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Introduction.

Robusta coffee (*Coffea canephora*) and **black pepper** (*Piper nigrum*) are important cash crops grown in the **Central Highlands (CH)** of Vietnam, covering **710** and **270 thousand ha**, respectively, and crucial to the livelihoods of CH's farmers (GSO, 2022). Recently, farmers have begun **diversifying** their **cropping systems**. As a result, various systems can now be observed in the CH, ranging from monocultures to diversified cropping systems with coffee, pepper, and fruit trees. However, **diversification impacts farmers' production costs and labor requirements** (Phan et al. 2019). To better understand these impacts, the present study introduces early findings of a survey on **labor and economic performances** in CH's **coffee-pepper-fruit trees cropping systems**.

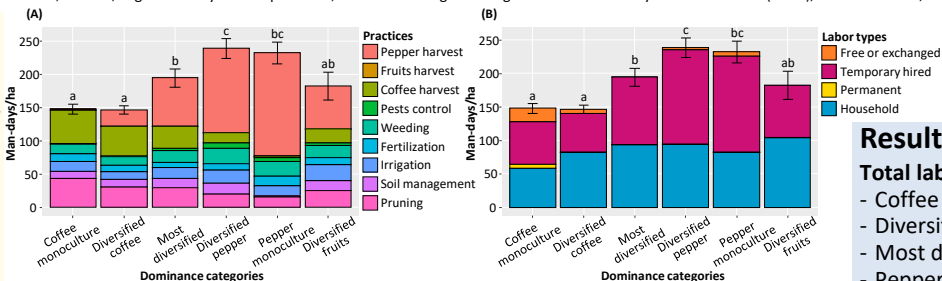


Figure 1: Labor in man-days per hectare, (A) per dominance category for each type of practice, and (B) per dominance category for each type of labor. Significant differences in total labor are denoted by different letters obtained after post-hoc multiple comparisons based on the fitted generalized linear mixed model with FDR-adjusted *p*-values and $\alpha = 0.05$. Error bars represent standard errors of the means.

Results/Discussion.

Total labor demands:

- Coffee systems : 147 – 148 man-days
- Diversified fruits systems: 183 man-days
- Most diversified systems: 195 man-days
- Pepper systems: 232 – 239 man-days

Labor demand by practice:

Pepper harvest > Coffee harvest > Pruning > Weed control > Irrigation > Soil management > Fertilization > Pest Control > Fruits harvest

Total labor share by type of labor:

- Family labor: 36 – 57%
- Temporary hired: 39 – 61%
- Permanent: 0 – 3%
- Free or exchanged: 0 – 13%

Gross margins range: 77.8 – 112.7 million VND/ha

Return to labor range: 0.48 – 0.92 million VND/day

Materials/Methods.

Socioeconomic survey on 239 households in Dak Lak, Dak Nong, and Gia Lai provinces conducted as part of ACIAR-funded V-Scope project.

Stratified sampling to study **labor** (duration by practice and type of labor) and **economic performances** (gross products, costs, gross margins and return to labor) of coffee-pepper-fruit trees cropping systems at plot level.

Plots (n = 246) categorized based on **density equivalent ratio (DER)** (Malézieux et al., 2009) and **crop dominance** indices calculated as follow:

$$DER_{crop_i} = \frac{Density_{crop_i}}{Density_{crop_i \text{ in monoculture}}}$$

$$DER_{plot} = \sum DER_{all \ crops} \text{ and } DER_{fruits} = \sum DER_{all \ fruit \ crops}$$

$$Dominance_{crop_i} = DER_{crop_i} / DER_{plot}$$

Cropping systems groups:

- Coffee monoculture systems (coffee dominance = 1)
- Diversified coffee systems ($0.5 < \text{coffee dominance} < 1$)
- Most diversified systems (all indices of dominance ≤ 0.5)
- Diversified pepper systems ($0.5 < \text{pepper dominance} < 1$)
- Pepper monoculture systems (pepper dominance = 1)
- Diversified fruit trees systems ($0.5 < \text{fruit dominance} < 1$)

Economic indicators (million VND per ha)

| Dominance category | Coffee mono. | Divers. coffee | Most divers. | Divers. pepper | Pepper mono. | Divers. Fruits |
|----------------------|-----------------|-----------------|------------------|------------------|------------------|------------------|
| Gross product | 157.5 +/- 7.7 a | 159.6 +/- 6.8 a | 162.0 +/- 13.3 a | 172.0 +/- 12.5 a | 152.1 +/- 20.4 a | 141.2 +/- 16.9 a |
| Costs of inputs | 36.9 +/- 2.5 ab | 35.1 +/- 2.2 a | 34.6 +/- 2.9 a | 49.9 +/- 3.1 b | 45.8 +/- 3.4 ab | 29.5 +/- 5.6 a |
| Costs of hired labor | 13.8 +/- 1.6 ab | 11.7 +/- 1.1 a | 20.2 +/- 2.3 bc | 28.1 +/- 2.5 c | 28.4 +/- 2.9 c | 15.6 +/- 4.1 abc |
| Total costs | 50.7 +/- 3.5 a | 46.8 +/- 2.5 a | 54.8 +/- 4.6 a | 78.0 +/- 4.6 b | 74.2 +/- 4.9 b | 45.1 +/- 8.4 a |
| Gross margin | 106.8 +/- 7.1 a | 112.7 +/- 6.6 a | 107.1 +/- 13.6 a | 94.0 +/- 11.7 a | 77.8 +/- 19.1 a | 96.1 +/- 14.8 a |
| Return to labor* | 0.92 +/- 0.07 a | 0.92 +/- 0.06 a | 0.74 +/- 0.09 ab | 0.57 +/- 0.06 b | 0.48 +/- 0.09 ab | 0.84 +/- 0.26 ab |

*Return to labor is expressed in million VND per man-day (= gross margin without labor costs/total labor)

Table 1. Economic indicators per dominance category. All means are expressed million VND per ha, except for return to labor expressed in million VND per man-day. Significant differences are denoted by different letters obtained after post-hoc multiple comparisons based on generalized linear mixed models with FDR-adjusted *p*-values and $\alpha = 0.05$. Standard errors of the means are indicated after +/-.

Conclusion/Perspectives. As **labor requirements** emerge as a **key factor** in explaining farmers' decision-making, this research presents **labor dynamics** and **overall profitability** of coffee- and pepper-led cropping systems in the CH. Given the inherent **volatility of commodity prices** and the **potential for shifts in labor wages**, the **profitability** of these **labor-intensive systems** could be **significantly affected**. The results seek to provide valuable insights for optimizing agricultural practices and enhancing the efficiency and sustainability of **smallholder coffee- and pepper-based farming systems**.

References. GSO (2022). Socio-economic situation report in the fourth quarter and 2022. Ministry of Planning and Investment
 Malézieux et al. (2009). Mixing plant species in cropping systems: concepts, tools and models. *Agron. Sustain. Dev.* 29, 43–62
 Phan et al. (2019). Economic analysis of perennial crop systems in Dak Lak Province, Vietnam. *Sustainability* 11:81