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Research Article

Agronomic Evaluation of Improved Chickpea (*Cicer arietinum* L.) Varieties and Seeding Rates on Vertisols in Abeshige, Central Ethiopia

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Abstract

Identification of appropriate varieties and seed rates for different agroecology are important agronomic practices to increase the productivity of chickpea. A field experiment was conducted during the cropping season to evaluate the performance of chickpea varieties and their seed rates on Vertisols of Abeshige district. Four chickpea varieties (Minjar of 100, 125, 150 kg ha^{-1}), Teketay of 120, 150, 180 kg ha^{-1}, Habru of 130, 162.5 195 kg ha^{-1} and Yelbe of 120, 150, 180 kg ha^{-1})] and three levels of seed rates were used and combined factorially in randomized complete block design with three replications. Interaction of Chickpea varieties and seed rates were significantly affected number of days to 50% emergency, days to 50% flowering and 90% maturity, plant height, seed yield, number of pods per plant, number of seed per pod, hundred seed weight, harvest index and dry biomass of chickpea. Teketay varieties showed better performance on seed yield, harvest index and number of seed per pod in response to seed rate. Teketay with 180 kg ha^{-1} was gave better yield and yield components of Chickpea variety. Therefore, Teketay variety with 180 kg ha^{-1} is recommended to sustain chickpea production in Vertisols of Abeshige areas in central mid-lands of Ethiopia.

Keywords

Plant Density, Variety, Seed Yield, Chickpea, Correlation Coefficient

1. Introduction

Chickpea (*Cicer arietinum* L.) is the third most important grain, self-pollinating legume crop, and it is a basic component of the human diet in many countries. The leading chickpea producing countries in the world are India, Australia, Turkey, Myanmar, Ethiopia, Russia, Pakistan, United state of America, Iran and Mexico as FAOSTAT 2015-2020 years average report chickpea production top ten producers [5] Chickpea is a high-value crop that is adapted to deep black soils in the cool semi-arid areas of the tropics, sub-tropics as well as the temperate areas. Ethiopia is ranked third and fifth in the world in terms of yield and production, respectively [5] and accounts for over 90% of chickpea production in sub-Saharan Africa [4]. Importantly, it is among the principal legumes in the highland Vertisols mainly in the maize, tef, wheat, and sorghum-based cropping systems. Chickpea can grow well in elevation range of 1500 and 2700 m. Economic yield, however, is obtained within an altitude range of 1700 – 2600 m.

Both (Desi and Kabuli) seed types of chick pea are grown in Ethiopia [4]. Despite the fact that Ethiopia's agroclimatic

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conditions are suitable for both types. International markets favor the Kabuli types and offer higher prices for them, this has attracted attention in Ethiopia, and steps have been taken to increase Kabuli production and export [1].

However, the national yield of check pea was very low as compared to other countries. The main reasons of low yield of Chickpea is improper plant population. Too low and high plant population beyond a certain limit often adversely affects the crop yield. The optimum planting density for chickpea varies with location, the growing conditions, and growth habit of the varieties. The use of a low seeding rate has no significant effects on seed yield due to the capacity of the crop to produce a large number of branches to compensate for low plant population. However, it is essential to use high seed rate in ensuring good plant stand under adverse environmental conditions.

The recommendation for row planting of chickpea indicates a spacing of 30 cm between rows and 10 cm between plants which gives a density of about 333,334 plants ha^{-1} [7]. A reduced spacing between the plants can be used for varieties that are more erect and hence plant density can be increased. However, the seed rate by broadcast application method appears to be varying depending upon the seed size of the cultivars and growth habit. High seed rates (120-140 kg ha^{-1}) for large seeded and low seed rates (65-75 kg ha^{-1}) for varieties with small seed size are recommended [12]. The reduced plant population will be increasing the performance of individual plant. However, this does not indicate that maximum productivity as per a given area of land because of the inefficient utilization of plant growth factors such as moisture, air, space (land). In short, too dense plant population resulted from reduced inter and intra-row spacing and fewer plant population resulted from increased inter and intra-row spacing will adversely affect productivity per a given area of land. Higher plant population is producing taller, spindly, and more susceptible to lodging [8].

The national chickpea breeding program in Ethiopia has developed several improved varieties that are being promoted for large-scale adoption by farmers. The improved chickpea varieties differ in important agronomic attributes including seed size and grain yield. Nonetheless, chickpea landraces continue to be widely grown in large parts of Ethiopia [10]. It is often believed that crop landraces display a specific adaptation that may confer yield advantages over modern varieties under abiotic stress situations such as drought [9]. It may, therefore, be important to examine the differential performance of landrace and modern chickpea varieties when subjected to different levels of management regimes such as sowing dates and drainage methods.

Indeed, there will be a need to evaluate the performance of chickpea varieties in varying seed rate to determine the optimum plant density and promising varieties of the crop for maximum yield in the study area. In the study area, no research work has been done on the interaction effects of various agronomic practices such as plant density, identifying adaptive and yield promising of Chickpea varieties. Thus, knowing the seed rate recommendation for chickpea varieties in the studying area could improve the yield and yield components for small holder farmers. The objective was to determine the effect of seed rate and varieties, and their interaction on yield and yield components of chickpea in Abeshige district, Gurage, SNNPR Ethiopia.

2. Material and Methodology

2.1. Description of Experimental Site

The experiment was conducted in 2021 cropping season at SNNPR, Gurage zone Abeshige woreda fite Jeju kebele farmers training center which located at a latitude 8°19'16.06"N North and longitude 37°36'10.40"E East with an altitude of 1580 m.a.s.l (Figure 1).

2.2. Please Take and Put All Graphs and Tables After References

The mean temperature, precipitation, potential of evapotranspiration, water vapor pressure, wind speed, sun fraction and sun hours representing chickpea growing season of 2021 year (Table 1). Climate data were interpolated from New LocClim software of FAO, 2006. New LocClim is especially designed for the interpolation of agroclimatic data, offering the possibility of producing climate maps from user provided station data.

Table 1. *Climate Analysis: Temperature, Precipitation, and Solar Data for Each Month in Ethiopia.*

Months	T_Mean [℃]	Prec [mm]	PET [mm]	Vapor [hPa]	Wind [km/h]	Sun Fraction [%]	Sun hrs [h]
January	18.2	30	114.7	11.1	4.32	69	8:03
February	19.0	52	113.6	11.3	4.68	70	8:17
March	19.2	128	131.1	12.6	4.68	71	8:34
April	19.2	93	120.2	12.6	4.32	66	8:06
May	19.0	120	122.2	15.0	4.68	61	7:36

Months	T_Mean [℃]	Prec [mm]	PET [mm]	Vapor [hPa]	Wind [km/h]	Sun Fraction [%]	Sun hrs [h]
June	17.3	134	93.6	14.7	2.88	52	6:31
July	16.3	194	79.0	14.1	2.88	43	5:23
August	16.1	163	82.0	13.9	2.88	44	5:26
September	16.6	127	91.2	13.1	3.6	43	5:13
October	17.2	6	120.3	11.8	5.76	69	8:13
November	17.1	4	116.5	10	5.4	76	8:55
December	17.7	11	114.5	9.3	5.4	72	8:22

T_Mean = mean temperature, Prec = precipitation, PET = potential of evapotranspiration

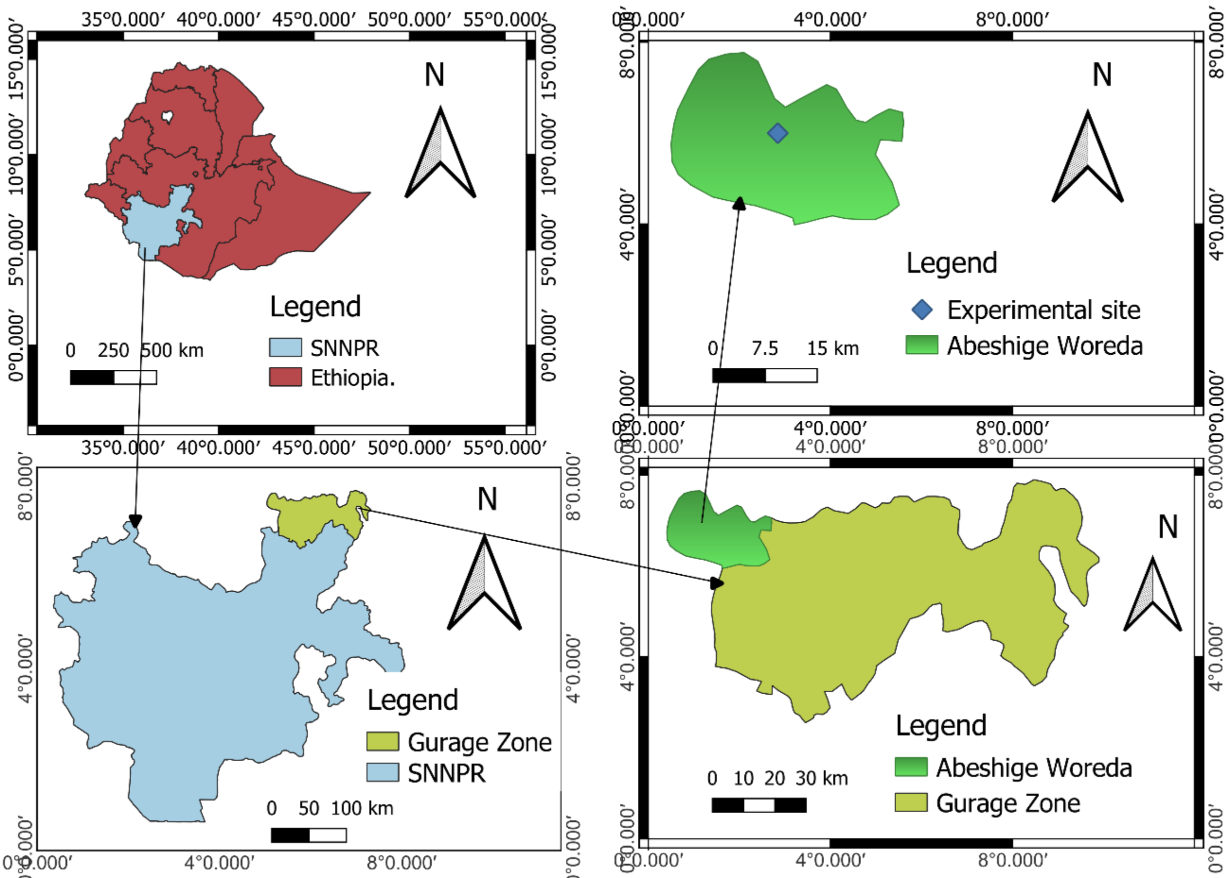

Figure 1. *Location map of study area.*

2.3. Experimental Treatments and Procedures

The field experiment comprised four improved chickpea varieties with three levels of seed rates [Minjar of 100, 125, 150 kg ha^{-1}), Teketay of 120, 150, 180 kg ha^{-1}, Habru of 130, 162.5 195 kg ha^{-1} and Yelbe of 120, 150, 180 kg ha^{-1}] were used. The design of the experiment was randomized complete block design in 3m × 3m factorial arrangements with three replications. Four chickpea varieties were used as Factor A and three seed rates as Factor B. In each season normal cultural practices for raising successful chickpea crop were applied. The recommended dose of fertilizer i. e. 23 Kg N and 100 Kg NPS ha^{-1} was applied in the form of urea at the time of seed sowing.

Table 2. *Description of chickpea varieties used for the study.*

S/N	Chick pea varieties	Year of released	Seed color	Type
1	Teketay (ICCV-00104)	2013		Desi
2	Habru (FILP88-42C)	2004	White	Kabuli
3	Yelbey (ICCV-14808)	2006	Yellowish	Kabuli
4	Minjar (ICCV-03107)	2010	Golden	Desi

Source; MoARD, 2018

Data collected

Soil Sampling and Analysis

Pre-planting and post-harvest soil samples (0-20 cm depth) were collected from five spots diagonally and composited. Composited soil sample was prepared following standard procedures and analyzed for soil pH, organic matter, organic carbon, available phosphorus and cation exchange capacity (CEC) [11]. After harvest, soil samples were also collected from each plot and composited treatment wise for the identification of resource change. Particle size distribution determination was following [13] procedure.

Table 3. *Soil physiochemical properties of the experimental sites.*

Time of sample collection	pH (1:25 H_2O)	Available phosphorus (mg/kg)	Organic carbon (%)	Organic matter (%)	CEC (Cmol (+) kg $^{-1}$ soil)	Texture (%)			
						Sand (%)	Clay (%)	Silt (%)	Class
Before planting	6.242	5.436	1.456	2.508	43.960	21.917	44.000	34.083	Clay
After harvesting	6.100	7.120	1.770	3.050	39.830	19.000	46.000	35.000	Clay

2.4. Crop Parameters

All-important phenology, growth, yield and yield parameters were collected following the standard procedure for the crop.

2.4.1. Phenological Data

Number of days to 50% emergence: was recorded as the number of days taken from sowing up to 50% of seedling emergence from each plot.

Number of days to 50% flowering: was recorded when 50% of the total plants flower in the plot and computed from the date of sowing till 50% of the plants attained flowering.

Days to 90% physiological maturity: was recorded as the number of days from the day of planting to the date when 90% of the plants attained physiological maturity in each plot.

2.4.2. Growth Parameters

Plant height: was measured in centimeters from ground level to the plant tip at physiological maturity using ten plants taken randomly from each plot.

Yield and yield components

Number of pods per plant: was computed by dividing total number of pods obtained from ten plants by ten.

Number of seeds per pod: was recorded by dividing total number of seeds from ten plants by total number of pods from ten plants.

Hundred seed weight: was taken by weighing 100 seeds drawn randomly from the grain yield obtained from each experimental plot.

Dry biomass yield: The weight in grams was recorded by weighing the total above ground biomass harvested from the two central middle rows from each experimental plot after air dried and was converted to get biomass yield per hectare.

Seed yield: Seed yield obtained in grams from each experimental plot's central two rows (2.4 m^2) and was converted to get seed yield per hectare.

Harvest index: was calculated as a ratio of total seed yield to total above ground biomass yield harvested from the two middle rows.

2.5. Statistical Analysis

The collected data were subjected to the analysis of variance (ANOVA) using statistical computer software R version 3.5.2 (2018) and R studio Version 1.4.1106 [7]. Mean separation was done using least significance difference (LSD) procedure at 5 % probability level.

3. Result and Discussion

Interaction effect of chickpea varieties with seed rate on crop phenology and growth parameters of Check pea.

The interaction effects of seed rates and varieties were significantly (P<0.05) influenced on number of days to emergency of chick pea (Table 4). The longest (12.27,12.00) number of days to emergency were obtained from 180 and 150 kg ha $^{-1}$ seed rates with the Yelbe variety and the shortest (9.33 and 9.67) number of days to emergency with 100, 125 and 150 kg ha $^{-1}$ seed rates of Minjar at Abeshige (Table 4). The data indicate that Yelbe variety considered as relatively late emergency while Habru and Teketay were medium days to emergency and shortest number of days to emergency recorded from minjar.

The interaction effects of seed rates and varieties were significantly (P<0.05) influenced on number of days to flowering chick pea (Table 4). The longest (63.67) number of days to flowering was obtained on 162.5 kg ha^{-1} seed rates with the Habru variety, and the shortest (45.33 and 9.67) number of days to flowering with 100and 150 kg ha $^{-1}$ seed rates of Minjar and Teketay variety (47.00) with 120 seed rate at Abeshige (Table 4). Similarly on lentil Varieties were significantly varied in days to 50% flowering and 95% maturity, number of nodules, plant height and biological yields [14].

The interaction effects of seed rate and varieties were significantly (P<0.05) influenced on number of days to 90 % maturity of chick pea (Table 4). The longest (111) number of days to maturity were obtained on 180 kg ha^{-1} seed rates with the Yelbe variety, and the shortest (9.33 and 9.67) number of days to 90 % maturity of with 100, 125 and 150 kg ha $^{-1}$ of seed rates from Minjar at Abeshge (Table 4). The data indicate that Yelbe variety considered as relatively late mature while habru and teketay were medium days to mature and early mature recorded on minjar from three four varieties at the study area.

The interaction effects of seed rate and varieties were significantly (P<0.05) influenced on plant height of chick pea (Table 4). The tallest (47cm) plant height was obtained from 130 kg ha^{-1} seed rates with the Habru variety, and the shortest (34.60cm) plant height with 125 kg ha $^{-1}$ seed rates with Minjar at Abeshige (Table 4).

Table 4*. Interaction effect of varieties and seed rate on number of days to 50% emergence, number of days to 50% flowering, number of days to 90% physiological maturity and plant height.*

Varieties and Seed Rate (kg ha^{-1})	number of days to 50% emergence	number of days to 50% flowering	number of days to 90% physiological maturity	Plant height (cm)
Yelbe:S_150 kg ha^{-1}	12.00^{a}	56.00^{ab}	109.00^{ab}	41.90^{abcd}
Habru: S_130 kg ha^{-1}	11.33^{ab}	59.67^{ab}	105.67^{abcd}	47.00^{a}
Teketay:S_150 kg ha^{-1}	11.33^{ab}	49.33^{ab}	101.00^{bcd}	43.07^{abcd}
Habru:S_162.5kg ha^{-1}	10.67^{ab}	63.67^{a}	107.33^{abc}	45.33^{ab}
Teketay:S_120 kg ha^{-1}	10.67^{ab}	47.00^{b}	105.33^{abcd}	39.87^{abcde}
Habru:S_195 kg ha $^{-1}$	10.33^{ab}	53.00^{ab}	105.67^{abcd}	46.33^{ab}
Teketay:S_180 kg ha^{-1}	10.33^{ab}	57.33^{ab}	103.33^{abcd}	39.80^{abcde}
Yelbe:S_180 kg ha^{-1}	12.27^{a}	54.33^{ab}	111.00^{a}	43.53^{abc}
Minjar:S_125 kg ha^{-1}	9.67^{b}	50.67^{ab}	97.33^{d}	34.60^{e}
Yelbe:S_120 kg ha^{-1}	11.50^{ab}	50.75^{ab}	104.75^{abcd}	39.35^{bcde}
Minjar:S_100 kg ha^{-1}	9.33^{b}	45.67^{b}	98.67^{cd}	36.13^{de}
Minjar:S_150 kg ha^{-1}	9.33^{b}	45.33^{b}	100.00^{cd}	36.73^{cde}
LSD (5%)	1.112	7.993	4.456	3.619
CV (%)	11.032	15.549	4.384	9.015

3.1. Interaction Effect of Seed Ratesand Varieties on Seed Yield and Yield Traits of Chickpea Varieties

Seed yield is one of the most important and phenomenal yield components which describe the overall potential of the genotypes and response to plant density and varieties. The seed yield of chickpea was highly significantly (P<0.01) affected by interaction effects of seed rates and varieties on chick pea (Table 5). The highest (1732kg ha^{-1}) grain yield was obtained from 180 kg ha^{-1} seed rate with the Teketay variety, followed by seed yields (1596 and 1564kg ha^{-1}), respectively from Teketay with 150 and 120 kg ha^{-1} seed rates, and the lowest (357 kg ha^{-1}) seed yield with 130 kg ha^{-1} seed rate of Habru variety at Abeshige (Table 5). [2]

The interaction effects of seed rate and varieties were highly significantly (P<0.01) influenced on dry biomass of chick pea (Table 5). The highest (2984 kg ha^{-1}) dry biomass was obtained from 180 kg ha^{-1} seed rates with the Teketay variety, followed by (2984.074, 2668.889 kg ha^{-1}), respectively dry biomass of Teketay with 120 and 150 kg ha^{-1} seed rates, and the lowest (1126 kg ha^{-1}) dry biomass with 120 kg ha^{-1} seed rates with Yelbe variety at Abeshige.

The interaction effects of seed rate and varieties were significantly (P<0.05) influenced on harvest index chick pea (Table 5). The highest (67.5%) harvest index was obtained from 180 kg ha^{-1} seed rates with the Teketay variety, and the lowest (26.6 and 27.9%) harvest index with 130 and 162.5 kg ha^{-1} seed rate from Yelbe variety. [3] Similarly reported that harvest index of chickpea variety influenced by seed rate and variety.

The interaction effects of seed rate and varieties were significantly (P<0.05) influenced on hundred seed weight of chick pea (Table 5). The varieties with the highest hundred seed weight (Yelbe with 150 kg ha^{-1}, Habru 162.5 kg ha^{-1}, and Yelbe 120 kg ha^{-1} seed rates).

The interaction effects of seed rate and varieties were significantly (P<0.05) influenced on number of pods per plant chick pea (Table 5). The highest (87.13) number of pods per plant was obtained from 180 kg ha^{-1} seed rates with the Yelbe variety, and Habru with 195 kg ha^{-1} seed rates was (75.57) and the lowest (39.93) number of pods per plant with the three of seed rate of Teketay at Abeshige.

The interaction effects of seed rates and varieties were significantly (P0.05) influenced on number of seed per pod of chick pea (Table 5). The highest (1.234) number of seeds per pod was obtained from 150 kg ha^{-1} seed rate with the Teketay variety, and Minjar with 195 kg ha^{-1} seed rate of (1.243) and the lowest (0.91, 0.904 and 0.928) number of seed per pod with the three seed rate of Habru at Abeshige this report were supported by [6].

Table 5. *Interaction effect of plant density and varieties on seed yield and yield traits of chickpea at Abeshige in 2021.*

Variety and seed rate	Seed yield (Kg ha^{-1})	Dry biomass (Kg ha^{-1})	Harvest index (%)	Hundred seed weight (g)	Number of pods per plant	Number seeds per plant
Teketay: S-180	1731.852^{a}	2984.074^{a}	0.675^{a}	25.33^{d}	39.93^{b}	1.242^{a}
Teketay: S-150	1595.556^{ab}	2668.889^{ab}	0.626^{ab}	26.33^{cd}	46.33^{b}	1.234^{a}
Teketay: S-120	1564.074^{ab}	2984.074^{a}	0.521^{abcd}	25.67^{d}	45.00^{b}	1.043^{ab}
Minjar: S-125	1184.444^{bc}	2142.593^{bc}	0.548^{abc}	18.67^{e}	46.20^{b}	1.164^{ab}
Minjar: S-150	1122.963^{bcd}	2050.37^{bcde}	0.550^{abc}	17.67^{e}	51.73^{ab}	1.178^{ab}
Minjar: S-100	1045.185^{cde}	1800.37^{cdef}	0.573^{abc}	18.00^{e}	66.60^{ab}	1.243^{a}
Yelbe: S-180	711.111^{cdef}	1619.63^{cdef}	0.432^{cde}	30.67^{ab}	87.13^{a}	1.127^{ab}
Habru: S-195	664.444^{def}	2109.26^{bcd}	0.296^{e}	28.33^{bc}	75.57^{a}	0.904^{b}
Yelbe: S-150	603.333^{ef}	1338.89^{def}	0.451^{bcde}	32.00 ^{a}	62.00^{ab}	1.197^{ab}
Habru: S-162.5	402.222^{f}	1502.22^{cdef}	0.266^{e}	32.33^{a}	63.73^{ab}	0.91^{b}
Yelbe: S-120	400.000^{f}	1126.11^{f}	0.345^{de}	31.25^{a}	60.85^{ab}	1.123^{ab}
Habru: S-130	357.037^{f}	1285.56^{ef}	0.279^{e}	30.00^{ab}	83.57^{a}	0.928^{b}
LSD (5%)	251.538	403.252	0.097	1.298	13.745	0.147
CV (%)	27.288	21.378	21.625	5.044	23.398	13.823

Means within the same column followed by the same letter non-significantly influenced at 5% probability level.

3.2. The Correlation Between Yield and Yield Attributes of Chickpea

The relationship among yield and yield components of chickpea varieties were presented in Figure 2. Correlation analysis indicated that seed yield was significantly and positively associated with dry biomass and harvest index (0.87) and (0.85) respectively. Days to maturity were significantly and negatively correlated with grain yield (-0.37). The association between number of pods per plant and seed yield were highly significant and negatively correlated. These may imply that chickpea varieties those bear densely pod per plant may not contain two or more seeds per pod whereas some varieties with a smaller number of pods per plant contains two or more seeds per pod that directly and positively related with seed yield. In addition to these hundred seed weight also had negatively correlated with seed yield, kabuli type of chickpea varieties had large seed size low productivity as compared to desi type of chickpea while desi type of chickpea varieties had small seed size and some of them were high yielder.

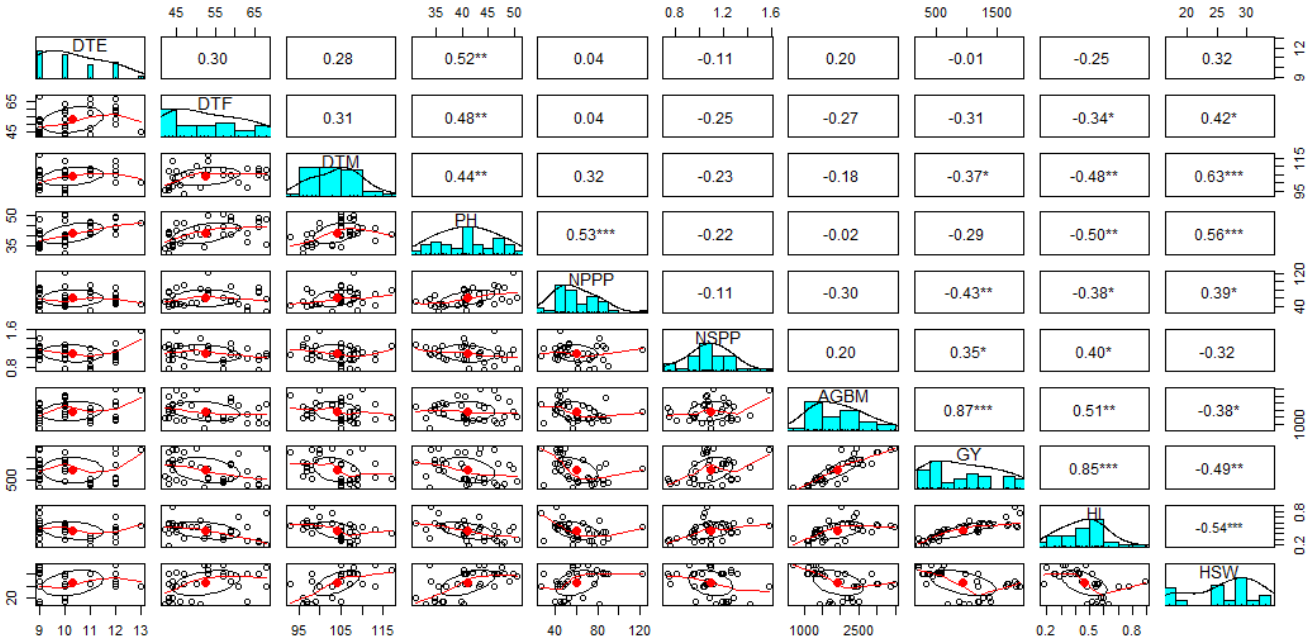

Figure 2. *Pearson correlation () of yield and yield related parameters of chickpea varieties grown in the field at Abeshge in 2021 cropping season.*

DTE=Days to Emergence; DTF=Days to 50% Flowering; DTM=Days to 90% Maturity; PH = plant height; NSP = number of seed per pod, NPPP = number of pods per plant, AGBM = above ground biomass, GY = grain yield, HI = harvest index, HSW = hundred seed weight.

4. Conclusions

The chickpea varieties evaluated showed significant variation in some of the yield and yield parameters. There was significance and positive correlation with most growth parameters, yield and yield components. Planting density influenced some parameters of chickpea varieties, The interactions of teketay variety with 180 seed rate was produced higher (1731.852 kg ha $^{-1}$) seed yield of chick pea. Significantly improved mean harvest index and higher (0.675%) and number of seed per pods (1.242) of chickpea were obtained from teketay with 180 kg ha $^{-1}$ Thus, chickpea teketay variety with 180 kg ha^{-1} can tentatively be recommended as best for double cropping maize production in the study area as compared to the other three varieties. Conclusive recommendation could be obtained if the study is repeated at more locations and seasons. Further study over years, locations and different chickpea varieties with different planting densities to suggest valid recommendation for the area.

Abbreviations

MoARD Ministry of Agriculture and Rural Development

Author Contributions

Takele Zike is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflict of interest.

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