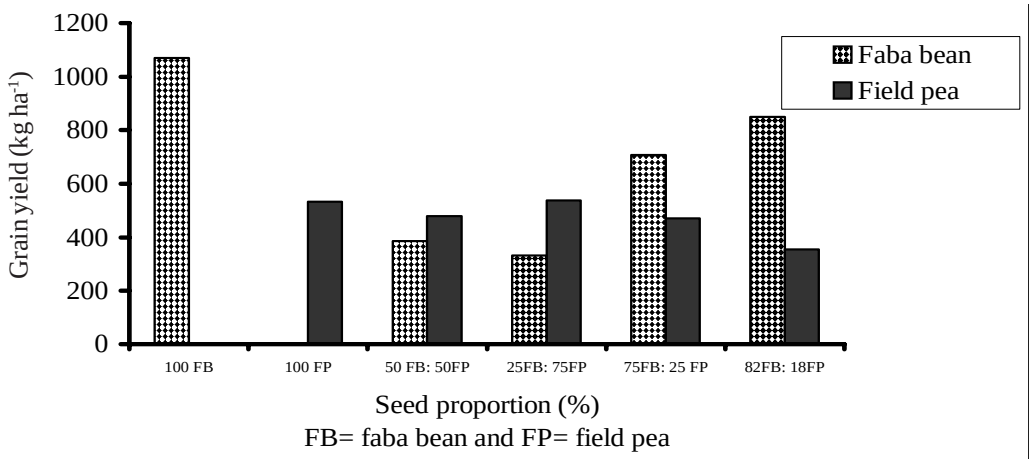

Figure 1. Effect of seed rate proportion on the grain yield kg ha^{-1} of faba bean and field pea.

TABLE 5. Partial budget and marginal rate of return (MRR) analysis for intercropping of faba bean and field pea across seed rate proportions at Shambo, 1997-1999

Item	Seed rate proportion					
	25% FB: 75 % FP	50 %FB: 50 % FP	75% FB: 25 % FP	(82% FB: 18 % FP)	100 % FB	100 % FP
Yield of (kg ha^{-1}) Faba bean	332	385	708	849	1071	-
Adjusted yield (kg ha^{-1}) Faba bean	298.8	346.5	637.2	764.1	963.9	-
Yield of (kg ha^{-1}) field pea	537	478	470	354	-	533
Adjusted yield (kg ha^{-1}) field pea	483.3	430.2	423	318.6	-	479.7
Gross field benefit of Faba bean	854.57	990.99	1822.39	2185.33	2756.75	-
Gross field benefit of field pea	1691.55	1505.7	1480.5	1115.1	-	1678.95
Total benefit (EB ha^{-1})	2546.12	2496.69	3302.89	3300.43	2756.75	1678.95
Faba bean seed cost (EB ha^{-1})	175.00	350.00	525.00	574.00	700.00	-
Field pea seed cost (EB ha^{-1})	506.25	337.50	168.75	121.50	-	765
Total Cost that vary (EB ha^{-1})	681.25	687.50	693.75	695.50	700.00	765.00
Net benefit	1864.87	1809.19^{D}	2609.14	2604.93	2056.75^{D}	913.95^{D}
Marginal rate of return (MRR)			5954 %			
Value to cost ratio	2.73	2.63	3.76	3.74	2.93	1.19

Note: D= dominated treatment; grain price= EB 2.86 kg^{-1} for faba bean; Field pea= EB 3.50 kg^{-1}; Faba bean seed= EB 3.50 kg^{-1}; Field pea seed= EB 5.1 kg^{-1}, Yield was down adjusted with 10%, FB= Faba bean, FP= Field pea

proportion. This was followed by 82: 18 % ratio, or farmers practice, and next best was the Faba bean sole crop. The sole crop of Faba bean gave significantly higher net return than the other Faba bean return mixed with field pea. Economic analyses confirmed the fact that mixing of Faba bean and field pea at 75:25% Faba bean to field pea was profitable for Horro highlands.

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