Beef Cattle Integration on Dry-Land Farming in Sragen Central-Java Indonesia: Improvements of Economic and Environmental Carrying Capacity Aspects

M Rahardjo[1)]* and Suroyo[2)]

[1)] **Faculty of Economic and Business, University of Sebelas Maret Surakarta**
Jl. Ir. Sutami 36A Kentingan, Surakarta, Central Java, Indonesia, Telp/Faks: +62.0271.647481/638143
[2)] **Center for Education and Training, Kementerian Dalam Negeri, Daerah Istimewa Yogyakarta**
Jln. Melati Kulon No. 1, Baciro, Yogyakarta, 55225
***Corresponding author email: mugi.raharjo.febuns@gmail.com**

Abstract. This study aimed to investigate the impact of beef cattle integration on dry land farming of peanut and maize with a focus on the economic and the environmental carrying capacity aspects. The multiyears of field experiments were conducted on the Kebun Pengembangan Pertanian Terpadu, Lembaga Pendidikan Pelatihan dan Penelitian Wiyata Dharma located at Geneng Duwur Village, Gemolong Distrik, Sragen Regency, Central-Java Indonesia. The experimental design was a randomized complete block with three replications. Six block combinations were implemented: block 1 (no-beef cattle integration), block 2 (1-year beef cattle integration), block 3 (2-year beef cattle integration), block 4 (3-year beef cattle integration), block 5 (4-year beef cattle integration), and block 6 (5-year beef cattle integration). Spatial separated integration of beef cattle were implemented on the peanut and maize crop of dryland farming. A major advantage of the integrated system of crop and beef cattle is that nutrients from the wastes can be recycled efficiently on the farm. The results showed that there was an increase in productivity and efficiency of farm enterprises, as well as an increase in the environment carrying capacity. The impact of beef cattle integration was that, it improved the enterprises productivity (75%) of dryland farming (during 5 years period) and created sustainable agriculture. In order to improve farmers' livelihoods and develop sustainable dry land farming systems, the changing of practical agriculture especially farmer in dry land areas for peanut and maize should receive more attention of researchers, government institutions and stakeholders.

Keywords: farming, crop-livestock integration, dry-land, beef cattle, environment carrying capacity

Abstrak. Tujuan penelitian ini adalah mengkaji pola integrasi sapi potong pada usahatani lahan kering tanaman kacang tanah dan jagung dengan fokus pada aspek ekonomi dan daya dukung lingkungan. Penelitian multi tahun ini dilaksanakan pada Kebun Pengembangan Pertanian Terpadu, Lembaga Pendidikan Pelatihan dan Penelitian Wiyata Dharma Desa Geneng Duwur Kecamatan Gemolong Kabupaten Sragen, Jawa Tengah. Rancangan Acak Kelompok Lengkap diterapkan pada penelitian ini dengan tiga kali ulangan. Diterapkan enam blok kombinasi perlakuan yaitu: blok 1 (bukan integrasi), blok 2 (integrasi sapi potong, 1 tahun), blok 3 (integrasi sapi potong, 2 tahun), blok 4 (integrasi sapi potong, 3 tahun), blok 5 (integrasi sapi potong, 4 tahun), blok 6 (integrasi sapi potong, 5 tahun). *Spatial separated integration* diterapkan dengan melibatkan sepuluh ekor sapi potong pada pertanian tanaman kacang tanah tumpangsari tanaman jagung. Keuntungan utama penerapan integrasi tanaman dengan ternak adalah nutrien dari limbah mampu didaur ulang secara efisien di dalam sistim pertanian. Hasil penelitian menunjukkan terjadi peningkatan produktivitas dan efisiensi usahatani, serta peningkatan daya dukung lingkungan. Dampak penerapan integrasi sapi potong mampu meningkatkan hasil usahatani lahan kering sebesar 75% (selama 5 tahun) dan terbentuk pertanian berkelanjutan. Upaya meningkatkan kesejahteraan petani dan mengembangkan sistem pertanian lahan kering yang berkelanjutan, diperlukan perubahan pengelolaan pertanian utamanya petani kacang tanah dan jagung harus mendapat perhatian lebih dari para peneliti, lembaga pemerintah dan pemangku kepentingan.

Kata kunci: usahatani, integrasi tanaman-ternak, lahan kering, sapi potong, daya dukung lingkungan

Introduction

The condition of food demand is expected to continue to increase for at least the next 40 years (Godfray et al., 2010), and food production will need to increase by 70 to 100% by 2050 (World Bank, 2008). However, this has to be done in the face of growing competition for land, water, and energy, and without harming the environment. In recent years, although the condition of Indonesian agricultural development is able to increase farm productivity, the environmental carrying capacity in agriculture tends to decline gradually. Factors that may affect declining environment carrying capacity include the use of chemical fertilizers and pesticides in the farm. Suntoro (2003) stated that after more than 30-year period of the implementation of national agricultural system, several indicators were found that could be taken into account, include: the decreases of land and soil productivity, the increases of agricultural land conversions and the number and quality of critical land, the decrease of environmental support capacity of agriculture land, the increase of the number of unemployments in rural areas, the decrease in the value of farmer exchange and farmer income, and the decrease in the quality of life and livelihoods of farm families.

The Indonesian agriculture development is strongly depend on the condition of dryland farming. This case happens because the number of dryland is much larger than the wetland (paddy) of 7.8 million ha and half of the them (3.24 million ha) is located in Java Island (BPS, 2007). The total area of Sragen Regency (94,155 ha) comprises of paddy and dryland land, namely 40,129 and 54,026 ha, respectively. Particular lands for food crops cultivation of wet and the dry land are 40,129 and 24,795 ha, respectively (Pemkab. Sragen, 2011). Actually, Indonesia has a high potential of dry lands and it should be taken into more attention for its development (Minardi, 2009), as well as the creating development strategic need in the management of dry land in order to produce agricultural crops optimally. It is recommended that using organic fertilizer is very important for the management of soil fertility because it macro nutrients contents (N, P, and K) and micro nutrients for plant growth also for the soil improver functions in term of improving soil structure and fertility. Organic fertilizers derive from crop residues, livestock manure, compost or other organic matter sources.

The increasing demand for food with the associated rise in global population has led to elevated demand for scarce fertilizers to maintain crop production. However, the current energy crisis coupled with the rise in cost of raw materials and labour has lead to the increased prices and reduced production of inorganic fertilizers (Asaad et al., 2010). In the current environment, there is a need to consider substitutes and/or supplements to the use of organic fertilizers. Faridah (2001) recomended that integrated farming is one good way to optimize the use of resources and to maximize income.

Integration of the system components minimizes the use of agrochemicals, reduces environmental impacts, increases biodiversity, reduces soil erosion, and improves soil structure and fertility, particularly in combination with the conservation of zero-waste agriculture practices such as zero-tillage (Landers 2007; Gupta et al., 2012). Integrating livestock into crop production may provide a cost-effective on-farm source of soil fertility. Animals recycle nutrients that are contained in forages and feed and make them available in their excreta, thus become part of the on-farm nutrient cycle. The crop-livestock integration seeks to intensify land use to increase farm productivity and efficiency. Therefore, the objective of this research was to determine the effects of beef cattle integration in dry-land farming of peanut and maize crops in Sragen

Regency that were focused on economic and environmental aspects.

Material and Methods

Location and Experimental Design

The multiyears of field experiments were conducted on the Kebun Pengembangan Pertanian Terpadu, Lembaga Pendidikan Pelatihan dan Penelitian Wiyata Dharma located at Geneng Duwur Village, Gemolong Distrik, Sragen Regency, Central-Java Indonesia. Soil was dominated by litosol. The experimental design was a randomized complete block with three replications. Treatments were beef cattle integration on peanut and maize crops. Six block combination were implemented: Block 1 (no-beef cattle integration), Block 2 (1-year beef cattle integration), Block 3 (2-year beef cattle integration), Block 4 (3-year beef cattle integration), Block 5 (5-year beef cattle integration), and Block 6 (5-year beef cattle integration). Ten beef cattles were integrated on the peanut and maize crop of dryland farming. A major advantage of the integrated system of crop (peanut and maize) and beef cattle for dry land farming in Sragen Regency is that nutrients from the wastes can be recycled efficiently on the farm. Spatial separated integrated (Hilimire, 2011; Powell et al., 2002, and Ghebremichael et al., 2009) was implemented in this study.

Data Collection and Statistical Analysis

Crop productivity analysis was evaluated by conversion of average yield of crop sample multiplied by the population crop per hectare. Farm productivity was obtained by converting the weight of crop sample (total seed pods per hectare, the weight of stover per hectare multiplied by the price of the item). Beef cattle productivity was obtained by converting livestock weight gain during 6 months period of every one hectare of land area. Productivity of beef cattle business was calculated by the conversion of body weight gain multiplied by the price of meat minus the additional external inputs. The analysis of the integration of beef cattle farm productivity was obtained from the total productivity of crops and beef cattle. The productivity analysis was also calculated by converting total farm production (in units of energy called calories) refers to the results of previous studies and references.

BC ratio was used to assess the efficiency of crop and livestock enterprises. Crop farming business included peanut and corn crops in monoculture, as well as peanut and maize intercropps. Livestock farming revenue was generated from the sales of beef cattle. The calculation of efficiency (energy) was calculated by converting production output and production inputs into units of energy (calories) refers to the information from previous studies and references (Hartadi et al., 1980; Wahyudi, 2006). In this study, the energy factor which was absorbed by plants in the photosynthesis process is not taken into account. Environmental carrying capacity was than calculated that referred to the Regulation of the Environment Ministry Number 17 Year of 2009 (KNLH, 2009) by a formula:

$$S_L = \frac{\sum (P_1 x H_1)}{Hb} x \frac{1}{Ptv_b}$$

S_L = Land availability (ha)

P_1 = Actual production for each commodity (the unit depends on the commodity type, includes: plantation, forestry, livestock and fishery).

H_1 = Unit price for each commodity (Rp/unit) at the producer level

H_b = Price unit of rice (Rp/kg) at the producer level

Ptv_b = Productivity of rice (kg / ha)

Availability of land was determined based on the actual data on total local production of each commodity in the region, by summing all commodities product in that region. Price was used as the conversion factor. Land requirement was calculated based on the needs of living (KNLH, 2009).

Statistical Data Analyses

Descriptive statistical analysis was applied to describe the characteristics of body weight and energy production of beef cattle in the production systems, and also economic and environmental capacity aspects of dry land farming. The analysis of correlation regression was used to describe the relationship between total crop farm production and livestock integration in term of the period of beef cattle integrated into the farm.

Results and Discussion

Livestock Body Weight and Energy Production of Farming

Understanding production systems, management and roles of beef cattle are an essential basis for any initiative aiming at an improvement of the livelihoods of dryland farmers. Traditionally, beef cattle production is a major source of income for many farmers in the Central Java region. The productivity of beef cattle can be measured by the average daily gain (ADG). In the current study daily body gain of beef cattle during six months ranges from 0.46 until 0.91 kg/day with the average 0.76 $\pm$ 0.17 kg/day (Table 1). Body weight gain of beef cattle during 6 months keeping was 128.08 kg. The ADG of Peranakan Ongole cattle fed rice straw and concentrate was 0.69 kg (Adiwinarti et al., 2010), and under intensive feeding management was 0.78 $\pm$ 0.30 kg (Lestari et al., 2011).

Ruminants livestock including beef cattle were high importance for the farmer and played multi-purpose roles in both monoculture and multiple cropping systems. In these systems outputs from one sector were used as inputs for other sectors. In dry land areas, some farmers have been concerned mainly with manures, and these have been subjected to minimum manipulation by the farmers to improve the quality of the compost. Farmers keep livestock, which are tethered and fed using the cut-and-carry systems using assorted by-products of crops as fodders after harvesting the crop. Daily dung production of beef cattle during six months ranges from 13.68 until 15.42 kg/day with the average 14.71 kg/day (Table 1). The dung production tended to increase gradually from the first to sixths month. During six months period the total dung production was 2471 kg.

Based on the calculation in this study, the output energy of beef cattle business was obtained from the energy conversion of dried meat and bone, as well as the energy output of beef cattle dung, so that the energy output of beef cattle business was 31839783.9 kcal. While the inputs energy of farming was calculated from the energy conversion of manpower and cattle feed, so the energy input of beef cattle business was 89413362.0 kcal . Finally, the total energy of cattle business was -57573577.9 kcal. The calculations of this study showed that the productivity of energy output was lower than the energy input (negative energy), this condition doe to the most of energy iput used for livestock activity.

Maize crop has a large habitus (heavy weight of stover), consequently they are able to absorb energy in the soil (above minimum conditions) and stored in the soil. In the intercropping system of peanut and maize crops and integrated with beef cattle, it showed that the production of energy output was lower than the energy input (negative energy). These results happened because the number of plants were dominated by peanut crops and fewer number of corn crop (number per hectare of peanuts and maize crops were 225,000 and 12,860, respectively). Under crop-livestock integration farming, the production of energy output was calculated based on the energy conversion from dried peanuts and corn seeds, stover of dry peanuts and corn, energy content of meat and bone and also dung energy (Table 2). The results of the calculation of the energy production for crop-livestock integrated farming in dry-land areas was lower than the

Table 1. Average daily body weight gain and dung production of beef catlle during six months

Variables	Month					
	I	II	III	IV	V	VI
Average daily body weight gain (kg)	0.46	0.69	0.79	0.84	0.91	0.88
Average daily dung production (kg)	13.68	14.40	14.68	14.92	15.16	15.42

Table 2. Energy production of crop-livestock integration farming during five year

Year & Farming System	Energy Output (kcal)	Energy Input (kcal)	Energy Production (kcal)
Year 1, no-integration	34,335,044.63	69,067,844.94	-34,732,800.31
Year 1, integration	38,932,422.69	97,577,235.84	-58,644,813.15
Year 2, integration	48,927,683.67	97,583,715.84	-48,656,032.17
Year 3, integration	54,874,875.81	97,588,035.84	-42,713,160.03
Year 4, integration	57,559,038.26	97,593,435.84	-40,034,397.58
Year 5, integration	57,802,529.26	97,598,835.84	-39,796,306.58

energy input (negative energy) because energy input dominated for beef cattle activity.

The Impact of Livestock Integration on Farm Economic

Integrated farming is one good way to optimize the use of resources and to maximize income (Faridah, 2001). Ruminant livestock such as beef cattle plays an important role insustainable agricultural systems because this type of livestock produces fertilizers and can utilize agricultural waste as their fodder. In this study, the gross income was calculated from the conversion (in rupiah) of dried peanut and corn seeds production, as well as the livestock production in term of beef cattle manure. Net income was derived from gross income minus total cost. The results of the application of crop-livestock integration in this study showed an increasing economy in term of farm income of dry-land farming (Table 3).

Intercropping is a cropping pattern by planting more than one crop at the same time of period on the certain land. In subsistence farming, intercropping is widely practiced by farmers in order to meet their family needs. Intercropping can reduce the high risk of agricultural enterprises, while failing to harvest a certain commodity therefore, the farmers can harvest other commodities. The advantages of intercropping practices is also able to optimally and efficiently utilize land. BC ratio was used to assess the efficiency of crop and livestock enterprises. BC ratio from non-integrated and crop-livestock integrated in dry-land farming were presented in Table 4. Anderson and Schatz (2003) found that integrated systems is more profitable than crop-only systems. A study conducted in North Dakota found a net worth could be increased by $8,000 for crop-only farms converting to integrated beef cattle-crop management. Other findings, Khan and Iqubal (2010) and Devendra (2011) reported that the integrated crop-livestock enterprise is economically viable and environmentally friendly.

This results (Table 4) revealed that the farm efficiency of crop-livestock integration significantly higher than non-livestock integration farming. In overall, there was increased efficiency of farm livestock integration (during the 1st until 5th year) ranged from 31.5 until 31.9% with the average of 32%. Land use efficiency is the practice of layering enterprises or crop types to generate more food or income than a field otherwise would if managed for a single enterprise or a single crop (Gliessman, 2007). Integration of animals into a

Table 3. Income of integrated crop-livestock farming during 5 years

Year & Farming System	Income (Rp, Million)
Year 1, no-integration	14.37
Year 1, integration	22.70
Year 2, integration	26.77
Year 3, integration	28.88
Year 4, integration	30.94
Year 5, integration	33.20

Table 4. Farm efficiency of non-integration and crop-livestock integration in dry-land farming

Year	Farm Efficiency (B/C Rasio)		Improvement (%)
	No Integration	Beef Cattle Integration	
0	0.50	0.50	0.0
1	0.94	1.24	31.9
2	1.30	1.71	31.5
3	1.50	1.99	32.7
4	1.68	2.22	32.1
5	1.84	2.43	32.1

farm can increase land-use efficiency beyond that of crop-only farms. Animals may facilitate crop growth through manure deposition. One study from Cuba found that integrated dairy-crop farms had a higher land use efficiency than non-integrated farms, meaning that overall food production from the same amount of land was higher on the integrated farms (Funes-Monzote, 2009).

The Impact of Livestock Integration on Environmental Carrying Capacity

The environment carrying capacity of the crop-livestock farming was calculated based on the actual production of commodities include dried peanuts and corn seed weight, peanut and corn fresh weight stover, and beef cattle which were converteed to the unit price at local base. This current study (Table 5) revealed that the impact of beef cattle integration on the environmental carrying capacity was significant and increased gradually with the increase of the integration period. During five years period of beef cattle integration of peanut and maize farming, the environment carrying capacity increased from 1.24 up to 1.88 ha with an average of 1.46 ha.

Table 5. Environmental capacity of integrated crop-livestock farming during 5 years

Year & Farming System	Environmental carrying capacity (ha)
Year 0, no-integration	0.73
Year 1, integration	1.24
Year 2, integration	1.49
Year 3, integration	1.63
Year 4, integration	1.76
Year 5, integration	1.88

This calculation of the land carrying capacity reflects an increase of carrying capacity in term of the supply capacity aspects. In overall, increasing the land carrying capacity should consider to waste capacities aspects which indicate increasing soil fertility. In Central Java, animal manure is the most basic agricultural by-product as a fertilizer in agriculture. Integrating animals into crop production may provide a cost-effective on-farm source of soil fertility in the form of animal manure. Animals recycle nutrients contained in forage and feed and make them available in their excreta, thus becomes part of the on-farm nutrient cycle. Relative quantities of nitrogen, phosphorus, and potassium vary considerably among species, depending on the forage preferences

Table 6. Crop productivity of integrated crop-livestock farming during 5 years

Year & Farming System	Peanut Yield (dried peanut seed, kw/ha)	Maize Yield (dried corn seed, kw/ha)
Year 0, no-integration	1.44	0.73
Year 1, integration	6.68	8.94
Year 2, integration	7.32	23.11
Year 3, integration	8.79	23.58
Year 4, integration	10.22	24.17
Year 5, integration	10.88	30.32

of the animal as well as the supplemental feed the grower chooses to provide (Watson et al., 2005). Animal excreta can be applied in many ways in integrated systems, via deposition during free-range grazing or through application of raw or composted manure collected from animal barns (Hilmire, 2011). Animal manure can provide the soil organic matter, macronutrient, and trace mineral needs of the soil microbial community and crops being grown (Russelle et al., 2007) and potentially decrease the need for external inputs of purchased fertilizer.

Animal manure is an important natural resource in a sustainable livestock-crop farming system. Manure utilization is therefore an important component of a sustainable crop farming systems in order to optimize the use of livestock manures as organic fertilizers for cropping. Furthermore, improving soil fertility resulted in increasing crop productivity. The results of this study (Table 6) demostrated that beef cattle integration significantly affected the peanut and maize yields. The averages of crops yield of peanut and maize increased with the advance in the year of beef cattle integrated period at least up to the 5th years of beef cattle integration. Peanut Yield (PY) and Maize Yield (MY) crops could be described by regression equation: $PY = - 0.352X^2 + 3.456X + 2.146$ ($R^2 = 0.947$); $MY = -1.153X^2 + 11.31X + 0.765$ ($R^2 = 0.939$) where X was the period of beef cattle integration. Maughan et al. (2009) reported that soil quality enhancement in integrated systems is also associated with increased yield. A 4-year 2009 study assessed yield and soil quality under a cattle/corn integrated system in comparison to a system continuously cropped with corn. The study found significantly higher corn yield in the integrated system. Others researchers studied on the integration between crops and livestock made by farmers where fecal waste was used as organic fertilizer and agricultural waste was used to feed animals and therefore it is expected that the farming done integratedly can reduce production costs, solve the problem of shortage of chemical fertilizers, improve profits and sustainable (Priyanti et al., 2001; Rohaeni et al., 2006). The integration crops and animals enables synergistic interactions, which have a greater total contribution than the sum of their individual effects (Devendra, 2002; Devendra 2004; Devendra 2007; and, Devendra and Thomas, 2002) and ensure both ecological and economic sustainability.

Conclusions and Recommendation

The present study demonstrated that beef cattle is an essential part of the integrated crop-livestock farming systems in terms of improving economic productvity and farm efficiency, and ensuring the environmental carrying capacity of dry land farming. Crops yield of peanut and maize increased with the advance in the year of beef cattle integrated period at least up to the 5th years. In order to improve farmers' livelihoods and develop sustainable dry land farming systems in Sragen Regency of Central-Java, the changing of practical agriculture circumstances of farmer and especially farmer in dry land areas for peanut and maize production should receive more attention of researchers, government institutions and stakeholders.

Aknowledgement

We thank the participating farmers and the staff of the Kebun Pengembangan Pertanian Terpadu, Lembaga Pendidikan Pelatihan dan Penelitian Wiyata Dharma located at Geneng Duwur Village, Gemolong Distrik, Sragen Regency, Central-Java, for their kind support.

References

Adiwinarti R, CMS Lestari and DK Widyastuti. 2010. Efisiensi Penggunaan Pakan Jerami Padi dan Konsentrat pada Sapi Peranakan Ongole (PO) dan Peranakan Friesian Holstein (PFH). Prosiding Seminar Nasional Perspektif Pengembangan Agribisnis Peternakan di Indonesia. Faculty of Animal Husbandry, Jenderal Soedirman University, 10 April 2010. Page 177-181.

Anderson V and B Schatz. 2003. Biological and Economic Synergies, and Methods of Integrating Beef Cow and field Crops Enterprises. 2002 Unified Beef Cattle and Range Research Report. Dep. of Animal and Range Sci., Agric. Exp. Stn., North Dakota State Univ., Fargo. March 2003.

Asaad CO, FG Rivera, MM Palis, AO Yambot, JS Rojales, CR Bersabe, EB Bayalas, AJ Gonzales, PB Tigno, F Moneda and R. Cuevas. 2010. Integrated Approach in Improving Livestock-Crop Farming Using Indigenous Resources and Conserving the Environment. Improving Livestock Production Using Indigenous Resources and Conserving the Environment. Animal Production and Health Section International Atomic Energy Agency Vienna International Centre PO Box 100 1400 Vienna, Austria. 147-159.

BPS (Badan Pusat Statistik). 2007. Statistik Indonesia. BPS. Jakarta.

Devendra C. 2002. Crop–animal systems in Asia: future perspectives. Agric. Syst. 71:179– 186.

Devendra C. 2004. Organic farming—closing remarks. Lives. Prod. Sci. 90:67–68.

Devendra C. 2007. Perspectives on animal production systems in Asia. Lives. Sci. 106:1- 18.

Devendra C. 2011. Integrated tree crops-ruminants systems in South East Asia: Advances in productivity enhancement and environment sustainability. Asian Australian J. Anim. Sci. 24(5):587–602.

Devendra C. and D Thomas. 2002. Crop–animal interactions in mixed farming systems in Asia. Agric. Systems. 71(1-2):27-40.

Faridah A. 2001. Sustainable Agricultural System in Malaysia. Paper presented at Regional Workshopon Integrated Plant Nutrition System (IPNS), Development in Rural Poverty Alleviation, 18-20 September 2001, United Nations Conference Complex, Bangkok, Thailand.

Funes-Monzote FR, M Monzote, EA Lantinga, CHF Ter Braak, JE Sanchez and H Van Keulen. 2009. Agro-ecological indicators (AEIs) for dairy and mixed farming systems classification: Identifying alternatives for the Cuban livestock sector. J. Sustainable Agric. 33:435–460.

Ghebremichael LT, TL Veith, PE Cerosaletti, DE Dewing and CA Rotz. 2009. Exploring economically and environmentally viable northeastern US dairy farm strategies for coping with rising corn grain prices. J. Dairy Sci. 92:4086–4099.

Gliessman S. 2007. Agroecology: The Ecology of Sustainable Food Systems. 2nd ed. New York, CRC Press.

Godfray HCJ; Beddington JR; Crute IR; Haddad L; Lawrence D; Muir JF; Pretty J; Robinson S; Thomas SM; Toulmin C. 2010. Food security: the challenge of feeding 9 billion people. Science. 327:812–818.

Gupta V, PK Rai and KS Risam. 2012. Integrated crop-livestock farming system : a strategy for resource conservation and environmental sustainability. Indian Res. J. Extension Education, Special Issue II: 49-54.

Hartadi H, S Reksohadiprodjo, S Lebdokusumo, AD Tillman, C Kearl and LE Harris. 1980. Table of Feed Composition for Indonesia. Published by the International Feedstuffs Institute Utah Agricultural Experiment Station, Utah State University Logan, Utah.

Khan N. and MdA Iqubal. 2010. Livestock revolution and its impacts on the sustainability of margial and small farmers in India : a case study. J. Geography. 5(2):95-108

Hilimire K. 2011. 2011. Integrated crop/livestock agriculture in the United States: A review. J. Sustainable Agric. 35:376–393.

KNLH (Kementerian Negara Lingkungan Hidup). 2009. Peraturan Menteri Negara Lingkungan Hidup Nomor 17 Tahun 2009 Tentang Pedoman Penentuan Daya Dukung Lingkungan Hidup dalam Penataan Ruang Wilayah. 40p.

Landers JN. 2007. Tropical Crop–Livestock Systems in Conservation Agriculture: the Brazilian

Experience. Integrated Crop Management 5. Food and Agriculture Organization of the United Nations, Rome, Italy. 92p.

Lestari CMS, R Adiwinarti, M Arifin and A Purnomoadi. 2011. The performance of Java and Ongole Crossbred Bull under intensive feeding management. J. Indonesian Trop. Anim.Agric. 36(2):109-113.

Maughan MW, JPC Flores, I Anghinoni, G Bollero, FG Fernandez and BF Tracy. 2009. Soil quality and corn yield under crop-livestock integration in Illinois. Agronomy J. 101:1503–1510.

Minardi S. 2009. Optimalisasi Pengelolaan Lahan Kering untuk Pengembangan Tanaman. Pidato Pengukuhan Guru Besar Ilmu Tanah Pada Fakultas Pertanian Universitas Sebelas Maret. Surakarta, 26 Pebruari 2009.

Pemkab (Pemerimtah Kabupaten) Sragen. 2011. Peraturan Daerah Kabupaten Sragen Nomor 11 Tahun 2011. Pemerintah Kabupaten Sragen.

Powell JM, DB Jackson-Smith and LD Satter. 2002. Phosphorus feeding and manure nutrient recycling on Wisconsin dairy farms. Nutrient Cycling in Agroecosystems 62:277–286.

Priyanti A, T Kostaman, B Haryanto and K Diwyanto. 2001. Study of the economic value of cattle business through the utilization of rice straw. Wartazoa. 11(1):28-35.

Rohaeni ES, N. Amali, Sumanto, A Darmawan and A Subhan. 2006. Assessment of integration of maize and cattle farming in dryland Tanah Laut, South Kalimantan. J. Agric. Technol. Asses. and Dev. 9(2):129-139.

Russelle MP, MH Entz and AJ Franzluebbers. 2007. Reconsidering integrated crop-livestock systems in North America. Agronomy J. 99:325–334.

Suntoro. 2003. Peranan Bahan Organik Terhadap Kesuburan Tanah dan Upaya Pengelolaannya. Pidato Pengukuhan Guru Besar Ilmu Kesuburan Tanah Fakultas Pertanian Universitas Sebelas Maret. Surakarta.

Wahyudi. 2006. Penelitian nilai nalor biomassa: perbandingan antara hasil pengujian dengan hasil perhitungan . J. Ilmiah Semesta Teknika. 9(2):208-220.

Watson CA, I. Oborn, J Eriksen, and AC Edwards. 2005. Perspectives on nutrient management in mixed farming systems. Soil Use and Management. 21:132–140.

World Bank. 2008. World development report 2008: agriculture for development. Washington, DC. 365 p.