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Seed Fortification and Foliar Spraying with *Moringa oleifera* Leaf Extract Enhances Yield and Yield Attributes in Blackgram [*Vigna mungo* (L.) Hepper]

P. Nivethadevi, C. Swaminathan, P. Kannan[1], E. Tamilselvi[2]

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ABSTRACT

Background: Blackgram (*Vigna mungo* L.), the most important highly prized pulse crops is grown throughout India. The productivity can be evaluated through various input management practices including inorganic and organic as well as natural way of cultivation. **Methods:** Both lab and field investigations were carried out to choose best tree leaf extracts for seed fortification and foliar nutrition in blackgram and also to evaluate performance of *Vrikshayurvedic* farming practices with seed fortification and foliar spraying of Moringa *oleifera* leaf extracts and basal nutrition of *Delonix regia*. Comparison with conventional scientific practices and do-nothing farming practice was also made.

Result: *Vrikshayurvedic* farming (*Delonix regia* + *Moringa oleifera* @ 5%) as green leaf manure and foliar spray with tree leaf extract, respectively, registered highest vales for growth and yield parameters. It was at par with conventional scientific practice (RDF @ 25:50:25 NPK kg ha^{-1} and foliar spray with DAP 2% twice @ 30 and 45 DAS). It is inferred that *vrikshayurveda* treatments resulted in better plant growth, DMP, seed yield, pod yield equivalent as that of conventional practice and superior to do-nothing practice. It also helps to improve and maintain soil fertility over a long period of time.

Key words: Do-nothing farming, Foliar nutrition, *Moringa oleifera,* Seed fortification, Tree leaf extracts, *Vrikshayurvedic* farming.

INTRODUCTION

Blackgram, botanically *Vigna mungo* (L.) Hepper is an ancient and third most important legume crop of Asia, commonly known as urdbean belongs to family fabaceae. It is widely considered as an important pulse crop from the point of food and nutritional security due to presence of excellent source of high quality protein (25 g/100 g) with good digestability and also contains water soluble vitamins *viz.*, niacin, riboflavin and thiamine *etc.*) and minerals like Iron, copper, calcium, magnesium and phosphorus. The sluggish productivity of blackgram is due to various physiological, biochemical and other external and internal factors (Mahala, Dadheedh and Kulhari, 2001). For improving productivity of blackgram, proper fertilization is an essential pre-requisite which can meet its nutrient requirements besides symbiotic fixation of atmospheric nitrogen (Mir *et al*., 2013), which also maintains soil fertility. But repeated and unscientific usage of agro-chemicals including fertilizers has made an adverse impact on environment, bio-diversity and soil fertility.

Ancient India has adopted many traditional practices to maintain and sustain soil fertility thereby crop yields and one such aspect is "*Vrikshayurveda",* centuries old traditional practices in Indian system of farming. It has relevance to recent organic agriculture which ensures sustainability and soil fertility. According to Swaminathan and Nandakumar (2017), *Vrikshayurvedic* farming is defined as a traditional Indian system of farming which produces quality food products by using leguminous tree leaves as a source of soil nutrition and leaf extracts of various tree species that produce growth promoting secondary metabolites, serve as growth stimulants, pest and disease control agents as well as growth tonics for growth and development of crops. It is also referred as Low Budget Natural-way Farming (Swaminathan *et al.,* 2021). Based on previous several experiments conducted by Swaminathan and Nandakumar, (2017) in small millets and pulses (*Delonix regia* + *Moringa oleifera*) combinations registered the maximum growth and yield attributes. Accordingly we made this attempt to compare field performance of blackgram.

Department of Agronomy, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.

[1]Department of Soils and Environment, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.

[2]Department of Textile Science and Engineering, Community Science college and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.

Corresponding Author: C. Swaminathan, Department of Agronomy, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.
Email: brownrevolution@yahoo.com

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MATERIALS AND METHODS

Both laboratory and field experiments were conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai during *kharif* season, 2020. A lab experiment was set up at Agronomy laboratory and a field experiment to assess impact of seed infusion with leaf extracts of four tree species [*Moringa oleifera* L. (Murungai), *Aegle marmellos* L. (Bael), *Morinda tinctoria* Roxb. (Manchanathi) and *Annona squamosa* L. (Seethapal)] on germination attributes in blackgram. Fresh and clean leaves of four tree species were collected from central farm of Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, India. The leaf extracts for each species were prepared by grinding fresh leaves and distilled water at 1:1 proportion and extract was filtered and served as stock solution. From the stock solution, 5% solution was made for seed infusion for duration of 12 hours (Swaminathan and Nandakumar, 2017). The seeds were subjected to germination test with 8 replications. The Between paper (BP) technique prescribed by ISTA (2006) was employed for the study where-in seeds were placed between two layers of germination paper and rolled. Fifty number of blackgram seeds were placed in each roll of BP and placed in upright position in sterilised conical flasks, bottom filled with four leaf aqueous extractions. Distilled water alone served as control. The experiment was set up in octuplicate so as to make 400 seeds for each treatment (ISTA, 2006). The treated seeds and control seeds were evaluated for the germination and seed quality characters up to ten days. Germination percentage was calculated. Number of germinated seeds was counted daily by visual counting up to 10 days. After 10 days of germination period, the seedlings were evaluated and normal seedlings produced were counted and mean expressed in percentage. For measuring root length, ten normal seedlings from each replication were taken at random after germination period and length between collar and tip of the primary root was measured and mean value expressed in centimeter. For shoot length, length from collar region to tip of the primary leaves was measured and mean value expressed in centimeter. The vigour index was calculated by adopting the formula (Abdul-baki and Anderson, 1973) given as

VI = Germination % × Mean length of the total seedling in cm

From the results of lab experiment, the Moringa leaf extract was identified as the best and tested under field conditions during July-September (*kharif)* at experimental farm of Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, India to evaluate the influence of *Vrikshayurvedic* farming practices in blackgram with conventional practice and Do-nothing farming practices. Geographically, field was located at 9° 54′ N latitude, 78° 5′ E longitude and at an altitude of 147 m above sea level. The topography of the field was medium and the soil was sandy clay loam. The site selected for study was kept fallow for previous two seasons and this experiment was set up with 3 treatments *viz*., T_1 - *Vrikshayurvedic* farming practices; T_2 - conventional scientific practices (RDF 25:50:25 NPK kg/ha + DAP 2% foliar spray); T_3- Do-nothing farming practice (field was just prepared and seeds were sown) in a randomized block design with 7 replications. The blackgram variety VBN 8 was used. A uniform seed rate of 10 kg/ha was followed in all the systems and sowing was done on the same day on 09.07.2020 in blocks of 12 m^2. For *Vrikshayurvedic* farming practices, prior to sowing, green leaf manure *Delonix regia* (contained 2.76% N on air dry basis) @ 2.0 t/ha was applied and incorporated during field preparation and field was left undisturbed for 45 days to facilitate decomposition of applied leaf manure. Before sowing, seeds were fortified with moringa leaf extract @ 5% for 6-12 hours and sown. Foliar nutrition of leaf tea spray of *Moringa oleifera* at 5% was given thrice during 20, 35 and 50 DAS. The observations on growth and yield parameters were recorded at harvest and LAI was recorded at 45 DAS. Soil samples were taken before conducting the experiment and after the harvest of crop. Analysis of soil for organic carbon, available phosphorus and potassium was done for each treatment. Similarly uptake of nutrients by crops was estimated at harvest.

The data on observed soil status, growth parameters and yield attributes were analysed and subjected to Anova (Analysis of Variance) with 5% probability level (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Lab study

Among different leaf extracts, seed fortification with *Moringa oleifera* 5% leaf extract showed highest germination (94%), root length (28.03 cm), shoot length (24.57 cm) and vigour index (4944.09) in blackgram compared to other treatments (Table 1). Presence of plant growth hormone like zeatin in moringa leaves might have increased yield as revealed by Jason (2013) in many crops. Muhammad (2015) observed that moringa leaf extract at 5% encouraged germination rate and final germination percentage in cowpea. It could be due to botanicals contained micronutrients which are conducive for seed invigouration (Manimekalai, 2006); presence of tannins, glycoside and carbohydrates (Soni *et al.,* 2011); presence of biochemical properties *viz.*, phenolic compounds, organic acids, proteins and alkaloids (Senthilkumar *et al.,* 2016). On contrary, lowest germination (90%), shortest root (21.67 cm) and shoot (18.85 cm) and low vigour index (3647.40) was observed when seeds were fortified with *Aegle marrmellos* leaf extract which may be due to inhibition of germination in blackgram and presence of unsuitable phytochemical substances contained in leaves of *Aegle marmellos*.

Effect of different farming practices on growth parameters in irrigated blackgram

All the farming practices found to influence growth parameters of blackgram (Table 2) significantly. The tallest plant (30.3 cm) at harvest was observed in *vrikshayurvedic* farming practice with *Delonix regia* as green leaf manure and 5% *Moringa oleifera* as foliar spray. The same treatment had more plant population/m^2 (26.7), no. of branches $plant^{-1}$

(16.6), leaf area index (1.91) and produced longest roots (17.27). This might be due to continuous supply and subsequent availability of soil nutrients from decomposed green leaf manure, which favoured increase in cell division and elongation, thereby increased the crop growth (Tripathi *et al.,* 2000). This finding was also in close conformity with findings of Biswas *et al.,* 2016 when *Moringa oleifera* was experimented as foliar spray in maize. The effect of *vrikshayurvedic* farming practice was at par with conventional farming practices when DAP as foliar spray at 30 and 45 DAS. Similarly maximum DMP (2672.0 kg ha^{-1}) was also recorded in *Vrikshayurvedic* farming practices. The least growth attributes were registered when there was no external application of organic and inorganic sources of nutrients.

Effect of different framing practices on yield and yield attributes in blackgram

Three systems/practices significantly influenced yield parameters (Table 3) and maximum yield attributing characters like pod number (22.60 plant^{-1}) and number of seeds (7.00 pod^{-1}) were recorded in *vrikshayurvedic* farming when *Delonix regia* as green leaf manure and 5% *Moringa oleifera* as foliar spray were followed. It was at par with CPG practices when DAP was sprayed at 30 and 45 DAS. Minimum no. of pods/plant and number of seeds/pod were registered in do-nothing practices. It was in close similarity with Sakthivel *et al.* (2012), who reported *Pongamia pinnata* as green leaf manure and foliar sprays of *Moringa oleifera* 5% increased number of pods, number of seeds per pod and yield in blackgram. In this study, maximum seed yield (442.70 kg ha^{-1}), pod yield (625.00 kg ha^{-1}), haulm yield (3046.73 kg ha^{-1}) and dry matter production (2672 kg ha^{-1}) were recorded by adoption of *Vrikshayurvedic* farming practice *i.e.* using *Delonix regia* leaves as manures and foliar spraying of *Moringa oleifera* leaf extract. The improvement in field emergence by botanical leaf extracts could be ascribed to activation of cells that resulted in enhancement of mitochondrial activity leading to the formation of high energy compounds and vital biomolecules which were made available during early phase of germination (Renugadevi and Vijayageetha, 2007). Abusuwar and Abohassan (2017) reported application of Moringa leaf extract @ 10% increased number of pods, pods dry weight and shelling out turn in mungbean. Increased yield and yield attributes in moringa leaf extract sprayed crop plants may be due to presence of growth hormones, particularly zeatin which enhanced the yield to the range of 10-45%. Besides, it also contains sufficient micronutrients that also increase growth, yield components of variety of crops ranging from cereals to oilseeds (Muhammad, 2014).

The increased yield and yield attributes in blackgram due to DAP spray might be ascribed to enhanced mobilization of major nutrients and minor nutrients which resulted in easy translocation of photosynthates from source to sink. This principle could also be ascribed for green leaf manures incorporation and foliar spraying of leaf extract. The difference between conventional practice of CPG with DAP spray and *vrikshayurvedic* farming practice was on par. From the study, it was found that yield gap between conventional and do-nothing practices over *Vrikshayurvedic* farming practices was 13.72% and 68.62%, respectively (Fig 1). And also, Vrikshayurvedic farming practice significantly increased seed yield by 15.9% and 68.62% and pod yield 13.92% and 26.36% over conventional and do-nothing practices respectively.

Table 1: Effect of seed fortification on germination at 3 DAS and germination related attributes at 10 DAS of blackgram in Lab study.

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
S_1- *Moringa oleifera*	94	28.03	24.57	4944.09
S_2 - *Aegle marmellos*	90	21.67	18.85	3647.40
S_3 - *Morinda tinctoria*	92	23.81	20.78	4102.28
S_4 - *Annona squamosal*	92	26.63	23.20	4584.97
Control	82	24.00	22.67	3826.94
SEm ±	-	0.77	0.06	-
CD (P=0.05)	-	2.15	0.18	-

Table 2: Effect of different farming practices on growth parameters in irrigated blackgram (*Vigna mungo*).

Treatments	Plant population (No/m^2)	Plant height at harvest (cm)	LAI at 45 DAS	Number of branches/plant	Root length (cm)	DMP (Kg/ha)
Vrikshayurvedic farming practice	26.67	30.30	1.91	16.6	17.27	2672.0
Conventional practice	26.00	29.12	1.81	14.1	16.8	2234.0
Do-nothing farming	24.00	26.33	1.54	11.5	14.7	1518.0
S.Em ±	NS	0.59	0.073	0.36	0.27	118.71
C.D (P=0.05)	3.42	1.29	0.161	0.79	0.59	261.76

Note: Vrikshayurvedic farming practice: Application of *Delonix regia* by Biomass transfer technique and application of 5% *Moringa oleifera* as foliar spray at different growth stages.

Conventional practice: Applied RDF (25:50:25 NPK kg/ha) and DAP sprayed twice at 30 and 45 DAS.

Do-nothing practice: Field was prepared and sown.

Effect of different farming practices on initial soil, plant nutrient acquisition and post-harvest status of soil in irrigated blackgram

The nutrient status of soil was presented in Table 4 and 5. The nutrients were applied through different sources such as green leaf manures in *vrikshayurvedic* farming practice, chemical fertilisers at RDF 25:50:25 NPK kg/ha in conventional practice and no manures and fertilizers in do-nothing practice. The soil organic carbon status was markedly increased after a legume crop practiced with *vrikshayurvedic* farming practices from 0.54% to 1.17%. Keeping the experimental field fallow for previous two seasons might have also contributed for this; due to transformation in mobilization of organic bounded nutrients to inorganic form to the plant by the activity of decomposition of applied manures through micro-organisms and therefore increase in soil organic carbon which leads to increases in soil fertility. This result was in accordance with Puli *et al.* (2016). The acquisition of nitrogen (56.8 kg ha^{-1}), phosphorus (7.2 kg ha^{-1}) and potassium (28.32 kg ha^{-1}) kg ha^{-1} by crops was maximum in *Vrikshayurvedic* farming practice of soil application of *Delonix regia* as green leaf manure and foliar spraying of *Moringa oleifera*. This might be due to increased availability of nutrients and also increased photosynthetic activity thereby increased in biomass production and N supply during flowering and pod filling stage (Basvarajappa *et al.,* 2013). The same trend was followed in acquisition of P and K also. Foliar spraying of *Moringa oleifera* leaf extracts, which contains macro and micro nutrients and growth hormones that increased the favoured nutrient uptake from soil and also increase metabolic activity of plants. Similar results were reported by Deotale *et al.* (2011). The highest soil available N, P and K after harvest was recorded in *vrikshayurvedic* farming practice, which might be owing to

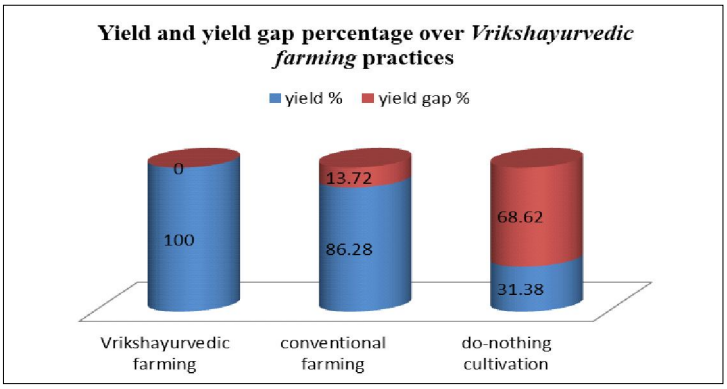

Fig 1: Yield and yield gap percentage of conventional farming and do-nothing cultivation over *Vrikshayurvedic* farming practices.

Table 3: Effect of different farming practices on yield and yield attributes in irrigated blackgram (*Vigna mungo*).

Treatments	Pods/plant (Nos)	Seeds/pod (Nos)	100 seed weight (gm)	Grain yield (kg/ha)	Pod yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)
Vrikshayurvedic farming practice	22.60	7.00	4.56	442.70	625.00	1819.1	19.57
Conventional practice	21.30	7.00	4.52	381.95	576.39	1738.2	18.01
Do-nothing farming	12.6	6.10	4.42	138.9	458.3	1432.6	8.83
S.Em ±	2.94	0.36	0.024	72.02	57.42	33.29	0.28
C.D (P=0.05)	6.39	0.79	0.52	157.01	124.61	72.54	0.61

Note: Vrikshayurvedic farming practice: Application of *Delonix regia* by Biomass transfer technique and application of 5% *Moringa oleifera* as foliar spray at different growth stages.

Conventional practice: Applied RDF (25:50:25 NPK kg/ha) and DAP sprayed twice at 30 and 45 DAS.

Do-nothing practice: Field was prepared and sown.

Table 4: Effect of different farming practices on soil organic carbon and nitrogen status in soil.

Treatments	Soil organic carbon (%)		Nitrogen (kg/ha)			
	Initial	Post-harvest soil	Initial	Applied N	Plant acquisition	Post- harvest available N
Vrikshayurvedic farming practice	0.54	1.17	246.0	55.2	56.8	171.2
Conventional practice	0.49	0.61	241.6	25	54.5	168.3
Do-nothing farming	0.36	0.4	235.4	0	48.6	162.0
S.Em ±	0.023	0.055	2.73	-	1.14	NS
C.D (P=0.05)	0.052	0.120	5.96	-	2.48	11.13

Table 5: Effect of different farming practices on phosphorus and potassium status in soil.

Treatments	Phosphorus (kg/ha)				Potassium (kg/ha)			
	Initial	Applied P	Plant acquisition	Post-harvest available P	Initial	Applied K	Plant acquisition	Post-harvest available K
Vrikshayurvedic farming practice	16.91	9.2	7.2	13.6	298	10	28.32	258
Conventional practice	16.0	50	7.0	13.2	293	25	27.65	254
Do-nothing farming	16.0	0	6.68	12.2	287	0	22.4	246
S.Em ±	0.37	-	NS	0.275	4.46	-	0.75	2.67
C.D (P=0.05)	0.81	-	0.49	0.598	9.72	-	1.64	5.81

better soil physical and chemical properties due to higher microbial activity, nutrient mobilization and root activity in rhizosphere soil. During mineralization, microorganisms convert organically bound nutrients to inorganic form, resulting in higher availability of nutrients (Muthuvel, 1985). The least NPK uptake and post-harvest available nutrients was recorded in do-nothing practice.

CONCLUSION

Vrikshayurvedic farming suggests that production of chemical free and quality food grains in blackgram is possible by following the practice of soil enrichment with green leaf manure and foliar spraying with tree leaf extracts. It also helps to maintains soil properties and keep the soil fertile.

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