Archives of Agriculture and Environmental Science 8(1): 8-13 (2023)
https://doi.org/10.26832/24566632.2023.080102

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

Effect of mulch on yield of groundnut (*Arachis hypogaea*) in Nepal

Sovika Bhattarai[1*], Pramod Wagle[2], Biplov Dahal[1] and Kalpana Jaggi[3]**

[1]Agriculture graduates, Amritsar Group of Colleges, Amritsar - 143001, Punjab, INDIA
[2]Scientist, Oilseed Research Program under Nepal Agricultural Research Council, Nawalpur - 45306, NEPAL
[3]Associate Professor, Department of Agriculture, Amritsar Group of Colleges, Amritsar - 43001, Punjab, INDIA
*Corresponding author's E-mail: sovikabhattarai@gmail.com
**Co-corresponding author's E-mail: sarlaheepramod@gmail.com

ARTICLE HISTORY

Received: 29 November 2022
Revised received: 28 February 2023
Accepted: 07 March 2023

Keywords

Lantana camara
Mulch
Rice husk
Weeds
Yield

ABSTRACT

Weeds are the most important biotic constraints to groundnut production in Nepal. They hinder the plant growth and increase the cost of production. A field based study was conducted from June, 2022 to December, 2022 at Oilseed Research Program, Sarlahi, Nepal to study the effect of mulch on the productivity of groundnut. The experiment was laid out in randomized complete block design with 7 treatments viz., rice husk, rice straw, black polythene sheet, *Lantana camara*, living mulch, sawdust and control in three replications. The fertilizer dose used for groundnut was 20:40:20 NPK kg per hectare. The pod yield in rice husk mulch and living mulch treatments were significantly higher (2.07 and 1.84 tons per hectare, respectively) whereas the lowest yield (0.83 tons/hectare) was observed in plot with no treatment). Lower weed infestation with weed biomass 0.046 tons/ha for narrow leaf weeds and 0.021 tons/ha for broad leaf weeds was observed in *L. camara* mulching. Rice husk mulching produced significantly higher number of pods (29 pods per plant) with the highest benefit cost ratio (1.15) whereas black polythene mulching produced lower number of pods (23 pods per plant) with lowest benefit cost ratio (-0.33). Conclusively, the study's finding suggests that rice husk can be used as a mulching material to increase the productivity of groundnut.

Citation of this article: Bhattarai, S., Wagle, P., Dahal, B., & Jaggi, K. (2023). Effect of mulch on yield of groundnut (*Arachis hypogaea*) in Nepal. *Archives of Agriculture and Environmental Science*, *8*(1), 8-13, https://dx.doi.org/10.26832/24566632.2023.080102

INTRODUCTION

Groundnut is one of the most important crops ranked fourth in oilseeds and 13th among food crop of the world (Nigam, 2014). Scientific name of groundnut is *Arachis hypogaea* which means the leguminous fruit formed beneath the surface of the earth. It is originally from South America (Hammons, 1994). The raw groundnut seeds contain 7.40 % moisture, 24.70 % protein, 46.10 % fat and 17.41 % carbohydrate. They also contain other beneficial minerals like sodium, phosphorous, potassium, zinc and iron (Ayoola *et al*., 2012). In Nepal, groundnut is grown from Terai to hilly region andSiraha, Dhanusa, Sarlahi, Nawalparasi and Banke districts are the largest producer of groundnut. According to (Thakur *et al*., 2013), groundnut was cultivated in the total area of around 6000 ha during early eighties in Nepal which increased to 15000 ha in recent years. In Nepal, groundnut is sown from the end of April to June and harvested during late August to October. The intensity of weed is more in Kharif season i.e., June to November (Jat *et al*., 2011) as several weeds including the annual grasses and seasonal broad leaf weeds grow abundantly during this time. Common weeds found in groundnut are *Digitaria sanguinalis*, *Cynodon dactylon* and *Cyperus rotundus* (Ghosh *et al*., 2000). The yield of groundnut was reduced by 13 to 80 %due to weed infestation in India (Kalhapure *et al*., 2013). Similarly, crop yield loss up to 50-70 % was noticed in Nepal (Bhattarai *et al*., 2021) that increased the cost of cultivation as timely weeding is required increasing the labor charges Kalaiselvan *et al*. (1991) stated that weed free condition from 15 to 40 days after sowing was essential for getting maximum yield. Since as many weed species are developing resistance to herbicides, making use of herbicide difficult and more expensive (Gaba *et al*., 2016). Mulching can be the

effective measure for weed control as it prevents sunlight from reaching the soil surface and maintains soil temperature to enhance the crop productivity. Organic mulch suppresses annual weeds and provides organic matter when decomposed (Veselinovic and Kupresanin, 1991). Black polythene sheet does not allow sunlight to pass into the soil arresting the weed growth completely because in the absence of sunlight there is no photosynthesis (Barche and Nair, 2014). Sawdust has allelopathic potential which when used as mulch, broadleaf weeds (eg-*Cyperus rotundus*) were more susceptible than grassy weeds (Abouziena and Radwan, 2015). The chemical composition of *L. camara* oil plays a role in the biological activity. The extracts, essential oil, leachates, residues and rhizosphere soil around *L. camara* suppressed the germination and growth of other plant species. Leachates from fruits and leaves of *L. camara* significantly inhibited the growth of *Setaria* species (Kato-Noguchi and Kurniadie, 2021). Different crops have different response to mulching, cucumber mulched with black film showed the highest plant height and number of leaves over other treatments and the highest number of fruits per plant followed by the highest yield within 30 first days of harvest was noticed in cucumber mulched with transparent film (Hallidri, 2000). According to the research conducted by El–Metwally *et al*., 2022, mulched plots were found effective in controlling weeds in onion and maintaining soil moisture. Moreover, the research showed the benefit of mulch as it allowed the possibility to gain acceptable crop yield and high benefit cost ratio. Keeping this in mind, a six-month field research was carried out using seven mulching treatments viz., rice husk, rice straw, black polythene sheet, *Lantana camara*, living mulch, sawdust and control with objective to find out the most effective mulching treatment to control weeds and increase the productivity of groundnut.

MATERIALS AND METHODS

Description of the experimental site

The research was conducted in the premises of Oilseed Research Program at Nawalpur, Sarlahi. The area is located at 26.9627° N, 85.5612° E with an elevation of 106m above mean sea level. The average annual temperature in Sarlahi is 24.5 °C | 76.1 °F (Climate-data.org, 2022).

Table 1. Description of the treatments.

Treatments	Treatment combinations
T_1	Mulching with rice husk
T_2	Mulching with rice straw
T_3	Mulching with black polythene sheet (9 micron)
T_4	Mulching with *Lantana camara* stubble
T_5	Mulching with living mulch
T_6	Mulching with saw dust
T_7	Un-mulched

Variety selection

'B-4' variety of groundnut was used for the study. The maturity duration of this variety is 160-180 days.

Collection of mulching materials

Rice husk and rice straw were collected locally from the field. Black polythene sheet of 9 micron was bought from the local shop and *L. camara* was collected from Forest Research and Training Center, Sagarnath, Sarlahi. Living mulches were collected from farmer's field and saw dust was purchased from furniture shop in Lalbandi, Sarlahi.

Experimental setup

The field experiment was conducted from 22nd June, 2022 to 6th December, 2022in the premises of Oilseed Research Program (ORP). The experiment was carried out in an area of 300.9 square meter (17m ×17.7m). Seven treatments and three replications were arranged in Randomized Complete Block Design (RCBD): rice husk, rice straw, black polythene sheet, *L. camara*, living mulch, sawdust and un-mulched (control). Individual plot size is 10.5 square meter i.e. (5×2.1) square meter with 1 m distance between replications and 0.5 m between treatments. The description of treatments is shown in Table 1. Each plot was ploughed two times followed by hoeing and leveling. The recommended fertilizer dose of 20:40:20 NPK kg per hectare was applied during final land preparation. Spacing of 40cm x15 cm was followed and groundnut was sown at the depth of 5 cm. The intercultural operations including irrigation and weeding were performed at regular intervals. Other agronomical practices such as control of pests and diseases were consistent for all treatments and performed as and when needed.

Harvesting and data collection

Harvesting was done manually at the first week of December when the nuts were fully matured i.e., when they turn brown. The weeds were collected and were categorized into two forms i.e., narrow leaf weed and broad leaf weed. Parameters such as days of flowering, days to maturity, pegging, weed infestation and plant height were noted earlier. After the harvest, pods per plant, actual plot yield, 100 seed weight and shelling percent were measured.

Statistical analysis

Data collected from field trials were compiled and analyzed using Statistical Tools for Agricultural Research (STAR). One-way ANOVA was performed to assess the effect of mulching treatments on growth parameters. Significant differences between treatment means were analyzed through Tukey's Honest Significant Difference (HSD) Test at a 5% level of significance. García-Orenes *et al*. (2009) also followed Tukey's Honest Significant Difference (HSD) Test at a 5% level of significance for studying different parameters. The differences between various treatments were significant at $p<0.05$ unless stated.

RESULTS AND DISCUSSION

Effect of mulching on plot yield

Groundnut mulched with rice husk and living mulch showed significantly higher yield (2.07mt/ha and 1.84mt/ha) followed by saw dust (1.63mt/ha) and rice straw (1.62mt/ha) mulching respectively whereas the lowest yield (0.83mt/ha) was observed in plot with no mulch. The yield of polythene sheet mulching (0.96mt/ha) was significantly lower in comparison to other mulching treatments. Our result is similar to that performed by Ekwu *et al*. (2017) where rice hull mulched plots were found giving the highest and black plastic mulch with lowest yield of cucumber. According to Sharma *et al*. (2023), tomato plants grown in plot mulched with rice husk produced higher number of fruits per plant over straw, saw dust and black plastic mulch treatments. Moreover, Fracchiolla *et al*. (2020) concluded that living mulch can be used for a sustainable and better production of broccoli raab. Rice husk contains 35-40% cellulose, 15-20 % hemicellulose and 20-25 % lignin (Gao *et al*., 2018). Lignin has a great contribution in tissue/ organ development and growth of plants (Liu *et al*., 2018). Similarly, rice husk contains 20% silica (Shi *et al*., 2022) which protects the plant from biotic and abiotic stresses and promotes root growth and water uptake by roots (Katz *et al*., 2021).

Effect of mulching on weed infestation

There was no significant difference among weed biomass between plots with different treatments. However, the lowest biomass for narrow leaf weed (0.046 t/ha) was recorded on *L. camara* mulched and black polythene sheet mulched plot whereas the lowest biomass for broad leaf weed (0.014 t/ha) was recorded on rice straw mulched plot, Table 2. The exudates, leachates from fruits and methanol extracted from leaves of *L. camara* inhibit different weed species (Mishra, 2015). Similarly, the leachates from fruits and leaves of *L. camara* suppressed the germination and growth of weeds like *Mimosa pudica*, *Eichhornia crassipes* and *Setaria* species (Kato-Noguchi *et al*., 2021).

Effect of mulching on plant height

Though the data was not significant, the higher number of plant heights were observed in *L. camara* mulched plot with an average height of 63.33 cm followed by black polythene sheet mulched plot with an average height of 62.47 cm. According to (Dutta, 2006) significantly higher plant height was observed under polythene mulched groundnut. Similarly, silver on black polythene mulch treatment and black polythene mulch treatment in cucumber recorded higher plant heights over rice straw and rice husk mulch treatments (Karki *et al*., 2020). *L. camara* is very good source of protein with the value of 24.84±0.51(%) and minerals with highest concentration in potassium of 1.05±0.03 ppm (Haruna *et al*., 2015). The greater height of plants mulched with *L. camara* may be due to the presence of protein and minerals that ensure a steady supply of nutrients to plants. Lower heights of plants were observed in saw dust treatment i.e., 56.27 cm followed by control with an average plant height of 56.80 cm as shown in Table 2.

Table 2. Effect of mulching on plant height and weed biomass.

Treatment	Plant Height	Narrow leaf weed weight (tons/ha)	Broad leaf weed weight (tons/ha)
T_1	57.53	0.047	0.025
T_2	57.47	0.049	0.014
T_3	62.47	0.046	0.023
T_4	63.33	0.046	0.021
T_5	55.53	0.047	0.023
T_6	56.27	0.053	0.025
T_7	56.80	0.053	0.019
p-value	0.75	0.996	0.28
Grand mean	58.49	0.049	0.0217
Standard errors	5.83	0.0162	0.0046
CV %	12.22	40.49	25.88

Table 3. Effect of various mulching treatments on crop yield parameters.

Treatment	Pods/plant	yield (ton/ha)	100 seed weight (gm)	Shelling percent (%)
T_1	29^{a}	2.07^{a}	199.67	66.67
T_2	26.67^{ab}	1.62^{ab}	206.67	68.33
T_3	23^{b}	0.96^{bc}	192.33	68.33
T_4	27^{ab}	1.37^{abc}	166.33	65
T_5	28.33^{ab}	1.84^{a}	210.67	66.67
T_6	26^{ab}	1.62^{ab}	192	66.67
T_7	23.67^{ab}	0.83^{c}	189.33	68.33
p-value	0.0320	0.0006	0.8010	0.71
Grand mean	26.24	1.47	193.86	67.14
Standard errors	1.70	0.2074	29.20	2.27
CV %	7.93	17.23	18.45	4.14
HSD	5.94	0.72		

Note: Means with the same letter are not significantly different.

Effect of mulching on shelling percent

There was no significant difference in shelling percentage for groundnut mulched with different mulching treatments which is shown in Table 3. Shelling percentage only differs statistically when different varieties of groundnuts are grown (Kurt and Arioglu 2018). In our study same variety of groundnut (B4) was cultivated.

Effect of mulching on pods per plant

The number of pods was found significantly highest in plot mulched with rice husk and lowest in plot mulched with black polythene sheet, Table 3. Our finding is in line with that of Dulur *et al.*, 2020 in which number of pods was higher on soybean direct-seeded following the red rice crops treated with rice husk ash. Rice husk contains 0.72-3.84 % K_2O (Muthadhi *et al.*, 2007). Potassium activates important enzymes which are useful in protein synthesis, photosynthesis improving the yield and quality of crops (Xu *et al.*, 2020). High content of potassium in rice husk may be the reason behind greater number of pods in groundnut whereas the lowest number of pods in black polythene mulched plot may be due to the thickness of polythene mulch that hindered the pegging of groundnut.

Effect of mulching on days to flowering and maturity

There was no significant difference in days of flowering and maturity between different mulching treatments and the control. This is in line with (Teame *et al.*, 2017) who reported the insignificant effect of mulching on days to flowering. The research predicted that due to weed suppression and moisture conservation ability of mulched plot, there was delay in flowering which resulted in insignificant difference between mulched plot and control. The research also revealed that insignificance maturity was shown by all mulching materials except sesame mulching.

Effect of mulching on cost of cultivation and returns

From economic view, the application of black polythene sheet as mulching material in groundnut recorded higher rate of cultivation costing NRs. 460900 per hectare followed by saw dust (NRs. 306634 per hectare) and rice straw mulch (NRs. 295185 per hectare). Among the seven treatments, the highest gross return (NRs. 331200 per hectare) was observed in rice husk mulched plot with net return of NRs. 44586 per hectare. The highest benefit cost ratio (1.15) was calculated in rice husk mulching followed by living mulch (1.11) and *Lantana camara* mulching treatment (1.003). To the contrary, plot mulched with black polythene sheet resulted the lowest benefit cost ratio (-0.33) followed by control (-0.77) and saw dust mulching (-0.84).

Table 4. Effect of various mulching treatments on days to flowering and maturity.

Treatments	Days to flowering	Days to maturity
T_1	31	131
T_2	32	131
T_3	31	129.67
T_4	30	131
T_5	31	129.33
T_6	31	130.33
T_7	31	131.33
p-value	0.38	0.17
Grand mean	31	130.52
Standard errors	0.75	0.79
CV %	2.99	0.74

Table 5. Economic analysis of various mulching treatments on groundnut.

Treatment	Cost of cultivation (NRs)	Gross return (NRs)	Net return (NRs)	B:C
T_1	286614	331200	44586	1.15
T_2	295185	274500	-20685	0.92
T_3	460900	153600	-307300	0.33
T_4	218519	219200	681	1.003
T_5	264509	294400	29891	1.11
T_6	306634	259200	-47434	0.84
T_7	170900	132800	-38100	0.77

Conclusion

Rice husk mulching treatment stood out to be more significant among all other treatments in context of higher yield and greater number of pods per plant in groundnut. Presence of cellulose, lignin and silica in rice husk help in overall growth and development of plants which could be responsible for higher yield. Similarly, higher number of pods may be due to the presence of higher amount of potassium in rice husk which aids protein synthesis and photosynthesis in plants improving their yield and quality. Also, rice husk mulching treatment recorded highest benefit cost ratio (1.15) over other mulching treatments. Thus, this paper suggests that using rice husk as mulching material enhances crop production and returns considerably. *L. camara* on the other hand, may provide advantage to the crop by suppressing the weeds with its allelopathic effect. The exudates, leachates from fruits and methanol extracted from leaves of *L. camara* inhibit the growth of different weed species and the plot mulched with *L. camara* recorded the highest plant height over other mulching treatments even though the data was not statistically significant. Also, the benefit cost ratio for *Lantana camara* was 1.003. Thus, *L. camara* can be used as an economically feasible mulching material for suppressing agricultural weeds. So, more research should be carried out to study the allelopathic effect of *L. camara* on several weed species.

REFERENCES

Abouziena, H. F., & Radwan, S. M. (2015). Allelopathic effects of sawdust, rice straw, bur-clover weed and cogon grass on weed control and development of onion. *International Journal of Chem Tech Research*, *7*(1), 337-345

Ayoola, P. B., Adeyeye, A., & Onawumi, O. O. (2012). Chemical evaluation of food value of groundnut (*Arachis hypogaea*) seeds. *American journal of food and nutrition*, *2*(3), 55-57, http://dx.doi.org/10.5251/ajfn.2012.2.3.55.57

Barche, S., & Nair, R. (2014). Mulching-an effective conservation technique in olericulture. *Popular Kheti*, *2*(2), 49-55

Bhattarai, R. K., Gautam, D.D., Yadav, B.P., Gyawaly, P., & Chaulagain, B. (2021). Weed Management in Groundnut (*Arachis hypogaea* L.) at Nawalpur Conditions in Sarlahi, Central Terai, Nepal. *Agronomy Journal of Nepal*, *5*(01), 46-51, https://doi.org/10.3126/ajn.v5i01.44782

Climate-Data.Org (2022). Available from https://en.climate-data.org/asia/nepal/central-development-region-2260/

Dulur, N. W. D., Wangiyana, W., Farida, N., & Kusnarta, I. G. M. (2020). Growth and yield of soybean direct-seeded following conventional and aerobic rice intercropped with peanut and amended with organic wastes. *International journal of Horticulture, Agriculture and Food Science*, *4*(5), 189-195, https://doi.org/10.22161/ijhaf.4.5.2

Dutta, D. (2006). Studies on effect of planting method and mulch on summer groundnut (*Arachis hypogaea* L.). *International Journal of Agricultural Science*, *2*(2), 441-443

Ekwu, L. G., Nwokwu, G. N., & Utobo, E. B. (2017). Effect of mulching materials and pruning on growth and yield of cucumber (*Cucumis sativus* L.). *Nigeria Agricultural Journal*, *48*(2), 51-59.

El–Metwally, I., Geries, L., & Saudy, H. (2022). Interactive effect of soil mulching and irrigation regime on yield, irrigation water use efficiency and weeds of trickle–irrigated onion. *Archives of Agronomy and Soil Science*, *68*(8), 1103-1116, https://doi.org/10.1080/03650340.2020.1869723

Fracchiolla, M., Renna, M., D'Imperio, M., Lasorella, C., Santamaria, P., & Cazzato, E. (2020). Living mulch and organic fertilization to improve weed management, yield and quality of broccoli raab in organic farming. *Plants*, *9*(2), 177, https://doi.org/10.3390/plants9020177

Gaba, S., Gabriel, E., Chadœuf, J., Bonneu, F., & Bretagnolle, V. (2016). Herbicides do not ensure for higher wheat yield, but eliminate rare plant species. *Scientific Reports*, *6*(1), 1-10. 6:30112, https://doi.org/10.1038/srep30112

Gao, Y., Guo, X., Liu, Y., Fang, Z., Zhang, M., Zhang, R., You, L., Tong, L., & Liu, R. H. (2018). A full utilization of rice husk to evaluate phytochemical bioactivities and prepare cellulose nanocrystals. *Scientific Reports*, *8*(1), 10482

García-Orenes, F., Cerdà, A., Mataix-Solera, J., Guerrero, C., Bodí, M. B., Arcenegui, V., Zornoza, R., & Sempere, J. G. (2009). Effects of agricultural management on surface soil properties and soil-water losses in eastern Spain. *Soil and Tillage Research*, *106*(1), 117-123, https://doi.org/10.1016/j.still.2009.06.002

Ghosh, P. K., Mandal, K. G., & Hati, K. M. (2000). Allelopathic effects of weeds on groundnut (*Arachis hypogaea* L.) in India - a review. *Agricultural Reviews-Agricultural Research Communications Centre India*, *21*(1), 66-69

Hallidri, M. (2000). Comparison of the different mulching materials on the growth, yield and quality of cucumber (*Cucumis sativus* L.). *Acta Horticulturae*, *559*: 49-54, https://doi.org/10.17660/ActaHortic.2001.559.3

Hammons, R. O. (1994). The origin and history of the groundnut. In J. Smartt (ED.), *The Groundnut Crop: A Scientific Basis for Improvement*, pp. 24-42. Springer, Dordrecht.

Haruna, S. S., Ahmed, O., & Johnson, O. T. (2015). Nutritional and anti-nutritional composition of *Lantana camara* leaf. *Journal of Investigational Biochemistry*,*4*(2), 58-60

Jat, R. S., Meena, H.N., Singh, A. L., Surya, J. N., & Mishra, J.B. (2011). Weed management in groundnut (*Arachis hypogaea* L.) in India-a review. *Agricultural Reviews – Agricultural Research Communication Centre India*, *32*(3), 155-171

Kalaiselvan, P., Ramadas, G. R., & Vaman, B. M. (1991). Studies on crop weed competition in groundnut Madra. *Agricultural Journal*, *43*, 122-125

Kalhapure, A. H., Shete, B. T., & Bodake, P. S. (2013). Integration of chemical and cultural methods for weed management in groundnut. *Indian Journal of Weed Science*, *45*(2), 116-119

Karki, A., Sapkota, B., Bist, P., Bista, K., Dutta, J. P., Marahatta, S., & Shrestha, B. (2020). Mulching materials affect growth and yield characters of cucumber (*Cucumis sativus* cv. Malini) under drip irrigation condition in Chitwan, Nepal. *Journal of Agriculture and Forestry University*, 153-159, https://doi.org/10.3126/jafu.v4i1.47061

Kato-Noguchi, H., & Kurniadie, D. (2021). Allelopathy of *Lantana camara* as an invasive plant. *Plants*, *10*(5), 1028, https://doi.org/10.3390/plants10051028

Katz, O., Puppe, D., Kaczorek, D., Prakash, N. B., & Schaller, J. (2021). Silicon in the soil–plant continuum: Intricate feedback mechanisms within ecosystems. *Plants*, *10*(4), 652, https://doi.org/10.3390/plants10040652

Mishra, A. (2015). Allelopathic properties of *Lantana camara*. *International Research Journal of Basic and Clinical Studies*, *3*(1), 13-28, https://dx.doi.org/10.14303/irjbcs.2014.048

Kurt, C. & Arioglu, H. (2018). Physical and mechanical properties of some peanut varieties grown in Mediterranean environment. *Journal of Applied Life Sciences and Environment*, *51*(2), 27-34, https://repository.uaiasi.ro/xmlui/handle/20.500.12811/805

Liu. Q., Luo, L., & Zheng, L. (2018). Lignins: biosynthesis and biological functions in plants. *International Journal of Molecular Sciences*, *19*(2), 335, https://doi.org/10.3390/ijms19020335

Muthadhi, A., Anitha, R., & Kothandaraman, S. (2007). Rice husk ash – Properties and its uses: A review. *Journal of the Institution of Engineers. India. Civil Engineering Division*, *88*(5), 50-56

Nigam, S. N. (2014). Groundnut at a glance, pp. 121. ICRISAT, Patancheru Hyderabad, Andhra Pradesh.

Sharma, S., Basnet, B., Bhattarai, K., Sedhai, A., & Khanal, K. (2023). The influence of different mulching materials on Tomato's vegetative, reproductive, and yield in Dhankuta, Nepal. *Journal of Agriculture and Food Research*, *11*, 100463, https://doi.org/10.1016/j.jafr.2022.100463

Shi, Y., Qian, M., Wang, X., Zhang, W., Zhang, X., Wang, X., & Zhu, Y. (2022). Effect of rice husk-based silica on the friction properties of high-density polyethylene composites. *Materials*, *15*(9), 3191, https://doi.org/10.3390/ma15093191

Teame, G., Tsegay, A., & Abrha, B. (2017). Effect of organic mulching on soil moisture, yield and yield contributing components of sesame (*Sesamum indicum* L.). *International Journal of Agronomy*, https://doi.org/10.1155/2017/4767509

Thakur, S. B., Ghimire, S. K., Chaudhary, N. K., Shrestha, S. M., & Mishra, B. (2013). Determination of relationship and path co-efficient between pod yield and yield component traits of groundnut cultivars. *Nepal Journal of Science and Technology*, *14*(2), 1-8, https://doi.org/10.3126/njst.v14i2.10409

Veselinovic, M., & Kupresanin, R. (1991). Importance of organic mulch in the technology of seedling transplanting in the nurseries. *Zbornikradova - nstitutzasumarstvo (Yugoslavia)*, *34-35*, 91-96

Xu, X., Du, X., Wang, F., Sha, J., Chen, Q., Tian, G., Zhu, Z., Ge. S., & Jiang, Y. (2020). Effects of potassium levels on plant growth, accumulation and distribution of carbon, and nitrate metabolism in apple dwarf rootstock seedlings. *Frontiers in Plant Science*, *11*, 904, https://doi.org/10.3389/fpls.2020.00904