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Effect of Mulching on Growth and Yield of Peanut (*Arachis hypogaea* L.) on the Coastal Sandy Land in Nghe An Province, Vietnam

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ABSTRACT

Background: Peanut (*Arachis hypogaea* L.) is one of the oil and cash crops in Vietnam. However, owing to the lack of appropriate management practices, the production and the area under cultivation of peanut have remained low. Mulches are the key factors contributing to promoting crop development and early harvest and increasing yields.

Methods: The experiment consisted of three mulch treatments, *viz*., plastic mulch, straw mulch and no-mulch control. All the treatments were replicated thrice in a complete randomized block design.

Result: In the conditions of mulch, the plant growth parameters (germination rate, growing time, plant height, number of branches per plant), leaf area index, the number of nodules per plant, dry matter accumulation, yield components and yield of peanut was much higher than that of no-mulch control. Among the mulches, plastic mulch was found superior to straw mulch in the pod yields and water-use efficiency and moisture conservation, thereby can be considered as a reliable practice for increasing the productivity of peanut on the coastal sandy land in Nghe An province, Vietnam.

Key words: Coastal sandy land, Mulching materials, Peanut, Plant growth, Yield components.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is one of the most valuable legumes of tropical and subtropical regions (Jadon *et al*., 2018). It is also an important oil and cash crop in Vietnam and worldwide (Le *et al*., 2019). Peanut in Dien Chau district, Vietnam is mainly grown on nutrient-poor soil. Therefore, to achieve high productivity and high efficiency of investment, should have the effect of technical measures accordingly.

The practice of mulching has been widely used as a management tool in many parts of the world. It makes more favourable conditions for plant growth and development as well as efficient crop production (Sathiya *et al*., 2020). Mulching can be used on the soil surface mainly to prevent loss of water by evaporation (Ji and Unger, 2001; Pawar *et al*., 2004), to cut down the weed growth (Lalitha *et al*., 2010), to reduce temperature fluctuations and to promote soil productivity (Khan, 2002; Sun *et al*., 2015). Different mulching methods *i.e.*, application of paddy straw and plastic mulching provide a better environment to the plant (Kader *et al*., 2017). When compared to other mulches plastic mulch plays a positive role in water conservation by forming a completely impermeable to water mainly due to prevention of direct evaporation of moisture from the soil limiting the water losses and soil erosion over the surface (Trivedi and Gupta, 2016). Straw mulch adds nutrients to the soil when decomposed by microbes and help in carbon sequestration (Raju, 2013; Marwein *et al*., 2019).

Peanut can be grown under different land configuration methods like flatbed method, broad bed furrow, ridges and furrows and raised bed and furrow and mulched with organic or plastic mulching as a better management practice to enhance the growth and yield of peanut over the conventional method of cultivation (Li *et al*., 2010). In this study, an experiment was designed and conducted in a farmer's field with the following objectives: (1) Assess the impact of different mulch treatments on peanut productivity. (2) Understand the yield contributing factors and identify economically viable and environment-friendly mulching options.

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MATERIALS AND METHODS

Experimental design

Field experiments were carried out during the 2019 spring crop at the research area of the Institute of Agriculture and

Natural Resources, Vinh University in Dien Chau district, Nghe An province, Vietnam (105.30-105.45° N, 18.20-19.50° E). This research was conducted on the peanut variety L14, which was recognized as a technically advanced variety according to Decision No. 5310 QD/BNN-KHCN, November 29, 2002.

The experiment consisted of three mulch treatments, *viz.*, plastic mulch, straw mulch and no-mulch control. All the treatments were replicated thrice in a complete randomized block design. Before sowing, 1 ton ha^{-1} of microbial organic fertilizers + 30 kg ha^{-1} N + 90 kg ha^{-1} P_2O_5 + 60 kg ha^{-1} K_2O + 500 kg ha^{-1} lime powder was applied. Mineral fertilizer rates were determined based on the nutritional requirements of peanut and soil nutrient availability.

Each experimental plot consisted of 40 plants m^{-2} (spacing 25 cm × 20 cm). In the broad bed furrow system, beds were formed at 1 m width followed by 50 cm furrows. Polyethene sheets of 7-micron thickness with holes at the required spacing were spread over the soil in the mulched plots and seeds were sown. Organic mulching with paddy straw was spread at 5 cm thickness two weeks after sowing. Cultural practices, such as land preparation and pest management practices, which were by the recommendations from the Industry-standard 10-TCN 340:2006 on peanut varieties-procedure to conduct tests for value of cultivation and use.

Data collection

The soil moisture (%) was measured on 15th Jan, 25th Jan, 04th Feb, 14th Feb, 24th Feb, 05th Mar, 15th Mar, 25th Mar, 04th Apr and 14th Apr by gravimetric method. Plant height (cm) was measured from the ground level (at the plant's base) to the top of the highest point, including the terminal leaflet using a graduated meter stick. It was recorded from 10 randomly selected plants within the net plot. The number of branches per plant was obtained by direct counting of branches from 10 randomly selected plants in each plot. LAI was estimated as (LAI = surface area of sampled leaf/ ground area occupied by the sampled plants). Dry biomass (g $plant^{-1}$) was obtained after oven drying plants at 105°C until the mass is constant. The number of pods per plant was counted directly from ten sample plants of each plot (with three replications) and an average was calculated after harvesting. One hundred pods weight (g) and one hundred seeds weight (g) are obtained from a random sample of 100 pods and 100 seeds, respectively and weighed.

Shelling per cent (%) =

$$\frac{\text{Weight of all seeds from random sample}}{\text{Weight of 100 randomly selected pods}} \times 100$$

In each experimental plot, data on pod yield were recorded on ten randomly selected plants harvested.

RESULTS AND DISCUSSION

Soil moisture

Mulch prevents soil water evaporation and thus helps retain soil moisture. The monthly rainfall figures for the experimental period are given in Fig 2, the average rainfall during the experiment was 48.98 mm. The effects of mulching on soil moisture depend on precipitation and climatic factors. The soil moisture variation is not the same under different mulching materials (Fig 1). In general, the mulching treatments store higher soil moisture compared to the bare soil (no mulch). Mulch retards soil erosion and rapid infiltration of rainwater into the soil. Optimum soil moisture ensures good emergence and seedling growth. Contrasting results were also reported in regard to soil moisture storage under different mulching materials. Ramakrishna *et al*. (2006) reported that plastic mulch treatment stored the highest amount of soil moisture compared to the organic mulch treatments, which stored greater moisture than the bare soil. Similar results under mulch were reported by Pawar *et al*. (2004), Ghosh *et al*. (2006), Raju (2013), Jain *et al*. (2018).

Growth parameters

Table 1 showed that, under the conditions of plastic mulch and straw mulch, the germination rate (97.5% and 96.7% respectively) was much higher than that of no-mulch control (77.8%). However, the results of LSD index analysis showed that the germination rate between plastic mulch and straw mulch had no significant difference.

In the condition of plastic mulch, the soil temperature increased by 2.5-3.9°C during the day at the early growth

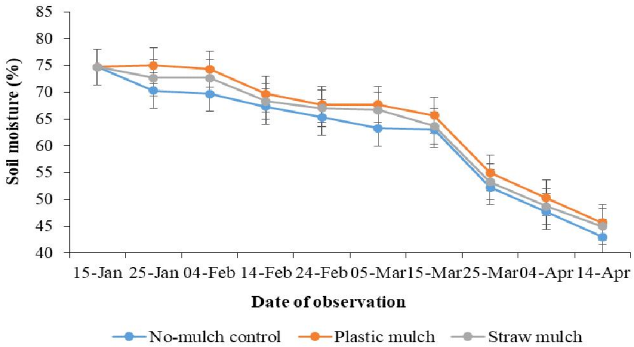

Fig 1: Soil moisture variation under different mulching materials during peanut cultivation periods (Jan - Apr 2019).

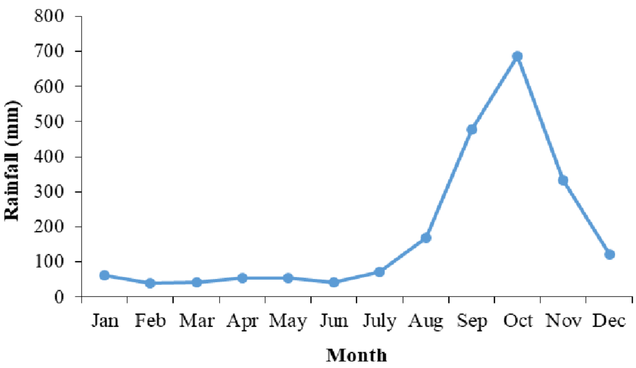

Fig 2: Rainfall distribution during the experimental period.

Table 1: Effect of mulching materials on the growth parameters of peanut.

Treatment	Germination rate (%)	Growing time (day)	Plant height (cm)	Number of branches per plant	
				Primary branches	Secondary branches
Plastic mulch	97.5b	128a	38.1a	4.3a	2.1a
Straw mulch	96.7b	130b	37.3a	4.0a	2.1a
No-mulch control	77.8a	134c	36.2a	3.8a	2.0a
CV%	5.6	0.4	9.0	5.7	11
LSD	11.4	1.3	7.5	0.5	0.5

Note: Different small letters in the table meant a significant difference among treatments at 0.05 level.

stage and 0.6-1.1°C at the late growth stage. The total cumulative temperature for the whole growth process is higher than that of no-mulch control at 195.3-379.8°C. Therefore, the growing time was shortened from 134 days to 128 days. Better seedling emergence in less time may be due to more ambient soil temperature, a more uniform supply of soil moisture and reduction in soil compaction around the seeds under mulch, which helps to promote faster germination and emergence. Similar results under mulch were reported by Shaikh *et al*. (2004), Ramakrishnan *et al*. (2006), Ghosh *et al*. (2006).

The mulching measure also affects the tree height and the number of branches per plant. Observations on plant growth showed that the peanut plants in plastic and straw mulched plots were generally tall, more vigorous than in the no-mulch control. The more favourable soil environment under the plastic and straw mulch, especially during the early part of the growing season, resulted in an increased number of branches per plant. Similar results have been reported by other studies (Kumar and Ngachan, 2001; Shaikh *et al*., 2004). Plastic mulching created a suitable condition for plant growth by influencing soil temperature, moisture retention, improved soil texture and microbial activities (Ghosh *et al*., 2006).

Leaf area index (LAI)

The data in Table 2 showed that the LAI of mulched treatments were larger than that of the control treatment and had a significant difference. It was a cumulative effect of a better growth environment, higher nutrient mobilization and better partitioning to shoot system that resulted in broader leaves (Jain *et al*., 2017). LAI increased and was maximum during the pod formation period and decreased during harvest. Magagula *et al*. (2019) observed that the highest LAI value was 4.63-4.93, which declined to 1.93-2.47 as maturity. Our results are also consistent with previous studies (Zhang *et al*., 2012; Jain *et al*., 2018; Mondal *et al*., 2020).

Nodule and dry matter weight

The number of nodules per plant had a significant difference in mulched treatments over no-mulch control at the flowering, pod setting and harvesting stages. Jain *et al*. (2017, 2018) reported that the number of nodules per plant was also recorded higher in polythene mulched peanut over no-mulch peanut.

The dry matter accumulation capacity of the peanut increases with the growing stages and obtained the highest value at harvest (Table 3). At this period, dry matter accumulation was highest in plastic mulch and lowest in no-mulch control. There was a significant difference in the dry matter weight between the mulched treatments and no-mulch control. The change in dry matter accumulation could be due to the leaf area and leaf area index (Olanyika and Etejere, 2015). Zayton *et al*. (2014) also reported that applying rice straw mulch lead to an increase in the biomass yield of about 28.90% as compared to no-mulching. Subrahmaniyan *et al*. (2008) and Jain *et al*. (2017) also reported that dry matter accumulation between polythene film mulches and no-mulch peanut differed markedly at all the crop growth stages. These results agreed with Mondal *et al*. (2018), Sathiya *et al*. (2020).

Table 2: Effect of mulching materials on leaf area index of peanut.

Treatment	Leaf area index (m^2 leaf m^{-2} ground)		
	Flowering	Pod formation	Harvesting
Plastic mulch	1.81a	4.82a	1.47b
Straw mulch	1.78a	4.75a	1.35b
No-mulch control	1.75a	4.46a	1.13a
CV%	6.2	5.1	5.2
LSD	0.2	0.5	0.1

Note: Different small letters in the table meant a significant difference among treatments at 0.05 level.

Yield components and yield

Mulch treatments have consistently yielded more than that of no-mulch control. Among the mulches, plastic mulch had significantly greater yields than straw mulch but there was no significant difference. Some authors report a significant increase in pod yields with the use of plastic mulch, which has been attributed to warmer soil temperatures. The warmer temperature may increase the absorption of nutrients and water as well as the production and translocation of carbohydrates. Our result conforms to the findings of Khistaria *et al*. (1994), Khan (2002), Pawar *et al*. (2004).

The number of pods per plant, the 100-pods weight and 100-seeds weight under plastic mulch were significantly higher as compared to straw mulch and no-mulch control. The shelling percentage under all the treatments is non-significant. Ghosh *et al*. (2006) also reported that the yield attribute significantly contributing to higher pod yield under mulch is the number of pods per plant, the 100-pods weight

Table 3: Effect of mulching material on the number of nodules and dry matter weight of peanut.

Treatment	Number of nodules per plant			Dry matter weight (g plant^{-1})		
	Flowering	Pod formation	Harvesting	Flowering	Pod formation	Harvesting
Plastic mulch	66.1c	156.5b	16.7a	6.51b	27.63a	31.59b
Straw mulch	60.7b	153.2b	15.8a	6.47b	26.91a	29.73b
No-mulch control	56.4a	134.3a	14.2a	6.23a	24.83a	26.54a
CV%	2.3	2.0	8.0	0.9	10.2	3.0
LSD	3.2	6.8	2.8	0.1	6.1	1.9

Note: Different small letters in the table meant a significant difference among treatments at 0.05 level.

Table 4: Effect of mulching materials on yield components and yield of peanut.

Treatment	Number of pods per plant	100 pods weight (g)	100 seeds weight (g)	Shelling per cent (%)	Theoretical yield (tons ha^{-1})	Net yield (tons ha^{-1})
Plastic mulch	7.2a	151.8a	62.8b	76.8a	4.39b	3.37b
Straw mulch	7.0a	149.7a	60.9ab	76.2a	4.18ab	3.26ab
No-mulch control	6.7a	145.7a	58.2a	75.9a	3.83a	2.89a
CV%	5.1	3.5	2.3	1.6	5.6	6.6
LSD	0.8	11.7	3.1	2.6	5.2	4.7

Note: Different small letters in the table meant a significant difference among treatments at 0.05 level.

and 100-seeds weight. A similar increase in yield due to mulching was reported in Peanut (Ramakrishnan *et al.*, 2006; Jain *et al.*, 2017).

Crop performance results demonstrate that pod yield was higher in mulched plots. There were variations in pod yield between three mulch treatments, which can be partly explained by the rainfall amount and soil moisture. An improved soil physical environment and retention of a greater amount of water under mulched conditions (give the 3.92% age increase in soil moisture) for a longer period might be the possible reason for better yield (Khan, 2002; Taufiq *et al.*, 2017). Ramakrishna *et al.* (2006) reported that the polythene mulched plots produced the highest yields - 94.5% higher than the unmulched plots and 25.5% higher than the straw mulched plots. The more favourable soil environment under the polythene and straw mulch, especially during the early part of the growing season, resulted in the increased number of pods per plant, pod mass and pod yield. Similar results under mulch were reported by Mondal *et al.* (2020), Jain *et al.* (2018).

CONCLUSION

In the conditions of mulch, the plant growth factors, leaf area index, the number of nodules per plant, dry matter accumulation, yield components and yield of peanut was much higher than that of no-mulch control. Among the mulches, plastic mulch was found superior to vegetative mulches in the pod yields and water-use efficiency and moisture conservation. However, every type of mulch has some strengths and weaknesses, making it suitable for some situations and not for others. Availability, durability and cost of the materials are the important issues to be taken into considerations for the selection of mulching materials. The straw mulch saves the labour cost and after decomposition, adds plant nutrients to soils; this is an extra advantage of the straw mulch over the plastic mulch.

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