The Journal of Animal & Plant Sciences, 23(1): 2013, Page: 210-215
ISSN: 1018-7081

ENHANCING CROP PRODUCTIVITY THROUGH WHEAT (T*RITICUM AESTIVUM* L.) - FENUGREEK INTERCROPPING SYSTEM

A. Wasaya, R. Ahmad*, F. U. Hassan, M. Ansar, A. Manaf and A. Sher

Department of Agronomy, PMAS-Arid Agriculture University Rawalpindi, Pakistan
*Department of Agronomy, University of Agriculture Faisalabad, Pakistan
Corresponding author email: wasaya@uaar.edu.pk

ABSTRACT

Intercropping of wheat and fenugreek may be a viable alternative to sole cropping to increase farmer's net income and provide understanding of crop performance and productive systems. A field study was conducted to quantify the "agro-economic assessment of wheat (*Triticum aestivum* L.) fenugreek intercropping system" at Agronomic Research Area, University of Agriculture, Faisalabad during winter 2005 and 2006. The experiment was laid out in a randomized complete block design (RCBD) and comprised of seven treatments viz. wheat alone 30 cm spaced single row, wheat alone 75 cm spaced 4 row strips, wheat +one row of fenugreek, wheat +2 rows of fenugreek, wheat +3 rows of fenugreek, wheat +4 rows of fenugreek and fenugreek alone. Although all the intercrops reduced number of tillers m^{-2}, number of grains per spike, weight of grains per spike, 1000-grain weight and grain yield of wheat significantly compared to its monocropping, nonetheless, the additional yield obtained from each intercrop compensated more than the losses in wheat production. The land equivalent ratio (LER) showed 19 to 38% yield advantage of intercropping system than sole cropping. The highest yield advantage (38%) was recorded in wheat+3 rows of fenugreek followed by wheat +4 rows of fenugreek (33 %) against the minimum of 19% in wheat +1 row of fenugreek. All the intercropping systems gave substantially higher net income ha^{-1} over pure stand of wheat. The maximum net income of Rs. 33647 ha^{-1} was obtained from wheat +3 rows of fenugreek against the minimum of Rs. 24791 ha^{-1} from sole cropping. It may be concluded that wheat +3 rows of fenugreek is the best intercropping system and can be practiced on large scale by farmers.

Key words: Intercropping, land equivalent ratio, wheat, grain yield, Economic analysis.

INTRODUCTION

The burgeoning population growth necessitates harnessing the existing crop production strategies to meet rapidly increasing demand. Raising productivity through more effective use of available resources (e.g. light water, fertilizer, etc.), is possible through intercropping which resulted to reduction in weed pressure and sustain plant health (Hauggaard-Nielsen *et al.,* 2003; Banik *et al*., 2006). Intercropping is a very profitable approach especially for the small land holders and intercropping of cereals (maize) with legumes (pigeon pea) proved to be more profitable with return rate of 343% compared with sole maize cropping (Rusinamhodzi *et al.,* 2012). Efficient utilization of the available resources occurred through cereal-legume intercropping systems. Intercropping resulted to increase the total productivity per unit area and time and equitable utilization of resources (Marer *et al*., 2007). In addition to resource use efficiency intercropping also plays a significant role in weed suppression due to spatial competition between the component crops. Weed suppression was observed in maize legume intercropping systems compared with sole maize cropping (Khan *et al.,* 2012).

In addition to resource use efficiency inclusion of legumes in intercropping systems also plays a significant role in improving fertility status of the soil. Intercropping legume crop (pigen pea) in maize added up about 60 kg N ha-1 and improves the fertility status of soil (Myaka *et al*., 2006). Component crops in intercropping systems uses the same resources in different forms (e.g., non-leguminous crops uptake N in the form of nitrate (NO_3^-) while leguminous crops uptake the molecular nitrogen (N_2) which is fixed in root nodules by bacteria), thus reducing competition for soil N (Szumigalski and Van Acker, 2005). The most important resources used by crops during its growth period are usually light, water, and nutrients (Faurie *et al*., 1996). A better understanding of resource partitioning among component crops help to identify more suitable agronomic manipulations for improved intercrop function (Midmore, 1993). Previous studies have shown significant yield advantage of intercropping as compared to monocropping (Patrick *et al*., 1995). Grain yield of wheat and chickpea was more in case of monocropping while reduced when intercropped. However, the land use efficiency and total productivity increased under intercropping systems (Banik *et al*., 2006).

Wheat (*Triticum aestivum* L.), is a leading cereal in Pakistan, and being staple food, it occupies a central position in agricultural policies and contributes 12.5% to the value added in agriculture and 2.6% to gross domestic product (GDP). It is grown on an area of 8.66 million hectares with production of 23.52 million tones with an average yield of 2714 kg ha^{-1} (Anonymous, 2011). Wheat as an intercrop is discouraged by the farmers due to facing problems during harvesting operations and most of Pakistani farmers prefer to cultivate wheat as a sole crop. But for the small land holders, growing wheat by intercropping with legumes is a viable option for improving soil fertility (Myaka *et al*., 2006) and earning more profit compared with sole crop (Rusinamhodzi *et al.,* 2012).

Fenugreek is a leguminous as well as medicinal crop and its seeds are used as condiment and dried leaves for flavoring. The vegetative parts are also rich in vitamin A, B and iron. The seeds are also used to resolve inflammatory tumors. The flower is recommended for aphtha, chapping, haemorrhoidal tumors, dysentery, diarrhea and inflammatory colics (Sharma, 2003). In addition to fixing nitrogen, it also covers the surface soil and suppresses weeds and reduces soil erosion.

Existing food supply systems demands more area to be grown under grains, pulses and oilseeds because of their ever increasing use in the daily human diet. Area under these crops, however, cannot be increased due to their competition with wheat. One of the promising ways to harness the crop productivity is utilization of intercropping without compromising over staple crops. The present study was, therefore, designed for with the objective for raising crop productivity through a more effective use of natural and added resources and to determine the agro-economic assessment of wheat-fenugreek intercropping system under prevailing semi-arid conditions.

MATERIALS AND METHODS

The study pertaining to the enhanced crop productivity through wheat-fenugreek intercropping system was carried out at Agronomic Research Area (Latitude 1.26° N, Longitude 73.06° E and Altitude 184.4 m), University of Agriculture, Faisalabad, Pakistan during the winter, season 2005 and repeated during 2006. The rainfall data for the whole growing season of wheat is given in the fig.1. The experimental soil was sandy clay loam containing 60.95% sand, 18.65% silt and 20.85% clay and was consisted of 0.84% organic matter by Walkley-Black method, 6.3 mg kg^{-1} of available phosphorus, 193 mg kg^{-1} exchangeable potassium (NH4O-Ac extraction), 0.038% available nitrogen, ECe 0.26 dSm^{-1} (1:2.5 soil-H2O mixture) and pH of 8.1 (1:2.5 soil-H2O mixture). The wheat was grown alone and in association with fenugreek. The experiment was carried out in a randomized complete block design (RCBD). The experiment comprised of following treatments i.e. wheat alone in 30 cm spaced single row, wheat alone 75 cm spaced 4 row strips, wheat (75 cm spaced 4 row strips) + one row of fenugreek, wheat + 2 rows of fenugreek, wheat + 3 rows of fenugreek, wheat + 4 rows of fenugreek and fenugreek alone. The experiment was laid out in randomized complete block design (RCBD), with three replications using a net plot size of 6.0 m × 3.60 m. Fertilizer was applied at the rate of 140 kg N and 100 kg P_2O_5 ha^{-1} in the form of urea and DAP, respectively. Half of the nitrogen with full dose of phosphorous was applied at the time of sowing, while remaining half of nitrogen was applied with first irrigation. The wheat cultivar Inqilab-91 was sown on 15th November 2005 and 11th November 2006, with single row hand drill using a seed rate of 100 kg ha^{-1}. Fenugreek was sown between wheat strips on the same day. A total of five irrigations were applied throughout the crop season for maturity of wheat and weeds were controlled through manual hoeing. The component crops were harvested on 23rd April, 2006 and 20th April, 2007. Observations on yield and yield components of the component crops were recorded at harvesting by using the standard procedures. For plant population, crop was harvested from an area of 1 m^2 and total number of plants was counted to determine plant density. Number of grains per spike and grains weight per spike was recorded from ten randomly selected plants from each plot of the respective treatment. Three lots of thousand grains were counted with the help of seed counter from the yield obtained from each plot and then weighed. Whole plot (6.0 m × 3.60 m) was harvested manually; sundried and biological yield was measured in kg per plot and then converted to t ha^{-1}. After which, each of the treatment crop was threshed with mechanical thresher to determine the grain yield and was also converted to t ha^{-1}. Harvest index was calculated to find out the physiologically efficiency of the crop by using following formula:

$$H.I. = Grain\ Yield / Biological\ Yield \times 100$$

Land equivalent ratio (LER) for each crop was computed by using the following formulae:

$$LER\ (Wheat) = \frac{Wheat\ yield\ of\ intercropped\ treatment}{Wheat\ yield\ of\ sole\ crop}$$

$$LER\ (Fenugreek) = \frac{Fenugreek\ yield\ of\ intercropped\ treatment}{Fenugreek\ yield\ of\ sole\ crop}$$

$$LER\ (Total) = LER\ (Wheat) + LER\ (Fenugreek)$$

The data collected was analyzed by using Fisher's analyses of variance techniques (Steel *et al*., 1997) and the treatment means were compared by least significant difference (LSD) test at 0.05 level of probability.

RESULTS AND DISCUSSION

Different intercropping treatments reduced the yield and yield components of wheat but overall results showed that the intercropping of fenugreek proved to be more profitable as compared to sole crop (Table -1 and

2). All the intercropping treatments gave more output in terms of economic benefit but the intercropping of 3-rows of fenugreek with wheat proved to be best as compared to rest of the treatments. Number of grains per spike was reduced significantly when wheat was intercropped with fenugreek while significantly highest number of grains per spike was recorded in case of sole wheat when grown alone at 30 cm spaced rows. Weight of grains per spike of wheat varied significantly in different intensities of fenugreek intercropping in wheat crop. However, maximum weight of grains per spike was recorded when wheat was grown alone, while minimum weight of grains per spike was recorded when wheat was intercropped with 4 rows of fenugreek (Table 1). Intercropping is an important resource conservation practice for the small land holders, practicing this, farmers can grow a variety of crops at the same time, at the same piece of land to fulfill their food requirements and earn more income from the limited land as compared to monocropping. The present study indicated that intercropping reduced number of grains per spike and grains weight per spike in wheat as compared to sole wheat crop. Reduced number of grains per spike and grains weight per spike of wheat has been reported when intercropped with sarsoon (*Brassica compestris* L.) (Anjum, 1996).

Wheat grown with different intensities of fenugreek reduced 1000-grain weight. The maximum reduction (11.4 %) in 1000-grain weight of wheat was observed when 3 rows of fenugreek were intercropped in wheat which was at par with all intercropped treatments except with one row of fenugreek. Significantly maximum 1000-grain weight of wheat was recorded when wheat grown as a sole crop. 1000-grain weight is an important yield contributing parameter and different intensities of fenugreek grown in association with wheat resulted in less 1000-grain weight. Reduced grain weight was probably due to poor grain development in the associated wheat. Similalry, Bajwa *et al*. (1992) reported significant reduction in 1000- grain weight of wheat when intercropped with *Linium ustitatisimum* L. and *Vigna radiate* L.

Biomass yield of wheat was significantly reduced in case of all intercropping systems. Maximum biomass was recorded in wheat alone grown at 75 cm spaced 4 rows strips which was at par with sole wheat grown at 30 cm spaced rows. Minimum biomass was recorded when 2 rows of fenugreek were intercropped in wheat (Table-1). Total biomass per hectare determines the overall growth and development behaviour of the crop. At all intensities, fenugreek intercropping reduced biomass yield of wheat as compared to sole wheat crop because of simultaneous competition between different intensities of component crop. Significant reduction in production of wheat biomass in different intensities of intercropping compared to sole wheat crop might be attributed to the direct competition between the component crops for plant growth factors which caused reduction in different growth and yield contributing factors especially total tillers m^{-2}. Reduction in biomass yield of base crop due to competitive effect of different intensities of intercrops was also reported by Mandal and Mahapatra (1990).

The final grain yield of a crop is a function of the combined effect of the yield components. It is evident that different intensities of fenugreek intercropping reduced the grain yield of wheat as compared to sole crop (Fig-2a). The comparison of individual treatments showed that the highest grain yield was recorded in wheat alone when grown at 30 cm spaced rows. However, minimum grain yield was found when 4 rows of fenugreek were intercropped in wheat. Wheat grain yield is directly related to yield components such as number of grains per spike, grains weight per spike and 1000-grain weight. Minimal grains number per spike, 1000-gain weight and grains weight per spike lead to reduced grain yield of intercropped wheat. Reduction in grain yield may be due to greater inter and intra specific competition of the component crops for different growth factors i.e. moisture, nutrient, space, solar radiation etc. Reduction in grain yield of wheat due to intercropping in linseed (Billare *et al*., 1992) and *Brassica juncea* L. (Singh and Gupta, 1994) has been previously reported. Riaz *et al*. (1993) also reported the reduction in intercropped wheat yield due to suppressive effect of intercrops on the yield of the base crop.

The physiological efficiency and ability of a crop plant for converting total dry matter into economic yield is determined by its harvest index (H.I.) value. Higher the harvest index values, more the physiological efficiency of dry matter conversion and vice versa. The data showed significant differences among different intensities of intercropping. Significantly highest harvest index was recorded when wheat grown at 30 cm spaced rows as a sole crop and minimum was recorded when wheat was intercropped with 4-rows of fenugreek (Table-1). Harvest index of wheat intercropped with different intensities of fenugreek was reduced to a significant extent as compared to sole wheat crop. The reduction in harvest index of wheat due to intercropping might be ascribed to heavy competition among the component crops for moisture, nutrients, space and light particularly at grain formation stage which probably reduced the supply of assimilates to the grain development. These results are in line with those reported by Nazir *et al*. (1988) who reported that harvest index of wheat reduced when intercropped as compared to monocropping.

Different intensities of intercropping have positive effect on land equivalent ratio. LER values were greater than one in all the intercropping treatments. The highest LER value of 1.38 was obtained when wheat was intercropped with 3-rows of fenugreek while lowest value was obtained in case of wheat + 1 row of fenugreek (Fig.

2b). However, in intercropping treatments the range of yield advantage over sole cropping was between 19 to 38% with highest (38%) in the case when 3 rows of fenugreek were intercropped in the wheat followed by wheat + 4 rows of fenugreek (33%). The rest of intercropping systems intermediated and showed yield advantage from 19 to 28%. The economic analysis of the experiment is done to look into experimental results from farmer's point of view as they are mainly interested in benefits and costs of a certain technology and also they like to know about risks involved in the adoption of new practices. The land equivalent ratio (LER) is the relative area of a sole crop required to produce the yield achieved in intercropping. LER value of more than one indicates yield advantage than less value without any advantage. Higher LER in intercropping treatments than monocropping of wheat was attributed to better utilization of natural and added resources. Highest LER value (1.38) was obtained when wheat was grown is association with 3 rows of fenugreek indicating yield benefit from 1.38 hectares of sole wheat crop can be obtained from one hectare of intercropped wheat. Higher LER in intercropping compared to monocropping was also reported by Mandal and Mahapatra (1990), Puste (1991), Prasad and Singh (1992) and Sharma and Sharma (1993).

The economic analysis was done to find out its farmer's feasibility of intercropping mainly interested in benefits and costs of a certain technology and about risks involved in the adoption of new practices. The efficiency of an intercropping system is determined either by the net income per unit area in a specified period of time, or benefit cost ratio (BCR). On the basis of recorded data highest benefit was obtained from the wheat grown with 3 rows of fenugreek (Table -2). Economic analysis was carried out by using the prices of inputs and outputs prevailing in the local market (Table-2). Data indicated that wheat + 3 rows of fenugreek gave the highest net income of Rs. 33,647.87 followed by Rs. 30805.83 per hectare, obtained in case of wheat + 4 rows of fenugreek. In term of benefit cost ratio (BCR), the highest value of 2.15 was obtained in case of wheat + 3 rows of fenugreek, followed by 2.09 in case of wheat + 2 rows of fenugreek. The minimum BCR value of 1.96 was obtained when wheat was grown alone at 75 cm spaced four rows strips.

On the basis of above mentioned results it is concluded that wheat grown in association with 3 rows of fenugreek is a viable option to get higher benefit.

Table-1. Agronomic traits and yield components of wheat as influenced by wheat-fenugreek intercropping system (Av. of 2 years 2005 and 2006)

Intercropping system	Number of grains per spike of wheat	Grains weight per spike	1000-grain weight (g)	Biological yield (t ha^{-1})	Harvest Index (%)
Wheat alone at 30 cm spaced rows	46.33 a	1.61 a	39.17 a	10.13 ab	41.49 a
Wheat alone at 75 cm spaced four row strips	45.67 a	1.62 a	39.73 a	10.35 a	39.80 b
Wheat + 1 row of fenugreek	44.0 b	1.55 b	36.83 b	9.68 c	39.99 bc
Wheat + 2 rows of fenugreek	43.67 b	1.52 bc	36.33 bc	9.47 c	40.44 b
Wheat + 3 rows of fenugreek	43.33 b	1.49 c	35.67 c	9.82 bc	39.46 c
Wheat + 4 rows of fenugreek	42.67 b	1.44 d	36.17 bc	9.67 c	39.15 cd
LSD (0.05)	1.357	0.0407	1.045	0.40	0.9348

Means not sharing the same letters in the column differ significantly at p (0.05)

Table 2. Economic analysis of wheat-fenugreek intercropping system.

Intercropping system	Wheat grain yield (kg ha^{-1})	Wheat straw yield (kg ha^{-1})	Fenugreek yield (kg ha^{-1})	Gross income (Rs. ha^{-1})	Total expenditure (Rs. ha^{-1})	Net income (Rs. ha^{-1})	Benefit Cost Ratio
Wheat alone at 30 cm spaced rows	4203.85	5928.86		52440.90	25742.50	26698.40	2.04
Wheat alone at 75 cm spaced four row strips	3961.1	6387.04		50533.42	25742.20	24791.22	1.96
Wheat + 1 row of fenugreek	3870.83	5808.79	179.47	55955.0	27742.50	28212.50	2.02
Wheat + 2 rows of fenugreek	3832.87	5642.63	270.32	58957.69	28242.50	30715.19	2.09
Wheat + 3 rows of fenugreek	3876.32	5946.41	346.60	62890.37	29242.50	33647.87	2.15
Wheat + 4 rows of fenugreek	3788.04	5886.06	328.16	61141.33	30335.50	30805.83	2.01

Price of Wheat grain (Rs. Rupees) = Rs. 8.50 kg^{-1}, Price of wheat straw= Rs. 1.50 kg^{-1}, Price of Fenugreek = Rs. 40kg^{-1}

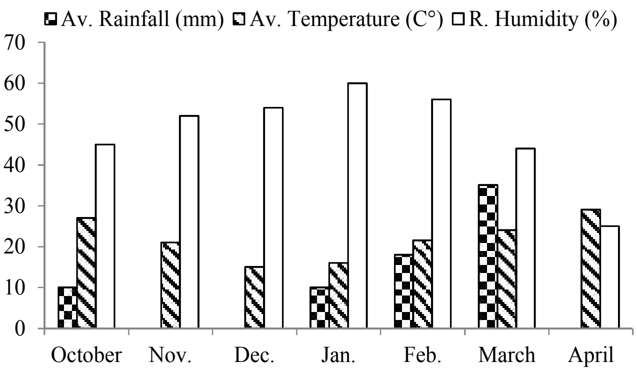

Figure-1: Meteorological data for the growing period of Wheat

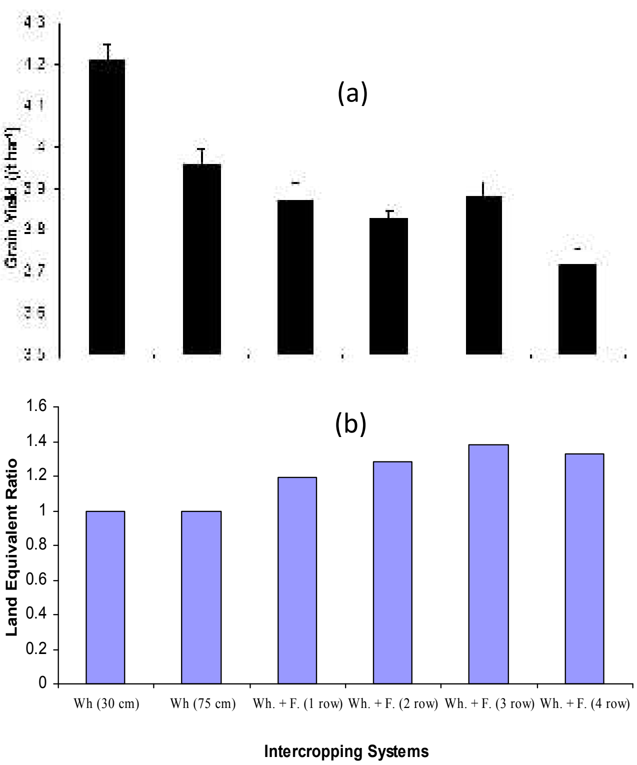

Figure-2. Effect of wheat-fenugreek intercropping systems on (a) Wheat grain yield (t ha^{-1}) and (b) Land equivalent ratio (Wh= Wheat, F= fenugreek)

REFERENCES

Anjum, M. A. (1996). Agro-management studies on biological fixation of nitrogen in wheat-legume intercropping system. Ph.D. Thesis Univ. Agri. Faisalabad Pakistan.

Anonymous (2011). Economic Survey, Ministry of food, Agriculture and Livestock (Federal Bureau of Statistics), Islamabad. pp. 11-26.

Bajwa, A. N., M. S. Nazir and S. Mohsin (1992). Agro-economic studies on some wheat based intercropping systems. Pakistan J. Agri. Sci., 29: 439-443.

Banik, P., A. Midya, B. K. Sarkar and S. S. Ghose (2006). Wheat and chickpea intercropping systems in an additive series experiment. Advantages and weed smothering. Europ. J. Agron., 24: 325-332.

Billare, S. D., K. Singh and S. B. Nahatkar (1992). Economic viability to wheat + linseed intercropping under different fertility levels. Crop Res., (Hisar). 5(3): 430-433.

Faurie, O., J. F. Soussana and H. Sinoquet (1996). Radiation interception, partitioning and use in grass clover mixtures. Ann. Bot., 77: 35–45.

Hauggaard-Nielsen, H., P. Ambus and E. S. Jensen (2003). The comparison of nitrogen use and leaching in sole cropped versus intercropped pea and barley. Nutr. Cycl. Agroecosys., 65: 289–300.

Khan, M. A., K. Ali, Z. Hussain and R. A. Afridi (2012). Impact of maize-legume intercropping on weeds and maize crop. Pakistan J. Weed Sci. Res., 18(1): 127-136.

Mandal, B. K. and I. C. Mahapatra (1990). Barley, lentil and flax yield under different intercropping systems. Agron. J., 82(6): 1066-1068.

Marer, S. B., B. S. Lingaraju and G. B. Shashidhara (2007). Productivity and economics of maize and pigeonpea intercropping under rainfed conditions in northern transitional zone of Karnataka. Karnataka J. Agric. Sci., 20(1): 1-3.

Midmore, D. J. (1993). Agronomic modification of resource use and intercrop productivity. Field Crops Res., 34:357–380.

Myaka, F. M., W. D. Sakala, J. J. Adu-Gyamfi, D. Kamalongo, A. Ngwira, R. Odgaard, N. E. Nielsen and H. Hogh-Jensen (2006). Yields and accumulations of N and P in farmer-managed intercrops of maize–pigeonpea in semi-arid Africa. Plant Soil 285: 207–220.

Nazir, M. S., H. Rehman, G. Ali and R. Ahmad (1988). Inter/relay cropping in wheat planted in multi-row strips at uniform plant population. Pakistan J. Agri. Res., 9(3): 305-309.

Patrick, M. C., J. C. Gardner, B. G. Schatz, S. W. Zwinger and S. J. Guldan (1995). Grain yield and weed biomass of a wheat-lentil intercrop. Agron. J., 87(3): 574-579.

Prasad, S. N., and M. Singh (1992). Intercropping of upland rice with pigeonpea, black gram and sesame. Annals of Agri. Res., 13(3): 240-244.

Riaz, A., M. Amjad, M. S. Nazir and T. Mahmood (1993). Agronomic studies on mash-soybean intercropping system. Pakistan J. Agri. Res., 14(4): 304-308.

Rusinamhodzi, L., M. Corbeelsc, J. Nyamangarad and K. E. Giller (2012). Maize–grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. Field Crops Res., 136: 12–22.

Sharma, R. (2003). Medicinal Plants of India. An Encyclopaedia. Daya Publishing House, Delhi.pp. 248-249.

Sharma, S. and E. Sharma (1993). Energy budget and efficiency of some multiple cropping systems in Sikkim Himalaya. J. Sustainable Agri., 3(3/4): 85-94.

Singh, R. V. and P. C. Gupta (1994). Production potential of wheat and mustard cropping systems under adequate water supply conditions. Ind. J. Agri. Res., 28(4): 219-224.

Steel, R. G. D., J. H. Torrie and D. A. Dickey (1997). Principles and Procedures of Statistics. A biometrical approach. McGraw Hill Book Co., New York, USA. pp 400-428.

Szumigalski, A. and R. V. Acker (2005). Weed suppression and crop production in annual intercrops. Weed Sci., 53(6): 813–825.