

Nutrient Uptake and Distribution in Black Pepper

By Nerrisa Paduit, Mirasol Pampolino, Tin Maung Aye, and Thomas Oberthür

Since the early days of trade between Asia and Europe, Black pepper (*Piper Nigrum* L.) has been known as the “King of Spices.” Still the most widely traded spice in the world, its berries are grown extensively for use in food and medicine. Today the world’s total harvested area for black pepper is over 500,000 ha (**Table 1**). The largest areas are in Asia: Indonesia (32%), India (24%), Vietnam (16%), and Sri Lanka (8%). Total world production is 546,000 t. Southeast Asia is taking the lead both in terms of production and harvested area.

Table 1. Production, area and yield of top black pepper producing regions in 2016.

Country/Region	Production, t	Area harvested, ha	Yield, t/ha
Brazil	54,425	25,830	2.1
China	34,360	18,175	1.9
India	55,000	129,000	0.4
Indonesia	82,165	168,080	0.5
Malaysia	29,245	10,900	2.7
Sri Lanka	28,900	41,560	0.7
Vietnam	216,430	81,790	2.6
Africa	25,890	39,435	0.7
Asia	453,775	453,315	1.0
Southeast Asia	333,735	263,825	1.3
South America	66,470	33,655	2.0
World	546,260	527,850	1.0

FAOSTAT, 2017

The world’s average yield for black pepper is only about 1 t/ha. Low productivity is the main challenge for many regions. This problem can be attributed to maintaining weak and unproductive vines or vines with poor genetic potential, biotic and abiotic stresses, weed competition, and inadequate or imbalanced fertilizer use (Thangaselvabal et al., 2008). Many black pepper farms are owned by smallholder farmers, who often apply inadequate amounts of fertilizer (Rosli et al., 2013). Research shows that without careful fertilizer application and soil fertility management, black pepper yields cannot be improved and it is even difficult to sustain current levels of production. Black pepper farms are predominantly established on soils with poor fertility and low nutrient retention capacity (Srinivasan et al., 2007).

Cultivation systems for black pepper vary among countries. In India and Vietnam, black pepper is often planted as a mixed crop on the homestead or in existing coffee planta-

tions. In Indonesia and Sri Lanka, the crop is intercropped with short duration crops and plantation crops like coffee and coconut (IPC, 2005). Black pepper has also been grown commercially as an intensive monocrop in major pepper production countries such as Thailand, Vietnam, and Brazil (Ravindran and Kallapurackal, 2012).

We estimate that with better nutrient management practices implemented as part of generally good agricultural practices (GAP), yields of current high-yielding varieties can be increased three-fold in many black pepper-growing areas. Black pepper is highly responsive to fertilizer application. Previous fertilizer trials on black pepper have examined crop yield responses to fertilizer application (Sadanandan, 1994). Fertilizer trials in Sarawak, Malaysia demonstrated high responses to N, P, and K (De Waard, 1969). However, there is a large variation among pepper production systems due to differences in crop management practices, soil and climatic conditions, and the socioeconomics of black pepper growers. Srinivasan et al. (2007) suggested the requirement of 6.4 g N, 6.3 g K, 1.1 g Ca, 0.5 g Mg, 0.4 g P, 0.3 g S, 43 mg Fe, 34 mg Mn, and 4.2 mg Zn for every 1 kg increase in black pepper berry yield in Kerala, India. To come up with an effective fertilizer recommendation, the crop’s nutrient uptake requirement and removal must be clearly understood. It should be noted that black pepper is a perennial crop and its utilization of nutrients could be different over time.

Nutrient Uptake and Removal

The influence of N, P, K, Ca, Mg, and micronutrients depends on their ratio in the soil and plant system (Srinivasan et al., 2007). Nutrient removal and composition of

SUMMARY

Black pepper is highly responsive to fertilizer application. Supplying adequate amount of nutrients is important to substantially increase growth and yield of the crop. Nutrient uptake and distribution in the different plant parts are key parameters in designing a better and more effective fertilizer management strategy.

KEYWORDS:

nutrient accumulation; nutrient partitioning; yield potential.

ABBREVIATIONS AND NOTES:

N = nitrogen; P = phosphorus; K = potassium; S = sulfur; Ca = calcium; Fe = iron; Mg = magnesium; Mn = manganese; Zn = zinc.

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A 4-year old black pepper smallholder farm in Gai Lai province of Vietnam. Photo by Tin Maung Aye.

pepper vines vary with variety, age, soil, season, and crop management. According to Yap (2012), there are three distinct growth stages of pepper—the early stage of development (first 18 months after planting), the period between fruit development and fruit maturity (18 to 26 months), and the period after harvesting or the “recovery” period (28 to 30 months).

Nutrient accumulation up to 30 months after planting is highest for N and K, which is followed by much lower accumulation of Ca, P, and Mg (Figure 1; Yap 2012). The crop’s demand for nutrients is strongest at around 12 to 20 months after planting with more than 50% of the nutrients taken up during fruit development.

Using data reported by Yap (2012) on fruit biomass, plant population, and nutrient accumulation up to first fruit maturity (26 months after planting), estimates of nutrient uptake indicate that the crop takes up 69 kg N, 5.1 kg P, 51 kg K, 18 kg Ca, and 6.8 kg Mg for every 1 t of berries.

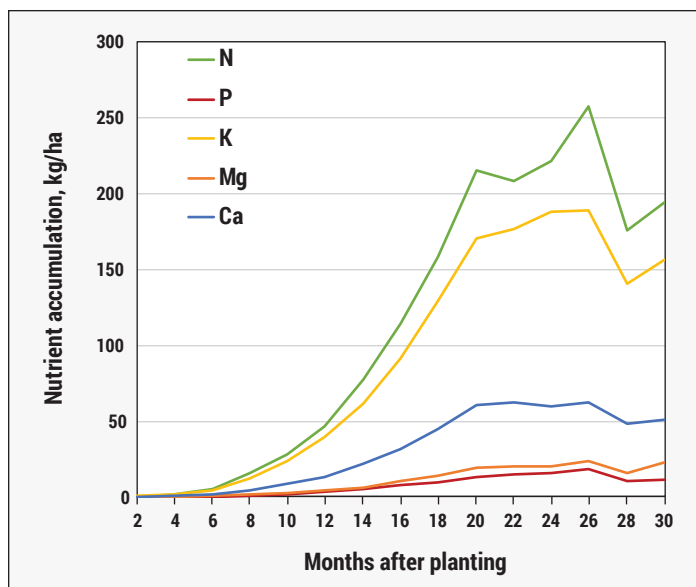


Figure 1. Total uptake of N, P, K, Mg, and Ca at different growth stages of black pepper. Yap, 2012.

Table 2. Estimated nutrient uptake and removal at current (2016) and projected black pepper yields with good agricultural practices (GAP) assumed at 100% increase over 2016 yield levels.

Country/Region	Current yield, t/ha	----- Current nutrient uptake and removal, kg/ha -----				
		N	P	K	Ca	Mg
Brazil	2.1	146 (52)*	11 (4.8)	108 (36)	37 (12)	14 (6.5)
China	1.9	131 (47)	9.7 (4.3)	97 (32)	34 (11)	13 (5.8)
India	0.4	30 (11)	2.2 (1.0)	22 (7.4)	7.6 (2.5)	2.9 (1.3)
Indonesia	0.5	34 (12)	2.5 (1.1)	25 (8.4)	8.7 (2.8)	3.3 (1.5)
Malaysia	2.7	186 (66)	14 (6.1)	137 (46)	48 (15)	18 (8.3)
Sri Lanka	0.7	48 (17)	3.6 (1.6)	36 (12)	12 (4.0)	4.7 (2.2)
Vietnam	2.6	184 (65)	14 (6.0)	136 (46)	47 (15)	18 (8.2)
Africa	0.7	46 (16)	3.4 (1.5)	34 (11)	12 (3.8)	4.5 (2.0)
Asia	1.0	69 (25)	5.1 (2.3)	51 (17)	18 (5.8)	6.8 (3.1)
South America	2.0	137 (49)	10 (4.5)	101 (34)	35 (11.4)	13 (6.1)
Southeast Asia	1.3	88 (31)	6.5 (2.9)	65 (22)	22 (7.3)	8.6 (3.9)
World	1.0	71 (25)	5.3 (2.3)	53 (18)	18 (5.9)	7.0 (3.2)
	GAP yield, t/ha	----- Projected nutrient uptake and removal, kg/ha -----				
Brazil	4.2	292 (104)	22 (9.6)	216 (72)	75 (24)	29 (13)
China	3.8	262 (93)	19 (8.6)	194 (65)	67 (22)	26 (12)
India	0.9	60 (21)	4.4 (2.0)	44 (15)	15 (5.0)	5.8 (2.7)
Indonesia	1.0	68 (24)	5.0 (2.2)	50 (17)	17 (5.6)	6.6 (3.0)
Malaysia	5.4	371 (132)	28 (12)	274 (92)	95 (31)	36 (17)
Sri Lanka	1.4	97 (34)	7.2 (3.2)	72 (24)	25 (8.1)	9.5 (4.3)
Vietnam	5.3	367 (131)	27 (12)	271 (91)	94 (30)	36 (16)
Africa	1.3	91 (32)	6.8 (3.0)	68 (23)	23 (7.6)	8.9 (4.1)
Asia	2.0	138 (49)	10 (4.6)	102 (34)	36 (12)	14 (6.2)
South America	4.0	274 (98)	20 (9.0)	203 (68)	70 (23)	27 (12)
Southeast Asia	2.5	176 (63)	13 (5.8)	130 (44)	45 (15)	17 (7.9)
World	2.1	143 (51)	11 (4.7)	105 (35)	36 (12)	14 (6.4)

*Values in parentheses refer to the nutrient removal from fruits. Estimates based on data from Yap, 2012.

Assuming that only the fruits are taken away from the plantations, net removal per t of fruits harvested would be 25 kg N, 2.3 kg P, 17 kg K, 5.8 kg Ca, and 3.1 kg Mg.

Estimated nutrient uptake and removal at current and projected yields with improved GAPs are presented in **Table 2**. Projected yields in the top five black pepper producing countries of Vietnam, Indonesia, India, Brazil, and China would result in the removal of about 21,900 t of N, 2,000 t of P, and 15,200 t of K. In Vietnam alone (the highest yielding), that would be 10,700 t of N, 990 t of P, and 7,400 t of K, which are quantities that almost equal the sum of removals for the remaining four top-producing countries.

Nutrient distribution in pepper plant parts during the entire growth cycle indicate that the fruit removes the highest amount of N, P, K, Ca, and Mg (Srinivasan et al., 2007; Yap, 2012). At the point of first fruit maturity, the nutrient content of the fruit + spike represents 37% of total plant N uptake, 46% for P, 36% for K, 48% for Mg, and 35% for Ca (**Figure 2**).

Conclusion

Large amount of nutrients are required to produce and sustain the economic yield of black pepper. To achieve high yields, growers must apply nutrients in sufficient quantity to satisfy the crop's total nutrient requirement. Knowledge of the crop's total uptake of nutrients and their distribution in the different plant parts (e.g., leaves, branches, fruit, roots, etc.) will be useful for agronomists in designing a fertilizer application strategy based on the principles of 4R Nutrient Stewardship.

The authors note that literature and information on black pepper nutrition are very limited and come from very few locations. Future research will be useful to clarify the following issues: crop stage definition and critical stages for nutrient management, effect of genetic material and environment or site characteristics on nutrient uptake and re-

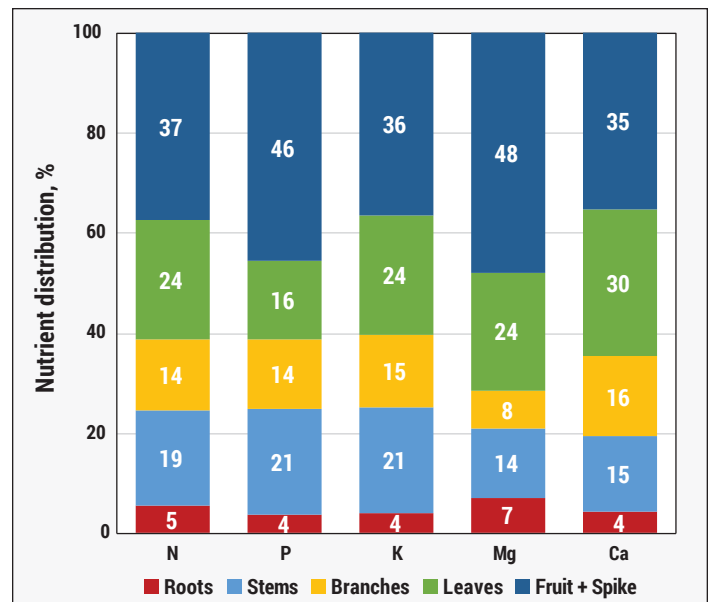


Figure 2. Distribution of N, P, K, Mg, and Ca in the different plant parts of black pepper at 26 months after planting (i.e., first fruit maturity). Yap, 2012.

moval, impact of nutrients on pest and diseases, and impact of nutrients on black pepper quality. **BC**

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