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Review Article

Towards Cultivating Black Pepper Using Geospatial Technology for Growth Monitoring and Mapping: A Review for Small Scale Practice in Malaysia

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Abstract: Alternative to black pepper cultivation is crucial to level up the productivity of crops. Application of geospatial technology in black pepper cultivation which has been classified as small scale agricultural activity is seen to enhance their production. In this paper, we use a comprehensive study on journal papers, conference proceedings, formal web sites and books as fundamental sources of information. Firstly, the study reviews on current black pepper cultivation and related producers in Malaysia. Secondly, it focused on geospatial technology especially on remote sensing and crop growth monitoring that have been implemented and well established. Lastly, limitation to implement geospatial technology on black pepper cultivation in Malaysia situation was discussed. Therefore, it is predicted that geospatial technology will improve black pepper productivity and implementation of this technology on small scale cultivation requires consolidation from various agencies since it requires high investment and foundation.

Keywords: black pepper; precision farming; crop growth monitoring; crop mapping; remote sensing

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1. Introduction

Black pepper is one of the important global commodity crops with increasing demand due to its multipurpose usage in human life (Abraham, 2018). It was also known as the 3rd most popular spices used in food ingredient (Kumar & Swarupa, 2017). In recent, black pepper is grown in about 26 countries and occupies 500,000 ha with the productivity of 790.2 kg/ha (Krishnamoorthy & Parthasarathy, 2009; Kumar *et al*., 2017; Paduit *et al.*, 2018). Vietnam, Indonesia, Brazil, Malaysia, and Thailand were recorded among the highest production of pepper around the world (Teuscher *et al*., 2016; Jasni *et al*., 2017; Sanny *et al*., 2018). Among the producer countries of black pepper, Malaysia contributes 7–8% of global market and it internationally traded as Sarawak pepper (Ravindran & Kallupurackal, 2012). However, black pepper is categorized as one of the perennial crops with high demand of nutrients (Yap, 2012a; Sulok *et al*., 2018), low productivity due to management and pest disease problems (Rosli *et al.*, 2013; Kamarudin *et al.*, 2013; Yap & Jarroop, 2018). Therefore, maintaining black pepper productivity is important to fulfil the demand for pepper market.

The National Policy on Industry 4.0 also known as Industry 4WRD is one of the initiatives by the government of Malaysia to enhance the implementation of precision agriculture in the industry (Ministry of International Trade and Industry, 2018). Precision agriculture has been popularized since the evolution of industrial revolution (IR) was introduced in the late 1960s. The concept of precision agriculture relies on monitoring, collecting and interpreting data which enable to create growing condition that is linked together continuously (Charyulu *et al*., 2019; Zambon *et al*., 2019). Besides, the concept requires producers and farmers to communicate with technology rather than operating them. This process integrates the combination of information technology tools to emphasize understanding on cultivated land and improve the management, quality of produces and environment respectively (Fardusi *et al.*, 2017). Therefore, implementation of geospatial technology for black pepper cultivation is suggested to ensure the productivity of black pepper, healthy environment and profitable income in the future.

Hence, this paper has the following objectives (1) to identify the gap and requirement needed for black pepper cultivation to improve their productivity (2) to provide an overview on related geospatial technology suitable for black pepper growth monitoring and (3) to discuss the limitation of geospatial technology for small scale cultivation practices.

2. Black Pepper Cultivation Scenario in Malaysia

Black pepper is a perennial crop of humid tropics, requires an adequate amount of humidity, rainfall and temperature (Sivaraman *et al*., 1999; Srinivasan *et al*., 2007). Cultivation of black pepper is recommended at soils ranging from heavy soil to light sandy clays that rich in humus since nutrient absorption commonly focus on top 50 – 60 cm layer of the soil (Sivaraman *et al*., 1999). In Malaysia, black pepper mostly cultivated in Sarawak with laterites type of soil (Oxisol). However, the inadequacy of soil nutrient is one of the crucial problems notably for supplying nutrient to the crops (Abd Hamid & Wan Yahaya, 2019).

Black pepper are recommended to be planted at 2.0 m x 2.4 m or 2.4 m x 2.4 m. Planting of cover crop and terracing are also suggested considering the hilly planting area with more than 40 degrees in most farm to conserve the soil (Malaysia Pepper Board, 2018b). Nonetheless, most of the farms in Sarawak, practising weeds cleaning with minimal consideration on the soil (Abd Hamid & Wan Yahaya, 2019) and nutrient requirement for the crop growth. Concurrently, this commodity crop experience declining in market prices (see Figures 1 and 2) as a result of domestic and international market factors.

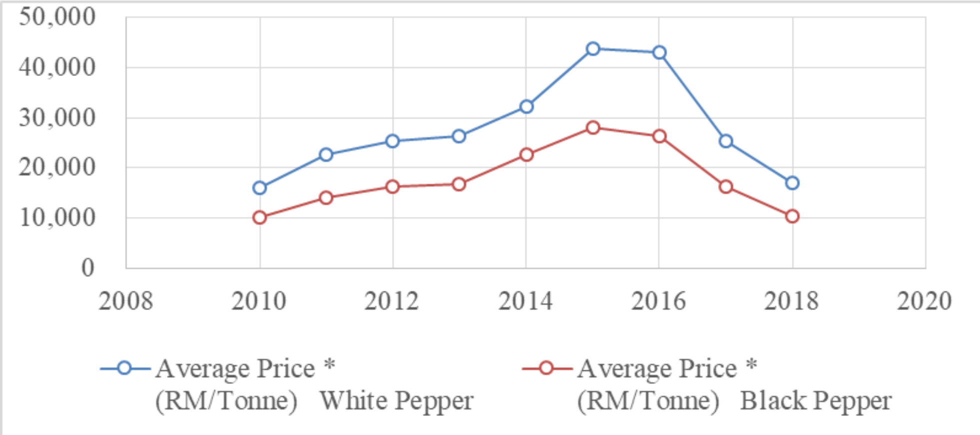

Figure 1. Average pepper price in Kuching, Sarawak (Malaysia Pepper Board, 2018).

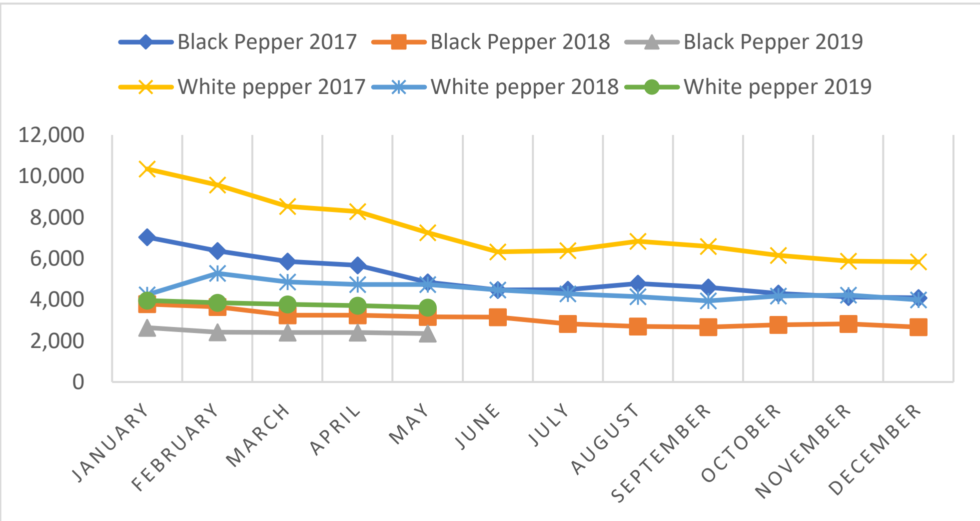

Figure 2. Composite price of black pepper and white pepper from 2017 to May 2019 (International Pepper Community, 2019).

Growth of black pepper veins requires proper fertilizer management along with their growing stages (Yap, 2012b) with good structure and water-holding capacity (Srinivasan *et al.*, 2007). Cultivation of pepper farm majorly conducted by small farmers, rarely implement the usage of technology (Bermawie *et al.*, 2019) and varies in term of soil, climatic conditions, demographic and socioeconomic (Paduit *et al*., 2018; Rosli *et al*., 2013).

In terms of nutrient uptake, growth of black pepper vines are influenced by macronutrients such as N, P, K, Ca and Mg (Srinivasan *et al.*, 2007; Yap, 2012a) and micronutrients such iron, zinc, manganese, molybdenum (Abd Hamid & Wan Yahaya, 2019). However, the responses by each individual vine may varies depends on its varieties, environment, and biophysical characteristic of the area. According to Yap (2012b), the growth stages of black pepper can be differentiate into three stages (refer Figure 3). However, precise information on individual vein or even at different stages are still not being discovered. Hence, the needs for implementing geospatial technology is suggested in order to fulfil this gap.

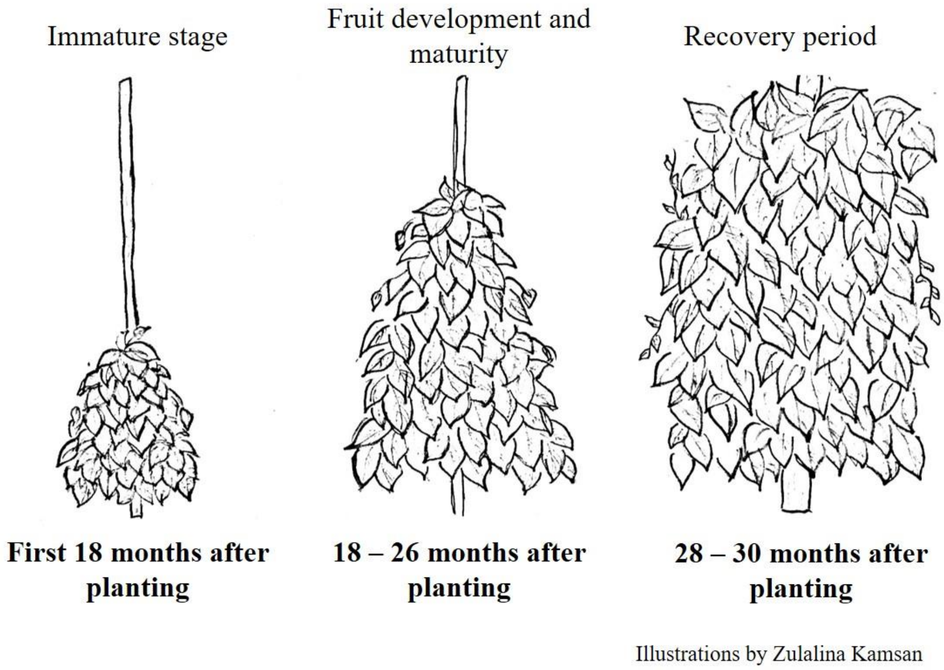

Figure 3. Growth stages of black pepper 30 months after planting. Illustration adapted from Yap (2012b).

Although the description for black pepper needs and requirements have been explained in general, detail information is scarce since the cultivation of this crop is varying. Improvement on black pepper cultivation that have been conducted until now is summarized in Table 1.

Table 1. Studies related with black pepper for cultivation amendment.

	Purpose of the study	Geospatial instrument	Methods of Analysis	Study Gap
(Kandiannan *et al.*, 2002)	Identifying method to estimate individual leaf area-efficient	Electronic leaf area meter LI-3000A (LI - COR)	Allometric relationship Logarithm transformation	Crop growth condition status

	Purpose of the study	Geospatial instrument	Methods of Analysis	Study Gap
(Yap, 2012b)	Study the effect of chemical and organic fertilizers on some physiological characteristics, yield and soil fertility	Leaf area meter (CI - 202 Laser Area Meter Potable photosynthesis system (PPS System, model TPS 200) Statistical Package for Social Science (SPSS)	Leaf area index Chlorophyll content Photosynthetic rate Transpiration rate One-way Analysis of Variance (ANOVA) Duncan Multiple Ranged test(Yap, 2012b)	The nutrient requirement at different stages
(Hao *et al.*, 2012)	Understanding bioclimatic distribution, maximum entropy based on ecological niche modelling for black pepper cultivation	Maxent software ver.2.3 GIS software ArcView GIS ver.3.2	Jackknife evaluation Ecological Niche Modelling (ENM) WorldClim bioclimatic data	Preferable ecology for black pepper in Malaysia
(Kho & Shang, 2016)	Establishment of new planting material cultivation methods for high production	-	W-configuration V-configuration Single post or normal planting (ANOVA) by SPSS Statistic Version 16.0 ROI analysis	New planting management requirement
(Yap, 2016)	Study the effect of foliar fertilizer when used in combination with soil NPK fertilizer on different growth parameters of the Cultivar Semongok Aman	-	Phytohormone analysis free amino acids analysis	Specific amount of fertilizer required by single vein
(Sulok ***et al***., 2018)	Introducing natural farming	-	-	Soil and water availability for black pepper crop

	Purpose of the study	Geospatial instrument	Methods of Analysis	Study Gap
	on black pepper cultivation			

In conclusion, there are gaps of study in black pepper cultivation and management which involve nutrient requirements and uptake by black pepper vein. Therefore, introducing geospatial technology to monitor the growth and condition of the crops may enhance the black pepper cultivation and productivity.

3. Geospatial Technology and Its Implementation in Malaysia

Geospatial technology is one of the categorizations in precision agriculture where the integration of technologies such as geographical information system (GIS), global navigation satellite system (GNSS) and remote sensing, resulting in decision making through accurate and timely manner data collection and analysis (Martinez, 2017; Prim, 2017). Data sources of geospatial can be obtained as spatial product or spectral resolution (Rudiyanto *et al*., 2019). Analysis of geospatial application for agriculture sector may encompass biophysical characteristics, growth monitoring, yield forecasting and market prediction (Nurmiaty *et al*., 2019).

Demand for geospatial technology and their service in Malaysia are still at the implementation level where the adaptation focusing mostly on large scale cultivation area such as for oil palm and paddy. This precision technology carried out activities which used sensor system and variable rate nutrient for crop, soil, pest diseases and water management (Geospatial Media and Communication, 2015). Therefore, by implementing the geospatial application in black pepper may improve black pepper productivity regardless of their variation in land agroecology and climate. Besides, the analysis may encompass biophysical characteristics, growth monitoring, yield forecasting and market prediction (Nurmiaty *et al*., 2019).

4. Crop Growth Monitoring System (CGMS) Based on Geospatial Application

Nowadays, monitoring of crop growth using the integration of geospatial based technologies have started to arise. The systems are implemented both in macro (such as mapping, surveying, land use and land cover classification) and micro levels of agricultural activities (such as mapping of ground water resources, drainage pattern, variable rate application and input management) (Geospatial Media and Communication, 2015*;* Chong *et al*., 2017). A framework to establish CGMS is described by Clevers *et al*., (1994) which focusing on integrating optical remote sensing data from various sources to estimate the parameters such as leaf area index (LAI), leaf angle distribution (LAD), and leaf colour (optical properties in the photosynthetically active radiation (PAR) region). Table 2 presents detailed system of CGMS that have been developed around the world. Global Information and Early Warning System (GIEWS) is meant to be the first crop growth monitoring model developed and provided information on food production. Modification of certain system is done to establish other monitoring systems based on specific region and crops interest.

Table 2. Crop growth monitoring systems around the world.

System	Year of establishing	Input/Parameter	Output of system
Global Information and Early Warning System (GIEWS) (FAO, n.d.)	1970	• Auxiliary data • Rainfall estimate • NDVI • Agriculture stress index (ASI) 2013	• Regular bulletin • Market on global scale • Specific regional report
Famine Early Warning System Network (FEWSNET) (Funk & Verdin, 2009)	1985	• Agro-climatology data • Field assessment • Market price monitoring • Nutrition surveillance conflicts	• Decision support to food assistance programs • Quantify chances in planting area with crop yield
World Food Studies (WOFOST) (Diepen & Wit, 2014)	1986	• Weather data • Crop data • Soil water balance data	• Growth and crop production analysis
Monitoring Agriculture with Remote Sensing (MARS) Crop Yield Forecasting System (MCYFS) (Boogard, *et al*., 2007)	1992	• Weather data • Crop model simulation • Biophysical parameter	• Operational estimate area • Yield and production • Independent evidence • Crop maps
Crop watch (Wu *et al*., 2015)	1998	• Global • Rainfall, temperature, photosynthetically active radiation, potential biomass • Regional • Vegetation health index, vegetation condition index • National / Sub - regional • Detailed crop conditional analysis	• Timely, reliable, independent prediction of crops condition and production within China and global
United States Department of Agriculture — Foreign Agriculture Services (USDA — FAS) (Baruth *et al*., 2008)	2001	• Extraction and process of agrometeorological data • Visualize data from TOPEX/Poseidon Jason - 1 Satellite • GLAM Project (2002) • Semi - automated classification algorithm and remote sensing	• Prediction of global crop production • Market intelligence
China Agriculture Remote Sensing Monitoring System (CHARMS)	2001	• Weather data • Crop characteristics data • Soil information data • Field survey data	• Crop growth condition at different level of aggregation

System	Year of establishing	Input/Parameter	Output of system
(Huang *et al*., 2011)		• Administrative region vector data • Agro - meteorological modelling • Statistical analysis tools	
GEOGLAM (Fritz *et al*., 2019)	2011	• Crop growing conditions • Crop status • Agro - climatic conditions	• Agricultural market assessment system
World Food Program Seasonal Monitor (Fritz *et al*., 2019)	2014	• Near real - time rainfall estimate (CHIRPS) • NDVI - MODIS • Anomalis of parameters • Seasonal explorer data • Price forecast information	• Monitoring of growing season status • Early warning • Visualized platform from World Food Program (WFP)
Anomally HotSpots of Agriculture Production (ASAP) (Rembold *et al*., 2017)	2017	• Rainfall estimation • NDVI - Remote sensing • Agricultural Monitoring Experts • Earth observation analysis • Weather data	• Unfavourable growing area identification for crops and rangeland

4.1 Remote Sensing-Based Mapping

Mapping using remote sensing is one of the essential fundamental for crop growth monitoring. The component helps in producing accurate crop maps throughout their growing season (Li & Chen, 2011; Song *et al.*, 2017; Sousa & Small, 2019) hence reassure for precise decision making. Recently, increase application of remotely sensed data for monitoring altered by the availability of open data, advanced machine learning methods, and access to cloud computing platforms to handle big data storage and processing (Kussul *et al*., 2018; Rudiyanto *et al*., 2019). Apart from that, these methods also provide a cost-effective and site-specific assessment for monitoring the crop growth condition in real-time (Carolita *et al*., 2018).

Satellite data sources for mapping can be obtained through optical product (Landsat, Sentinel-2, MODIS, RapidEye, SPOT and PROB-V) and synthetic aperture radar (SAR) or microwave product (Sentinel-1, RADARSAT) (Rudiyanto *et al*., 2019). Optical systems measure reflected sunlight and provide spectral properties of their targets. This system is known to be susceptible to the environment especially on cloud cover which resulting in difficulties for image classification and discrimination (Tan *et al.*, 2012; Kussul *et al.*, 2018). Whilst, SAR or microwave data are more stable towards atmosphere factors. As mentioned by Zainol *et al.*, (2019) feasible use of hyperspectral sensing for discriminating vegetation species and its potential use for habitat mapping .

However, selection of this method requires a better understanding of the complex relationship between the object and sensor parameter such as frequency, polarization setting and incidence angle (Yuzugullu *et al*., 2017). Images data were collected through the reflection of (red, green, blue and near-infrared, NIR) wavelength (Fieuzal *et al*., 2016). Berhane *et al*., (2018) approach mentioned that, combination of few nonparametric classifiers such as decision-tree-rule-based (RB), random forest (RF) can be coupled to improve overall accuracy (OA) of the image results produced. Table 3 shows satellite types that are commonly used in agricultural industry.

Table 3. Types of satellite commonly used for agriculture studies.

Types of satellite	Launch year	Resolution	Revisit cycle	Spectral band (μm)
Landsat 7ETM	1999	15–60 m	16 days	Blue (0.44–0.5) Green (0.52–0.60) Red (0.63–0.69) NIR (0.77–0.90) SWIR 1 (1.55–1.75) TIR (10.31–12.36) SWIR 2 (2.06–2.35) Pan (0.52–0.90)
MODIS	2000	500 m	1–2 days	**Bands are depending on its primary use. Available bands:* 1 (620–670), 2 (841–876), 3 (459–479), 4 (545–565), 5 (1230–1250), 6 (1628–1652), 7 (2105–2155), 20 (3.66– 3.840), 21 (3.929–3.989), 22 (3.929–3.989), 23 (4.020–4.080), 31 (10.780–11.280), 32 (11.770–12.270)
SPOT 5	2002	5–20 m	2–3 days, depending on latitude	Red (610–680) NIR (780–890) SWIR (1,580–1,750)
RapidEye (5 m)	2008	5m	Daily (off-nadir)/5.5 days (at nadir)	Blue (0.44–0.51) Green (0.52–0.59) Red (0.63–0.69) Red Edge (0.69–0.73) NIR (0.76–0.85)
SPOT 6	2012	1.5m (5–10 m accuracy)	Provide option of daily revisit	Blue (0.45–0.52) Green (0.53–0.59) Red (0.63–0.70) NIR (0.76–0.90)
Landsat 8	2013	15–30 m	Circle the earth every 98.9 minutes	Blue (0.45–0.51) Green (0.53–0.59) Red (0.64– 0.67) NIR (0.85–0.88) SWIR 1 (1.57–1.65) TIR 1 (10.6–11.2) TIR 2 (11.5–12.5) SWIR 2 (2.11–2.29) Cirrus (1.36–1.38) Pan (0.50–0.68)
Project for on Board Autonomy (PROBA-V)	2013	1 km–300 m	90 % daily coverage of equatorial zones and 100 % two-daily imaging	Blue (0.46; FWHM 0.042) Red (CWL 0.66; FWHM 0.082) NIR (0.83; FWHM 0.012) SWIR (1.61; FWHM 0.089)
Sentinel-2	2015		10 days at the equator with one satellite, five days with two satellite	Coastal (0.442) Blue (0.492) Green (0.559) Red (0.665) Vege Red (0.704) Vege Red (0.739) Vege Red (0.780) NIR (0.833) Narrow NIR (0.864) Water Vapour (0.943) SWIR Cirrus 1.377 SWIR (1.610) SWIR (2.186)

(NIR — Near Infrared, SWIR — Shortwave Infrared, CWL Central wavelength, FWHM — Full width at half maximum).

Therefore, in monitoring black pepper growth and condition, mapping based on satellite might give advantages in reducing cost and provide more accurate real-time data since this crop are labour dependent. However, to obtain clear and concise data from remote sensing sometimes withstanding issues like clouds cover and low spectral resolution which require expertise to handle such situation.

4.2 Unmanned Aerial Vehicle (UAV) based Mapping

Unmanned aerial vehicles (UAV) have been used for range of purposes including soil sampling, irrigation management, precision spraying, mechanical weeding, and crop harvesting (Bonadies *et al*., 2016; Mat Su *et al*., 2017). Apart from remote sensing based satellite images, UAV started to get attention among agricultural practitioner considering their capabilities to monitor (Chang *et al.*, 2017) and capture clearer image at specific height (Grenzdörffer, 2014) without the disturbance of cloud cover. Besides that, classification methods from UAV images may exhibits the effect of salt and pepper of the data *(*Chen *et al*., 2019). Despite its capabilities, this UAV are rarely being implemented on small scale cultivation since it requires high investment and skills to handle this technology. Hence, a better approach needs to be strategized either by the authority or responsible organization in order to enhance the application of UAV on small scale cultivation.

4.3 Monitoring Assessment

To improve crops productivity, farmers need to have detailed understandings on crop growth status during specific development stage throughout the growing season (Du & Noguchi, 2017). Using geospatial technology, monitoring of black pepper might help in reducing cost of production since black pepper are recorded as one of the commodity crops with high production cost issues (Kamarudin *et al*., 2013; Paduit *et al*., 2018). Detection of individual crops change based on variation of colour through satellite image (Martinez, 2017) may help to identify neither nutrient requirement nor pest or disease infection on individual vines hence fill in the gap on black pepper total nutrient uptake and distribution in different parts (Paduit *et al*., 2018).

Analyzation of vegetation indices calculation such as normalized difference vegetation index (NDVI), leaf area index (LAI), ratio vegetation index (RVI), and perpendicular vegetation index (PVI) (Panda *et al*., 2010; Martinez, 2017; Xue & Su, 2017) will derive an equation obtained from different shades of colour obtained from the images thus resulting an information for decision making (Raeva *et al*., 2019). Through the model, growth monitoring activity might grow and successful of each model will lead towards a better system as grown in other developed countries (Sharifi, 2000; Meng *et al*., 2006; Huang *et al*., 2011). The difference in reflected waves of different green leaves and crops canopy enable various analysis such as crop classification, pest disease detection and growing pattern of the crop from time to time. In Malaysia, monitoring of crops using geospatial only focus mostly on rice (refer Table 4) and large-scale cultivation commodity crops such as oil palm.

Hence, implementing geospatial application for black pepper are expected to show progression for the crops and arouse improvement on other small-scale cultivation in Malaysia.

Table 4. Geospatial application for crop monitoring.

	Area of study	Purpose of study	Subject of Study	Geospatial instrument	Methods of Analysis
(Sousa *et al.*, 2019)	Mapping and monitoring	Mapping and monitoring using optical and thermal measurement	Rice	Landsat 4–8 image time series.	• Spatiotemporal characterization • Temporal mixture modelling
(Franch *et al.*, 2019)	Forecasting	Developing new crop model based on Difference Vegetation Index (DVI) extracted from MODIS data	Winter wheat	MODIS	• (DVI)
(Defourny *et al.*, 2019)	Monitoring	Propose methods and develop an open source system suitable for most cropping systems.	Maize Vegetables Wheat Sunflower Rapeseed Soybean Rice Cassava wheat-oat Sorghum Millet Sesame Cotton Barley Fodder crops Oilseed crops	Copernicus Sentinel-2	Sen2-Agri system
(Li *et al.*, 2019)	Monitoring and classification	Exploring the potential of L-band fully polarimetric UAVSAR for monitoring and classification of crops	Almond Walnut Alfalfa Winter wheat Corn Sunflower tomato	Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)	· Linear polarization (HH, HV, VV) · Polarimetric decomposition (Cloude-Pottier & Freeman-Durden)
*(Rudiyanto *et al.*, 2019)	Mapping, monitoring and phenology study	Mapping and monitoring of rice growth extent and cropping patterns over a large area.	Rice	• Temporal Sentinel-1 Google Earth Engine (GEE) cloud-based platform.	• K-means clustering • Hierarchical cluster analysis (HCA) · Visual interpretation of VH polarization

	Area of study	Purpose of study	Subject of Study	Geospatial instrument	Methods of Analysis
					time series profile
(Kern *et al*., 2018)	Forecasting	Yield simulation using multiple linear regression model	Winter wheat Rapeseed Maize sunflower	• Open Database for Climate Change Related • Impact Studies in Central Europe (FORESEE) • Medium-Range Weather Forecast (ECMWF) ERA-Interim database • MODIS sensor on Terra satellite	• Multiple linear regression models - Co-linearity - Country-level models - Meteorological data - Soil data • NDVI
*(Che Ya *et al*., 2018)	Monitoring	Early stage of crop monitoring	Rice	• RGB digital camera • Multirotor UAV	• Spatial analysis
*(Abd Hamid *et al*., 2017)	Monitoring	Identification of spatial distribution of N, P, and K at two pepper farms planted in hilly topography	Black pepper	• ArcGIS	• Conceivable correlation • Kriging interpolation method
(Carolita *et al*., 2018)	Monitoring and phenology study	Growth profile analysis to estimate productivity age of oil palm	Oil Palm	• SPOT 6	• NDVI analysis • Regression analysis
*(Mohd Hazir & Tuan Muda, 2018)	Mapping and classification	Viability determination of spectral analysis to detect rubber smallholdings using satellite imagery	Rubber	• Landsat 8 OLI	• False Colour Method • Unsupervised Classification • Supervised Classification • Twenty-seven Spectral Vegetation Indices (SVIs)
(Chang *et al*., 2017)	Monitoring	Monitoring of Sorghum (*Sorghum bicolor)* using an Unmanned Aerial System (UAS)	Sorghum	• UAV-DJI Phantom 2 vision platform, 14 • Ground control point (GCP) • Real-time kinematic (RTK) GPS unit	• Processing of UAS data - Digital Terrain Model (DTM) - Digital Surface Model (DSM)

	Area of study	Purpose of study	Subject of Study	Geospatial instrument	Methods of Analysis
					• Crop Height Model (CHM) generation • Plant height extraction • Growth analysis with growth curve
(Fieuzal *et al.*, 2016)		Yield estimation using artificial neural networks	Corn	• Optical data - Formosat-2 - SPOT 4/5 • Microwave data - TerraSAR-X • Radarsat-2	• Diagnostic approach • Real-time approach
*(Ghobadifar *et al.*, 2016)	Monitoring	Detection of sheath blight using spot 5	Rice	• SPOT 5	• ENVI 4.8 • SPSS software
(Nandibewoor *et al.*, 2015)	Monitoring	Remotely monitoring maize crop	Maize	• Landsat 8 OLI/TRIS	• MATLAB (2011a) Tool • NDVI analysis
* (Rowshon & Amin, 2010)	Monitoring	GIS-based irrigation water management for rice	Rice	• MapBasic	• Water balance model • Cumulative Relative Water Supply (CRWS) • Ponding Water Index (PWI) • GIS user-interface development

** Indicates the study was conducted in Malaysia.*

5. Limitations to Implement Geospatial Technology on Black Pepper Cultivation

Earth observation (EO) has now considered as easily accessible data since the data can be retrieved freely (Kussul *et al*., 2018). Reliable and accurate crop classification maps are an important data source for agricultural monitoring and food security assessment studies (Orynbaikyzy *et al*., 2019). Anyhow, to obtain reliable data for small scale cultivation such as black pepper is challenging since the activities are done by small farmers and their location are mostly not a hot spot in order to be recorded frequently. Apart from that, geospatial technology requires specialists in order to run the analysis especially during implementation level yet, Malaysia is still not enough of expertise in this industry. Government policies are known to be one of the important drivers of technology utilization (Geospatial Media and Communication, 2015). Thereupon, both public and private agencies are needed in order to enhance the growth of this technology to be adapt in small scale crop cultivation.

Next, black pepper in Malaysia mostly being planted in the hilly area where soil erosions are common especially during raining seasons. Thus, in order to collect ground data, installation of durable equipment with well establish shelf life are preferred to sustain data transmission for the cultivation area. This might lead to add in cost since high quality equipment are preferred. As mentioned by Rosli *et al.* (2013), circumstances that affect the implementation of technology in black pepper cultivation are education level, farming experiences and total of pepper vines. Thence, it may be tough to convince farmers to apply geospatial for their crops improvement. Again, government and agencies play a role to convey intensive agriculture extension and support in order to ensure consummation of geospatial technology for black pepper cultivation.

6. Conclusion

In conclusion, geospatial technology is proved to improve crop monitoring, yield estimation and productivity. However, their implementation should be expended for small scale cultivation such as black pepper since these crops are profitable commodity crops for most farmers in Malaysia. To attain this technology implementation for small scale area, various efforts need to consolidate. Efforts such as enhancing farmers knowledge on geospatial technology as well as proper management practice on black pepper is one of the essential. Next, cooperation between farmers, government and private sector is essentially needed. Thus, black pepper farmers could enhance their crop productivity and sustain Malaysia's black pepper quality.

This study is based on comprehensive study focusing only on few relatable studies on geospatial technology and black pepper cultivation since there are limitations on black pepper study especially using geospatial technology. Therefore, consistent study is suggested to improve black pepper productivity; especially for small scale cultivation in the future.

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