INTRODUCTION

In production, potato ranks 3rd behind rice and wheat in terms of human consumption and, firstly, between tuber and root crops (FAO, 2021; Chandrasekara and Kumar, 2016). Potatoes have high nutritional value and are a crop leader in energy production per unit area. It gives a cheap human diet source. Compared to the primary cereal crops, potato produces more protein per hectare and dry matter (Roy et al., 2017). Potato production faces several problems, such as using local low-yielding cultivars, poor tillage, diseases, insect pest and weed management, and low soil fertility status (Reynolds et al., 2015). In addition, fertilizers are usually applied below the recommended rate (165 kg N/ha+137 kg P₂O₅) for potato production in Masha district, southwestern Ethiopia (Israel et al., 2012). However, the nutrient depletion extent is unknown and in the soil nutrient levels, and plant requirements are not proportionate with the fertilizer application done by farmers. For potato cropping, nutrients’ primary source is the chemical fertilizer (Gebru et al. 2017). Although chemical fertilizer’s continuous utilization results in nutritional imbalance, soil’s biological and physicochemical properties exert antagonistic effects. The potato requires high potassium, phosphorus, and nitrogen as a heavy nutrient feeder. Chemical pesticides and fertilizers’ indiscriminate and imbalanced use causes numerous dangerous effects on air, water,

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ABSTRACT

Multi-nutrients deficiency of soil in southwest Ethiopia is among the primary constraints for the very low productivity of potatoes (Solanum tuberosum L.). The combined use of organic and inorganic fertilizers is vital for resolving the common productivity issue. Thus, experiments were performed on potato variety “Belte” in Masha district, southwestern Ethiopia, in both Belg (February to May) as well as Meher (June to October) seasons of 2019 to evaluate the potato response to the vermicompost, mineral phosphorus, and nitrogen’s integrated applications. The experiment had three vermicompost rates with the factorial combination (2.5, 5, 7.5 t/ha) and three recommended rates inorganic NP’s 25%, 50% and 75% (124 kg N/ha and 103 kg P₂O₅/ha) fertilizer. Results have discovered that 75% inorganic NP and 7.5 t/ha vermicompost’s combined application significantly increase total tuber yield, marketable tuber yield, and individual tuber weight, giving the maximum net benefits and marginal return rate. Thus, it has been discovered from this work that for potato production at Masha area, 7.5 t/ha vermicompost with inorganic NP’s 75% recommended dose’s combined applications are best-integrated nutrient management options.
and soil, resulting in pollution (Muthoni, 2016). Therefore, integrated nutrient management is a better approach for providing nutrients to the crop, including nutrients’ mineral and organic sources (Kumar et al., 2017).

Mismanagement of agrochemicals under intensive cultivation has disturbed the harmony among human beings, animals, bio-life, plants, and soil (Ali & Shaari, 2015; Dash et al., 2017). It decreased soil efficiency by declining its health regarding biological activities and soil fertility. Consequently, nutrient supply integrated technique through chemical fertilizers in addition to organic manures is gaining significance, particularly for crops that are heavy feeders (Kumar et al., 2017). Furthermore, it has been observed that responsive and exhaustive yield such as potato’s quality and quantity has been improved significantly under mineral and organic fertilizers’ integrated use in comparison to the sole application of a recommended dose of applied nutrients as mineral (Alemayehu et al., 2020; Isreal et al., 2018). The environmental situation in this study area, i.e., the Masha district of southwestern highlands of Ethiopia, is part and parcel of the tropics. Masha climate represents weathered tropical soils as dominant ones. The inherent properties of these soils, being rich in oxides of Fe and Al, have high P-fixing capacity coupled with high erosion resulting from the high amount of rainfall and poor crop management practices that necessitate the increased use of fertilizers (Isreal et al. 2018). Low soil fertility resulted from the lack of an excellent agronomic management program, total plant residue removal from farmland, crop nutrients from the soil, and surface soil removal by erosion. These factors limit the potato yield in the study areas.

So far, there are no scientific studies that test the different dosage of mineral NP and vermicompost fertilizer effect on potato yield in the proposed area though there are some studies conducted in other parts of the country (Balemi, 2012; Masrie et al., 2015). The present research promises to gain insight into the various effects of vermicompost and mineral NP fertilizers on potato production. Most fertilizer studies on potatoes have been conducted using inorganic NP fertilizers and often with older crop varieties. These causes necessitated on-farm studies on the integrated utilization of inorganic and organic nutrient sources for soil fertility management and potato production. Therefore, this study was aimed to determine the vermicompost with mineral NP fertilizers combined application effect on the potato yield components, growth, yield, and economic feasibility.

**MATERIALS AND METHODS**

**About Experimental Area**

This research was conducted during 2019 in the farmer’s field in Meher and Belg cropping seasons at Abelo kebele in Masha district within latitudes of 7°44’17.14” North and longitudes of 35°30’16” East. This area’s rainfall patterns are categorized through bimodal distributions, i.e. primary rainy season in Meher and the minor one in Belg. In Meher growing season, total rainfall was 1145 mm and 625 mm in Belg and mean temperature of 20°C and 15.2°C in Belg and Meher cropping seasons, respectively.

**Experimental Materials**

TSP and urea were utilized as mineral N and P sources, respectively, whereas vermicompost was prepared from locally available materials as organic fertilizers. The vermicompost’s moisture content, CEC, Na, K, Mg, Ca, electrical conductivity, pH, K, P, N, and carbon can be seen in Table 1. The improved potato variety ‘Belete’ released in 2009 was used as a test crop.

**Table 1. Description of treatment combinations**

| Treatment | Description |
|-----------|-------------|
| T1        | No-fertilizer (control) |
| T2        | 100% NP      |
| T3        | 25% NP + 2.5 t/ha vermicompost |
| T4        | 50% NP + 2.5 t/ha vermicompost |
| T5        | 75% NP + 2.5 t/ha vermicompost |
| T6        | 25% NP + 5 t/ha vermicompost |
| T7        | 50% NP + 5 t/ha vermicompost |
| T8        | 75% NP + 5 t/ha vermicompost |
| T9        | 25% NP + 7.5 t/ha vermicompost |
| T10       | 50% NP + 7.5 t/ha vermicompost |
| T11       | 75% NP + 7.5 t/ha vermicompost |
Treatments and Experimental Design
The treatment combinations consisted of
three rates of vermicompost, i.e. 2.5, 5, 7.5 t/ha and
recommended mineral NP fertilizers’ three
rates (25%, 50% and 75%). Additionally, this
research utilized no-fertilizer (control) treatment
and mineral NP fertilizer’s 100% recommended rate
for comparison. The experiment was performed,
exercising all the precautions needed for the field
experiment, with three replications in a randomized
block design.

Materials Management
A thorough spread of vermicompost was
applied over respective plots and after that
combined in soil layers (0-20 cm) two weeks before
planting at 2.5, 5, and 7.5 t/ha rates. Phosphorus
application was conducted in TSP (20% P) per hill
form and mixed well with the soil, while in three split
applications, nitrogen was side-dressed that is: 1/4
at the initiation of tubers, 2/4th at mid-stage; and1/4th
at plant emergence.

Crop Data Collection
This research recorded yield data such as
marketable tuber number, unmarketable tuber
number, total tuber number, marketable tuber yield,
unmarketable tuber yield, total tuber yield and tuber
weight, and harvest index.

Statistical Analysis
Analyses of variances for the agronomic data
collected were conducted using SAS statistical
software 9.1.3 (SAS, 2004). F-test was chosen to
calculate the homogeneity of variances for every
agronomic parameter. F-test represented two
seasons’ heterogeneity of the variances. Thus, for
the two seasons, a separate analysis was utilized.
Further, for separating the treatment means,
LSD (least significant difference 0.05) was used
where there has been an occurrence of significant
treatment difference.

Partial Budget Analysis
A partial budget analysis was carried out for
determining the fertilizer application’s economic
feasibility (CIMMYT, 1988). For its computations, the
gross benefit gained from various treatments and
additional input costs (variable costs) were
considered. Also, cattle manure and vermicompost
preparations and their application, TSP and NPSB
and their application, and urea cost were included in
the variable expenses since they varied as per the
particular treatment. Assumptions were made for
25.0 Birr per person-day wage rate and 1-ton cattle
manure and vermicompost’s separate preparation
and application, two-person days were taken into
account. In addition to the average marketable
return on agricultural products and the farmers’
practices from the same medical treatments, the
mean yield was modified lower by 10 percent.
The reason behind this is the experimental yields,
which are typically more significant than the yields
farmers can get with the same treatments, even
from field tests under realistic conditions. The price
of the existing local market at potato harvest (5.00
and 4.00 Birr per kg in Meher and Belg seasons,
respectively) was utilized for computations to
determine the gross benefits. In the partial budget
analysis, a few concepts that were utilized included
net benefit (NB), total variable cost (TVC) and gross
field benefit (GFB). Also, for selecting the potentially
profitable treatments, dominance analysis was
performed as well as for the non-dominated
treatments, the marginal rate of return (% MRR)
was computed.

RESULTS AND DISCUSSION
The soil’s bulk densities are 1.38 g/cm³ in
Meher and 1.37 g/cm³ in Belg seasons, with total
porosity of 46.92% in Meher and 46.80% in Belg.
The total porosity of the soil (46.80% and 46.92%)
is classified as high (Shukla, 2013). Thus, for water
and air’s optimum movement through the ground,
the soil is good as there do not exist any
problems on soil’s expansion and tuber growth. It
has been shown by the results of soil particle size
analysis that soil texture is sandy-clay loam which
has a particle size distribution of 28% clay, 16% silt,
and 56% sand in Meher as well as 25% clay, 18%
silt, and 57% sand in Belg seasons.
The site soil consists of low organic carbon,
total N, and available exchangeable bases and
phosphorus. The soil was acidic with 4.8 pH (very
strongly acidic) in Meher and 5.01 (strongly acidic)
in the Belg season. The organic carbon’s low status
of 10.2 g/kg in Meher and 12 g/kg in Belg seasons
were recorded. Low C:N ratio in both Belg and Meher
seasons indicates net mineralization of applied
vermicompost. The soil’s available phosphorus low
status was registered as 5 ppm in Meher and 5.5
ppm in Belg seasons.
Yield and Yield Components

Total and Marketable Tuber Number Per Hill

The vermicompost and mineral fertilizers’ combined application has a highly significant (p<0.01) effect on the marketable and total tuber number per hill in the Belg and Meher seasons. However, no significant effect was observed in unmarketable tuber yield (Table 2). The vermicompost and mineral fertilizers’ combined application enhanced the number of total and marketable tubers per hill in Meher and Belg seasons. Therefore, 7.5 t/ha VC application with 75% mineral NP caused the maximum number of whole tubers of 14.21 and 10.90 per hill and marketable tuber numbers of 9.02 in Belg and 7.92 per hill in Meher season, respectively amounting to 30.84 and 13.57% increase in these parameters. These enhancements are due to the increased VC rate could have contributed to the nitrogenous fertilizer’s volatilization reduction to NH3 gas, soil water holding capacity improvement and NPK’s increased availability.

It has also been noticed that as the mineral NP rate increased from 25-75%, the number of total and marketable tubers in Belg and Meher seasons has also increased. The increased number of whole and marketable tubers at high rates of NP is due to the crop’s vigorous development and growth as mineral sources applied nutrients and organic sources. The combination contributes to enhanced nutrient availability, which plays a significant part in cell division. Further, it has been stated by Gunjal (2019) that 7.5 t/ha vermicompost + 75% inorganic NP (65 kg N/ha and 67 kg P2O5/ha) application resulted in significantly highest total tuber numbers of 11.73 per hill while the lowest value (8 per hill) was in the plot where fertilization has not been received. In line with this study, Abou El-Goud, Al-Masoodi, Elzopy, & Yousry (2021) also reported that 7.5 t/ha vermicompost application combined with 82 kg N/ha and 67 kg P2O5/ha raised marketable tuber number from 5.18 per hill in the plot which do not receive fertilization to 8.42 per hill. In addition, Yourtchi et al. (2013) point out that a higher dosage of nutrients (150 kg N/ha and 12 t/ha vermicompost) produced a higher total tuber number (54 per hill) than the lower nitrogen dosage (50 kg N/ha) at wider plant spacing (27 per hill).

Table 2. Marketable tuber number (MTN) (number per hill), unmarketable tuber number (UMTN) (number per hill) and total tuber number (TTN) (number per hill) of potato as influenced by the combined use of vermicompost and mineral NP in Belg and Meher seasons

| Treatment            | Belg MTN | Belg UMTN | Belg TTN | Meher MTN | Meher UMTN | Meher TTN |
|----------------------|----------|-----------|----------|-----------|-----------|----------|
|                      |          |           |          |           |           |          |
| 2.5 t VC + 25% RDF   | 7.80bcd  | 3.59      | 11.39cd  | 6.81cde   | 3.33      | 10.14b   |
| 2.5 t VC + 50% RDF   | 7.99abcd | 3.44      | 11.43cd  | 6.99cde   | 3.19      | 10.18b   |
| 2.5 t VC + 75% RDF   | 8.05abcd | 4.19      | 12.24bc  | 7.06abcd  | 3.20      | 10.26b   |
| 5 t VC + 25% RDF     | 8.33abcd | 4.01      | 12.34bc  | 7.18abcd  | 3.23      | 10.41bc  |
| 5 t VC + 50% RDF     | 8.52abcd | 4.93      | 13.45ab  | 7.27abcd  | 3.24      | 10.51ab  |
| 5 t VC + 75% RDF     | 8.63abcd | 5.41      | 14.04a   | 7.55abcd  | 3.13      | 10.68ab  |
| 7.5 t VC + 25% RDF   | 8.77abcd | 5.35      | 14.12a   | 7.55abcd  | 3.21      | 10.76a   |
| 7.5 t VC + 50% RDF   | 8.95abcd | 5.22      | 14.17a   | 7.88ab    | 2.90      | 10.78a   |
| 7.5 t VC + 75% RDF   | 9.03a    | 5.18      | 14.21a   | 7.92ab    | 2.99      | 10.90a   |
| 100% RDF             | 7.72c    | 3.32      | 11.04bc  | 6.62ab    | 3.30      | 9.92bc   |
| No-fertilizer (control) | 7.48a  | 3.38      | 10.86c   | 6.31a     | 3.28      | 9.59a    |
| LSD (5 %)            | 1.183    | NS        | 1.335    | 0.907     | NS        | 1.156    |
| Significance         | **       | NS        | **       | **        | NS        | *        |
| CV (%)               | 8.3      | 23.2      | 9.02     | 7.40      | 26.15     | 6.5      |

Remarks: Means followed by the same letter within a column are non-significantly (p>0.05) different from each other and *, ** denote highly significant difference at 5% and 1% level of probability, respectively; VC = Vermicompost, RDF = Recommended dose of inorganic NP fertilizers, NS = Non-significant.
Isreal Zewide et al.: Vermicompost and Mineral NP Enhanced Potato’s Yield

Total Tuber Yield, Marketable Tuber Yield, and Individual Tuber Weight

Total Tuber Yield

Individual tuber weight, marketable tuber yield, and total tuber yield were highly significant (p<0.01) affected by vermicompost and mineral NP’s combined use in both Belg as well as Meher seasons (Table 3 and Table 4). The combination of 7.5 t/ha VC with 75% mineral NP yielded the maximum total tuber yields of 41.6 t and 33.7 t/ha in Belg and Meher seasons. Though statistically at par with the products obtained at 5 t VC + 75% RDF and 7.5 t VC + 25% or 50% RDF, the lowest 25.42 t/ha total tuber yield in Belg and 21.67 t/ha were noted from the no-fertilizer treatments without affecting unmarketable tuber yield. This may be caused by the increased supply of nutrients in balanced proportion, the positive impact of natural plant growth regulators, and the beneficial effect of the microflora of VC, which is a rich source of nutrients and beneficial microorganisms resulting in higher total tuber yield. The results are also consistent with the Balemi (2012) findings that stated that 7.5 t/ha FYM + 75% inorganic NP application increased the total tuber yield by 47.74% over the control treatment (18.88 t/ha). In line with this, Abou El-Goud, et al. (2021) reported that higher vermicompost and mineral fertilizer tend to give total tuber yield from 27.11 t/ha in the control treatment to 37.95 t/ha at 7.5 t/ha vermicompost + 124 kg N/ha + 103 kg P₂O₅/ha. However, these yields were statistically at par with those of 5 t VC + 75% RDF, 7.5 t VC + 50% RDF, and 7.5 t VC + 25% RDF. The possible reason for the increased marketable tuber yield with higher VC and inorganic NP rates is that organic fertilizer sources’ mineralization and mineral fertilizer through the growing periods do not expose the plants to nutrient stress, which results in the plants’ nutrient stress maximum tuber yield. This result is also supported by several workers (Alemayehu et al., 2020; Gaur et al., 2017). Combined use of vermicompost and mineral NP showed a extremely significant difference (p<0.01) in the tuber dry weight. The highest average tuber weights (65.90 and 70.70 g/tuber) were obtained from 7.5 t/ha VC + 75% NP in Belg and Meher seasons (Table 3 and Table 4).

Table 3. Marketable tuber yield (MTY) (t/ha), unmarketable tuber yield (UMTY) (t/ha), total tuber yield (TTY) (t/ha), average tuber weight (ATW) (g/tuber) of potato as influenced by combined use of vermicompost and mineral NP in Belg season

| Treatment | MTY  | UMTY | TTY   | ATW  |
|-----------|------|------|-------|------|
| 2.5 t VC + 25% RDF | 24.68<bc | 3.82 | 28.5<bc | 56.15<bc |
| 2.5 t VC + 50% RDF | 25.17<bc | 3.86 | 29.03<bc | 56.94<bc |
| 2.5 t VC + 75% RDF | 25.48<bc | 6.23 | 31.71<bc | 58.17<bc |
| 5 t VC + 25% RDF | 26.43<bc | 5.70 | 32.125<bc | 58.44<bc |
| 5 t VC + 50% RDF | 26.54<bc | 8.78 | 35.32<bc | 59.21<bc |
| 5 t VC + 75% RDF | 30.17<bc | 7.71 | 37.88<bc | 60.77<bc |
| 7.5 t VC + 25% RDF | 30.19<ab | 8.64 | 38.83<ab | 61.94<ab |
| 7.5 t VC + 50% RDF | 31.85<bc | 8.34 | 40.19<bc | 63.82<bc |
| 7.5 t VC + 75% RDF | 32.23<bc | 9.41 | 41.64<bc | 65.90<bc |
| 100% RDF | 24.34<bc | 2.79 | 27.13<bc | 55.1<bc |
| No-fertilizer (control) | 22.18<bc | 3.24 | 25.42<bc | 52.44<bc |
| LSD (5 %) | 3.096 | NS | 4.997 | 3.687 |
| Significance | ** | NS | ** | ** |
| CV (%) | 6.68 | 9.06 | 8.77 | 7.63 |

Remarks: Means followed by the same letter within a column are not significantly different from each other and ** denotes highly significant difference at 1% level of probability; VC = Vermicompost, RDF = Recommended dose of inorganic NP fertilizers, NS = Non-significant.
The increase in average tuber weight when 7.5 t/ha VC was applied with 75% of RDF could be due to the enhancement of plant growth and development as a result of vermicompost, nitrogen and phosphorus fertilizer application. Moreover, mobilization of vermicompost with higher doses of mineral NP might have played a significant role in enhancing the average tuber weight over control treatment. It is claimed that mineralized vermicompost gradually releases essential nutrients over a longer period than applied mineral N, thus reducing their leaching and improving their uptake through reduced synchrony between crop nutrient needs and manure nutrients that might have contributed to the increased yield of potato (Arancon et al., 2004).

Partial Budget Analysis

According to the partial budget analysis, the application of 7.5 t VC + 75% RDF yielded the highest net returns of 115091 ETB (Ethiopian Birr) per ha in Belg and 118045 ETB per ha in Meher, followed by net returns of 113856.20 ETB per ha in Belg and 116045 ETB in Meher from 7.5 t VC + 50% RDF (Table 5 and Table 6). High net return from the above treatments are due to the high yield in Belg and high income over related costs except for three treatments (100% RDF, 2.5 t VC + 75% RDF and 5 t VC + 75% RDF) in Belg and six treatments (2.5 t VC + 50% or 75% or 100% RDF, 5 t VC + 50% or 75% RDF and 7.5 t VC + 50% or 75% RDF) in Meher season and all other treatments (control, 2.5 t VC + 25% or 50% or 75% RDF, 5 t VC + 25% or 50% or 75% RDF and 7.5 t VC + 25% or 50% or 75% RDF) in Belg and the treatment control, 2.5 t VC + 25% RDF, 5 t VC + 25% RDF and 7.5 t VC + 25% or 75% RDF in Meher season. The Meher season was chosen for the marginal rate of return analysis (MRR) since it was non-dominated.

### Table 4. Marketable tuber yield (MTY) (t/ha), unmarketable tuber yield (UTY) (t/ha), total tuber yield (TTY) (t/ha) and average tuber weight (ATW) (g/tuber) of potato as influenced by combined use of vermicompost and mineral NP in Meher season

| Treatment                | MTY    | UTY    | TTY    | ATW     |
|--------------------------|--------|--------|--------|---------|
| 2.5 t VC + 25% RDF       | 21.87<sup>bc</sup> | 2.97<sup>d</sup> | 24.84<sup>c</sup> | 55.369<sup>d</sup> |
| 2.5 t VC + 50% RDF       | 22.1<sup>bcd</sup> | 4.54<sup>b</sup> | 26.64<sup>bc</sup> | 59.224<sup>de</sup> |
| 2.5 t VC + 75% RDF       | 23.09<sup>cd</sup> | 5.28<sup>c</sup> | 28.37<sup>cd</sup> | 62.548<sup>d</sup> |
| 5 t VC + 25% RDF         | 23.42<sup>bc</sup> | 5.97<sup>d</sup> | 29.39<sup>cd</sup> | 64.052<sup>d</sup> |
| 5 t VC + 50% RDF         | 23.97<sup>bc</sup> | 6.54<sup>de</sup> | 30.51<sup>c</sup> | 65.955<sup>abc</sup> |
| 5 t VC + 75% RDF         | 24.27<sup>bc</sup> | 6.90<sup>de</sup> | 31.17<sup>ab</sup> | 66.902<sup>abc</sup> |
| 7.5 t VC + 25% RDF       | 27.29<sup>a</sup> | 4.63<sup>d</sup> | 31.92<sup>abc</sup> | 67.809<sup>abc</sup> |
| 7.5 t VC + 50% RDF       | 27.41<sup>a</sup> | 5.33<sup>d</sup> | 32.74<sup>ab</sup> | 69.437<sup>abc</sup> |
| 7.5 t VC + 75% RDF       | 27.88<sup>a</sup> | 5.82<sup>a</sup> | 33.7<sup>a</sup> | 70.701<sup>a</sup> |
| 100% RDF                 | 20.91<sup>bc</sup> | 3.24<sup>d</sup> | 24.15<sup>df</sup> | 55.122<sup>d</sup> |
| No-fertilizer(control)   | 19.95<sup>a</sup> | 1.73<sup>d</sup> | 21.68<sup>df</sup> | 51.406<sup>d</sup> |

LSD (5 %) 2.359 NS 3.498 5.567
Significance ** NS ** **
CV (%) 5.81 7.31 7.17 5.22

Remarks: Means followed by the same letter within a column are non-significantly (p>0.05) different from each other and ** denotes highly significant difference at 1% level of probability (p<0.01); VC = Vermicompost, RDF = Recommended dose of inorganic NP fertilizers, NS = Non-significant.
Table 5. Results of partial budget analysis to estimate the net benefit of the combined use of vermicompost and mineral NP in Belg season

| Treatment                      | A.Y  | Adj. Y | GFB  | TVC    | NB    | MRR (%) |
|-------------------------------|------|--------|------|--------|-------|---------|
| No-fertilizer (control)       | 22182| 199638 | 798552| 0      | 798,552|         |
| 2.5 t VC + 25% RDF            | 24677| 222093 | 88372 | 3135.5 | 885,236.5| 276.46  |
| 2.5 t VC + 50% RDF            | 2517 | 226530 | 906120| 4396   | 901,724 | 130.80  |
| 5 t VC + 25% RDF              | 26427| 237843 | 951372| 5010.5 | 946,361.5| 726.40  |
| 100% RDF                      | 24336| 219024 | 876096| 5042   | 871,054 | D       |
| 2.5 t VC + 75% RDF            | 25477| 229293 | 917172| 5656.5 | 911,515.5|         |
| 5 t VC + 50% RDF              | 26542| 238878 | 955512| 6271   | 949,241 | 228.44  |
| 7.5 t VC + 25% RDF            | 3019 | 271710 | 1086840| 6885.5 | 107,995.5| 2127.15 |
| 5 t VC + 75% RDF              | 30167| 271503 | 1086012| 7531.5 | 107,848.1| D       |
| 7.5 t VC + 50% RDF            | 31853| 286677 | 1146708| 8146   | 113,856.2| 464.95  |
| 7.5 t VC + 75% RDF            | 32231| 290079 | 1160316| 9406.5 | 115,091 | 97.96   |

Remarks: A.Y = Average Yield (kg/ha), Adj. Y = Adjusted yield (kg/ha), GFB = Gross field benefit (4 Birr per kg) (Birr per ha), TVC = Total variable cost (ETB per ha), NB = Net benefit (Birr per ha), D = Dominated treatment, MRR = Marginal rate of return

Table 6. Results of partial budget analysis to estimate the net benefit of the combined use of vermicompost and mineral NP in Meher season

| Treatment                      | A.Y  | Adj. Y | GFB  | TVC    | NB    | MRR (%) |
|-------------------------------|------|--------|------|--------|-------|---------|
| No-fertilizer (control)       | 19954| 179586 | 119793| 0      | 89793 |         |
| 2.5 t VC + 25% RDF            | 21870| 196830 | 100415| 2760.5 | 95654.5| 277.54  |
| 2.5 t VC + 50% RDF            | 22100| 198900 | 101450| 4021   | 95429 | D       |
| 5 t VC + 25% RDF              | 23425| 210825 | 107412.5| 4260.5 | 101152 | 877.27  |
| 7.5 t VC + 25% RDF            | 27286| 245574 | 124787 | 4742   | 118045 | 3508.41 |
| 100% RDF                      | 20911| 188199 | 94299.5| 5042   | 87257.5| D       |
| 2.5 t VC + 75% RDF            | 23090| 207810 | 105905 | 5281.5 | 96823.5| D       |
| 5 t VC + 50% RDF              | 23970| 215730 | 109865 | 5521   | 102344 | D       |
| 7.5 t VC + 50% RDF            | 27417| 246753 | 125376.5| 6002.5 | 117374 | D       |
| 5 t VC + 75% RDF              | 24288| 218412 | 111206 | 6781.5 | 102424.5| D       |
| 7.5 t VC + 75% RDF            | 27883| 250947 | 127473.5| 7263   | 118210.5| 6.55    |

Remarks: A.Y = Average Yield (kg/ha), Adj. Y = Adjusted yield (kg/ha), GFB = Gross field benefit (5 Birr per kg) (ETB per ha), TVC = Total variable cost (ETB per ha), NB = Net benefit (ETB per ha), D = Dominated treatment, MRR = Marginal rate of return
Further, the highest marginal rate of return (2127.15%) was recorded for the treatment 7.5 t VC + 25% RDF followed by that of 5 t VC + 25% RDF (726.40%) in Belg and 7.5 t VC + 25% RDF (3508.41%) followed by 5 t VC + 25% RDF (366.50%) in Meher season (Table 5 and Table 6). Based on these returns, for every 1 Birr spent on the respective treatments, it got a return of 21.27 Birr and 7.26 Birr per ha for Belg, 35.08 Birr and 3.66 Birr per ha for Meher season. However, according to CIMMYT (1988), all non-dominated treatments except 7.5 t VC + 75% RDF during the Meher season resulted in returns greater than the minimum acceptable value (50-100). Thus, the treatment consisting of 7.5 t VC + 75% RDF in Belg and 7.5 t VC + 25% RDF in Meher can be considered the best relative treatment in terms of economic returns compared with other nutrient integration ratios tested in this study.

CONCLUSION

The current study suggested that the combined vermicompost and mineral NP fertilizers are beneficial to potato yield and economics during both seasons. This study found the best crop performance when 7.5 t/ha VC and 75% of the recommended inorganic NP fertilizers (124 kg N/ha and 103 kg P$_2$O$_5$/ha) were applied to the potato crop. Thus, the combined use of 7.5 t VC per ha with 75% RDF or 50% RDF increased yield and economic feasibility of potato production in the study areas in Belg and Meher seasons, respectively.

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Isreal Zewide et al.: Vermicompost and Mineral NP Enhanced Potato’s Yield

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