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RESEARCH ARTICLE

INFLUENCE OF MIXED CROPPING OF CABBAGE AND MUSTARD ON WEED DYNAMICS AND YIELD OF POTATO (*SOLANUM TUBEROSUM*)

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ABSTRACT

A field experiment was conducted in Horticulture farm of Agriculture and Forestry University, Chitwan, Nepal during September 2018 to January 2019 to evaluate the influence of mixed cropping of cabbage and mustard in weed dynamics and yield of potato. The experiment was carried out in a split-plot design with three replications. The treatment consists of with mustard (M1) and without mustard (M2) as main plot factor and eight treatments namely, sole potato at 0.7m (T1) and 1.4m (T5) inter-row spacing, sole cabbage at 0.35m (T2) and 0.7m (T3) inter-row spacing, potato at 1.4 m row spacing with one (T4), two (T7) and three (T8) row cabbage, and potato at 0.7m row spacing with one-row cabbage (T6), as subplot factor. Effect of broadcasting mustard was found significant in the dry weight of broadleaf weed, the height of cabbage and potato, cabbage canopy, and net production of potato. Net production was calculated by converting the yield of all the three crops in the monetary value of potato. Similarly, the effect of different intercropping of cabbage and potato was found significant on cabbage and potato height, cabbage canopy, dry weight of weed, the yield of cabbage and potato, and net production of potato. The interaction of main plot factors and sub-plot factors was found statistically significant; mustard broadcasting on intercropping of 35cm cabbage within 70cm row to row spacing of potato (M1×T6) was found superior in terms of yield of all the three crops and net production of potato. Similarly, (M1×T6) had a lower dry weight of broadleaf; Solanum nigrum and Chenopodium album were major weeds—both being a broadleaf weed. Thus, it would be better to suggest vegetable growing farmers, to follow mixed cropping of cabbage, mustard and potato for higher return and sustainable ecological weed management.

KEYWORDS

split-plot design, broadcasting, main-plot, sub-plot, productivity

1. INTRODUCTION

Stability and functioning of terrestrial ecosystems are dependent on plant biodiversity and species composition (Neem et al., 1994, and Hooper and Vitousek, 1997). Besides, the types of crops grown in any area is largely determined by four fundamental factors namely, physical, social economic and political factors. Physical factors like soil, radiation, water, moisture and temperature significantly affects the ability of crops to grow; but, the influence of social (taste, tradition, religion, etc.), political (stable price and market) and economic factors (cost of production, demand, price etc) cannot be neglected (Norman, 1974). Mixing different species of plantsin the cropping system has a magnificent advantage to contribute to sustainable agriculture (Vandermeer, 1989). Mixed cropping is the system of growing two or more crops together on the same piece of land, in such a way that, the best possible return is expected. It helps to decrease the risk of crop failure during unfavourable climatic conditions, rehabilitate disturbed ecosystem services, and decrease the risk of invasion of disease and pests (Gurr et al., 2003).

Vegetable farming is a source of subsistence for more than 3.2 million farmers of Nepal (Dahal et al., 2019); besides, Vegetable crops share large figures in the agricultural GDP of Nepal. Potato(*Solanum tuberosum*) is one of the important vegetable crops of Nepal; it belongsto the family Solanaceae. It is a source of income to small landholding farmers of hilly regions of Nepal, more importantly, it is a major staple crop in hills of Nepal (Bajracharya and Sapkota, 2017). As a cool-season crop, potato, Nepalese farmers have been cultivating it since 200 years ago (Ojha et al., 2001). It is cultivated from 100 m altitudes in the south to 4000 m altitude in the northern part of the country (Dahal and Rijal, 2019). The productivity of potatoes in fiscal year 2016/17 was 13,943 kg/ha which is lower than the global average (MoALD, 2017). Low productivity of potato in Nepal is ascribed by the poor adoption of improved cultivation practices namely the adoption of improved varieties, fertilizer management, weed and pests management. Major weeds of potato are *Cyperus rotundus, chenopodium album, Phalaris minor, Coronophus didymus* . Weed is one of the major problems of potato as it competes with light, moisture, space nutrients and reduced potato tuber size (Love et al., 1995) but Nelson and Therson(1981) found that weed not only reduce tuber size but tuber number also; similarly, weed reduce tuber yield by more than 55% (Rana et al., 2004). There are three possible ways for weeds management: use of herbicides, manual and managing weed-crop competition. Use of either chemical or manual method for weed management reduces the benefit of potato farming; thus, changing crop-weed interaction is the economical method.

Intercropping, a method of changing crop weed integration is best suited for better use of environmental resources than mono-cropping (Fukai and Trenbath, 1993). It is important from the aspect of profitability and productivity in terms of time and area; furthermore, they are alternative to the use of herbicides (Liebman and Davis, 2000) as they reduce weed density and promote efficient growth of crop (Liebman and Dyck, 1993).

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Intercrops reduce weed density because they capture available nutrients and other resources. Mixed cropping is best suited to developing countries like Nepal, where most of the farmers are subsistence type. They are best for home gardens to produce a variety of products from limited land resources economically and sustainably. In such a scenario, mixed cropping of cabbage and mustard with potato helps to gain diverse crops from limited resources. Incorporation of Crucifers residue in potato reduces weed density by 73-85% and weed biomass by 50-96% (Boydston and Hang, 1995). Crucifers contain glucosinolate compounds which show allelopathic effects and contribute to weed suppression (Liebman and Davis, 2000). Intercropping of mustard in cabbage helps in the management of major lepidopterous pests as mustard is the preferred crop of the lepidopterous larva (Srinivasanet al., 2008). Mixed cropping is stable than mono cropping especially for small landholders where resources are scarce and it is suited with mechanized farming (Guvenc and Yildrim, 2006). Cabbage, mustard and potato are cultivated in the same season and their nutrient requirement is somewhat similar (MoAD, 2017). This type of intercropping is best suited for small land holding vegetable farmers and kitchen gardens, thus the main objective of the research is to study about the influence of mixed cropping of cabbage and mustard in weed dynamics and yield of potato.

2. Materials and Methods

2.1 Experimental detail

The experiment was conducted in Agriculture and Forestry University, Bharatpur metropolitan city, Rampur, Chitwan from October 2018 to February 2019. The geographical location of the experimental site is 27^{0}38 '50.92"N, 84^0 20' 49.43"E with an elevation of 228 meters above sea level. Soil type is sandy loam and acidic with greyish white colour (Jha et al., 2018). The climate of the experimental area is subtropical with unimodal rainfall patterns.

2.2 Experimental design

The experiment was carried out to find out the influence of mixed cropping of cabbage and mustard in weed dynamics and productivity of potato. As two different factors affecting the weed dynamics and yield of potato were examined, split-plot design with three replications was used to examine the effect of both the factors.

Factor 1: Different intercropping of cabbage and potato as subplot factor

T_1= sole potato at 0.7m inter-row spacing
T_2= sole cabbage at 0.35m inter-row spacing
T_3= sole cabbage at 0.7m inter-row spacing
T_4= potato at 1.4 m row spacing with one-row cabbage
T_5= sole potato at 1.4m inter-row spacing
T_6= potato at 0.7m row spacing with one-row cabbage
T_7= potato at 1.4m spacing with two-row cabbage
T_8= potato at 1.4 m spacing with three-row cabbage

Factor 2: with broadcasting and without broadcasting of mustard as the main plot factor

For the main plot factor, there were three replication and the replicated plots accommodate all the treatments. The size of the individual plot was 4.2×2m^2, the distance between the main plots was 1m and that of subplot was 0.5m.

2.3 Plant material

Ulhas (MYSL 203) variety of mustard, *Seet le nakhane aalu* (blight resistant) variety of potato and NT 766 variety of cabbage were collected from local agro vet under the periphery of Agriculture and Forestry University. The variety was selected under the recommendation of an expert because of the following features:the variety of mustard is suitable for well-drained soil type and is short-duration variety,the potato variety is blight resistant with a red colour tuber, and NT 766 is medium size with a compact and somewhat conical head.

2.4 Climatic condition during experimental duration

2.4.1 Nutrient management

Nutrient management is the main concern in inter-cropping. All the three crops have somewhat similar nutrient requirements thus blanket dose of NPK at 200:180: 100 kg per hectare was given. Half dose of Nitrogen was applied as basal dose and the remaining half was top-dressed after 45 days of sowing.

2.4.2 Sowing and Irrigation

The field was prepared by one deep ploughing and three light ploughing followed by planking. Potato tubers with 2-3 sprouts are sown in the ridge and cabbage seedling were transplanted in a flatbedon October 27 2018. Immediately after the transplanting of cabbage light irrigation was given with the help of rose can and frequent irrigation was given till the establishment of cabbage. The mixture of mustard seed and sand was made and broadcasting was done on October 28 2018. After 15 days of sowing the whole experimental plot was irrigated and frequent light irrigation was given at each 15-day interval.

2.5 Measurement of data

To measure the influence of mixed cropping of cabbage and mustard in weed dynamics and yield of potato, five plants of all the three crops were selected excluding border plants. Following parameters were selected for the study,

Plant height: plant height of all the three crops was taken; it was measured from the base of the plant to its tip. Data was collected from 30DAS and continued at the fortnight interval.

Canopy Length: Canopy length of cabbage was taken from 30DAS and continued at 15 days interval till harvesting. It was measured by using meter tape by taking the diameter of the canopy across the axes, after which mean was taken.

Leaf number: Fully opened leaves of cabbage and mustard were counted across the whole height of the plant.
Number of weeds: Number of weeds was taken by making a square of 1×1m^2 in 'N' patterns from an individual plot. The weed was categorized into narrow leaf, board leaf and sedges with their family and scientific name.

Fresh weight and dry weight: The fresh weight of weed was taken by using measuring box; 100 gm of each category was taken and placed in the oven at 105^{0}C for 72 hrs and their dry weight was measured. Data was collected from 30DAS and continued at fortnight intervals until the harvest of the crop.

Yield: Yield of mustard, as leafy vegetables was taken at 30DAS whereas potato and cabbage were harvested after 100 days of sowing.

2.6 Statistical analysis

The data entry was done on MS Excel and analyzed by using R studio. All the recorded data were subjected to analysis of variance and LSD test was done for mean comparison. The significant difference among the means was tested using least significant difference (LSD) at 5% level of significance.

Data transformation: Normal distribution of number and weight--both dry and fresh--of weed was checked and it was found abnormal distribution; thus square root data transformation was deployed (Gomez and Gomez, 1984).

Climate of the study area: Source: (World Weather Online, 2020)

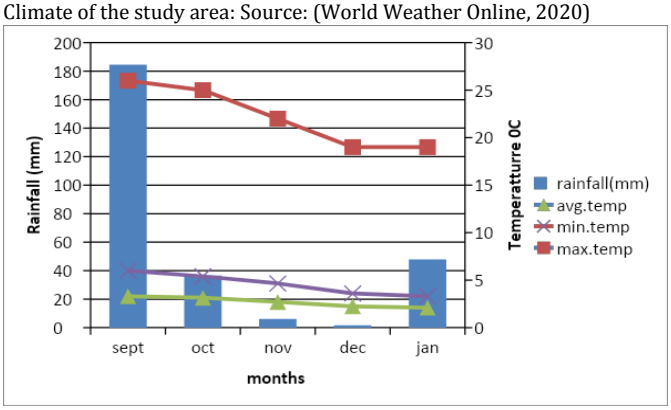

Figure 1: Weather condition during experimentation

The maximum temperature recorded was 26^{0}C, while the minimum temperature was 8^{0}C. The average precipitation in the experiment site was 55.34mm, shown in figure no.1

3. Results

The experiment was conducted to study two different factors with or without mustard and different inter-row cropping of cabbage and potato on the weed dynamics and yield of potato. The results of each parameterhave been discussed and interpreted in this section. The average height of cabbage was recorded higher in plots with mustard broadcasting, but the result was found to be statistically non- significant at 30DAS and 45DAS while it was found significant at 60DAS and 75DAS. The average height of cabbage in mustard broadcasted plot at 60DAS and 75DAS was 34.59 cm and 35.33 cm respectively (shown in table no.1)

Table 1: Influence of mixed cropping of cabbage, mustard and potato in Cabbage height under weed dynamics

	Height of plant (cm)			
Treatments	30DAS	45DAS	60DAS	75DAS
Main plot factor				
mustard broadcasting(M1)	23.10	31.28	34.59^{a}	35.33^{a}
without mustard(M2)	22.38	29.62	30.53^{b}	31.63^{b}
CV%	13.70	15.10	8.10	7.00
LSD(0.05)	4.48	6.54	3.77	3.37
F-test	NS	NS	*	*
Subplot factor				
35cm cabbage (T2)	23.56^{ab}	30.71^{ab}	32.63^{ab}	33.03^{ab}
70 cm cabbage (T3)	20.86^{b}	29.19^{b}	31.97^{b}	33.23^{ab}
140 cm potato+ 1 row cabbage (T4)	21.36^{b}	30.19^{ab}	32.28^{b}	33.76^{ab}
70 cm potato+ 35cm cabbage (T6)	24.8^{a}	31.60^{a}	34.17^{a}	34.96^{a}
140 cm potato+2 row cabbage (T7)	23.53^{ab}	29.92^{ab}	32.23^{b}	33.30^{ab}
140 cm potato +3 row cabbage (T8)	22.33^{ab}	30.02^{ab}	32.11^{b}	32.59^{b}
CV%	12.40	5.90	4.40	4.90
LSD(0.05)	3.40	2.16	1.74	1.98
F-test	*	*	*	*
Interaction				
M1×T2	24.80^{ab}	31.42^{ab}	34.46^{ab}	35.07^{abcd}
M1×T3	21.06^{b}	29.32^{b}	33.80^{bc}	34.13^{bcde}
M1×T4	20.26^{b}	31.57^{ab}	34.70^{ab}	35.93^{ab}
M1×T6	26.27^{a}	33.48^{a}	36.80^{a}	37.00^{a}
M1×T7	22.80^{ab}	30.74^{ab}	34.27^{b}	35.53^{abc}
M1×T8	23.40^{ab}	31.17^{ab}	33.56^{bc}	34.13^{bcde}
M2×T2	22.33^{ab}	30.01^{b}	30.80^{d}	31.00^{f}
M2×T3	20.67^{b}	29.07^{b}	30.13^{d}	32.33^{def}
M2×T4	22.46^{ab}	28.81^{b}	29.86^{d}	31.60^{ef}
M2×T6	23.33^{ab}	29.73^{b}	31.53^{cd}	32.93^{cdef}
M2×T7	22.26^{ab}	29.10^{b}	30.20^{d}	31.07^{f}
M2×T8	21.27^{b}	28.86^{b}	30.67^{d}	30.46^{f}
LSD(0.05)	4.82	3.06	2.41	2.80
F-test	*	*	*	*

Note: NS represent statistically non-significant whereas * represent significant at 5% level of probability

Effect of different inter-row cropping of cabbage and potato on cabbage height was found to be statistically significant at 5% level of probability. Cabbage height was found higher in of 35 cm cabbage within 70 cm inter-rows of potato (T6) whereas smaller height was found in single row cabbage within 140 cm inter-row spacing of potato (T4) at 30DAS and three rows of cabbage within 140 cm inter-row spacing of potato (T8) at 45DAS, 60DAS and 75DAS shown in table no.1. The effect of the interaction of the main plot factor (with or without mustard) on subplot factor (different intercropping of cabbage and potato) on plant height of cabbage was found to be statistically significant. Cabbage height was found higher, throughout the cropping period, when mustard was broadcasted in single inter-row cabbage within 70cm row spacing of potato (M1×T6) whereas smaller cabbage height was recorded in 140cm row spacing potato with 3-row cabbage and without mustard (M2×T8)throughoutthe cropping period shown in table no. 1.

Table 2: Influence of mixed cropping of cabbage, mustard and potato in cabbage canopy under weed dynamics

	Canopy of plant (cm)			
Treatments	30DAS	45DAS	60DAS	75DAS
Main plot factor				
mustard broadcasting(M1)	37.92	45.91^{a}	50.04^{a}	50.93^{a}
without mustard(M2)	36.52	41.31^{b}	44.44^{b}	45.64^{b}
CV%	14.4	6.10	6.40	6.00
LSD(0.05)	7.68	3.81	4.31	4.17
F-test	NS	*	*	*
Sub-plot factor				
35cm cabbage (T2)	37.63^{ab}	43.73^{ab}	47.03	47.78^{ab}
70 cm cabbage (T3)	38.93^{ab}	45.07^{a}	48.07	50.06^{a}
140 cm potato+ 1 row cabbage (T4)	33.95^{b}	43.55^{ab}	46.88	48.73^{ab}
70 cm potato+ 35cm cabbage (T6)	39.58^{a}	44.76^{a}	47.65	48.75^{ab}
140 cm potato+2 row cabbage (T7)	38.13^{ab}	43.72^{ab}	47.51	48.05^{ab}
140 cm potato +3 row cabbage (T8)	35.10^{ab}	40.83^{b}	46.31	46.35^{b}
CV%	11.5	7.3	4.9	4.7
LSD(0.05)	5.16	3.83	2.78	2.7
F-test	*	*	NS	*
Interaction				
M1×T2	37.93^{a}	46.37^{ab}	50.30^{a}	51.26^{ab}
M1×T3	38.60^{a}	47.28^{a}	51.03^{a}	52.50^{a}
M1×T4	30.63^{b}	43.69^{abc}	49.13^{a}	51.43^{ab}
M1×T6	40.43^{a}	46.88^{a}	51.37^{a}	51.13^{ab}
M1×T7	37.32^{ab}	46.88^{a}	50.27^{a}	49.60^{abc}
M1×T8	34.23^{ab}	44.35$_{abc}$	48.16^{ab}	49.66^{abc}
M2×T2	37.33^{ab}	41.08^{bcd}	43.76^{c}	44.30^{de}
M2×T3	39.27^{a}	42.85^{abc}	45.11^{bc}	47.63^{bcd}
M2×T4	37.27^{ab}	43.24^{abc}	44.63^{bc}	46.03^{cde}
M2×T6	38.73^{a}	42.64^{abcd}	43.94^{c}	46.36^{cde}
M2×T7	38.93^{a}	40.55^{cd}	44.76^{bc}	46.50^{cde}
M2×T8	35.97^{ab}	37.30^{d}	44.46^{bc}	43.3^{e}
LSD(0.05)	7.29	5.21	3.93	3.82
F-test	*	*	*	*

Note: NS represent statistically non-significant whereas * represent significant at 5% level of probability

The average canopy of cabbage was recorded higher in plots with mustard broadcasting; but the result was found to be statistically non- significant at 30DAS while it was found significant at 45DAS, 60DAS and 75DAS. The average canopy of cabbage for mustard broadcasted plot at 45 DAS, 60DAS and 75DAS was 45.91cm, 50.04cm, 50.93cm respectively. Similarly, the average canopy was found statistically significant for subplot factor throughout the cropping period, except at 60DAS. Longer canopy length was observed in single row cabbage (35cm) within70cminter-row spacing of potato (T6) at 30DAS and 45DAS whereas it was found longer in 70cm row spacing cabbage (T3) at 75DAS. Shorter canopy length was found inone-row cabbagewithin140 cm row spacing potato (T4) at 30DAS, and three inter-row cabbages (T8) within 140 cm row spacing potato at 45DAS and 75DAS shown in table no.2. The effect of the interaction of main plot factor (with or without mustard) on subplot factor (different intercropping of cabbage and mustard) on cabbage canopy was found to be statistically significant. Statistically higher canopy length was observed, throughout the cropping period, when mustard was broadcasted in 70cm row spacing of potato and single inter-row cabbage (M1×T6); similarly, smaller canopy cover was recorded in 140cm row spacing potato with 3-row cabbage and without mustard throughout (M2×T8) at 30DAS, 45DAS and 75DAS while 35cm row spacing of cabbage without mustard broadcasting (M2×T2) at 60DAS shown in table no.2.

Table 3: Influence of mixed cropping of cabbage, mustard and potato in cabbage leaf number and cabbage yield under weed dynamics

Treatments	30DAS	45DAS	60DAS	75DAS	yield(kg/ha)
Main plot factor					
mustard broadcasting(M1)	12.88	12.44	12.58	11.66	33703.85
without mustard(M2)	12.71	12.41	12.36	11.31	32490.07
CV%	6.70	6.6	4.00	3.1	55.4
LSD(0.05)	1.22	1.17	0.71	0.5	26278.64
F-test	NS	NS	NS	NS	NS
Sub-plot factor					
35cm cabbage (T2)	13.3^{a}	12.46	11.93	11.36^{ab}	42703.97^{a}
70 cm cabbage (T3)	13.33^{a}	13.1	13.06	10.96^{b}	38392.85^{ab}
140 cm potato+ 1 row cabbage (T4)	12.1^{b}	11.73	12.00	11.43^{ab}	15317.47^{c}
70 cm potato+ 35cm cabbage (T6)	13.13^{a}	12.13	13.00	12.26^{a}	38273.28^{ab}
140 cm potato+2 row cabbage (T7)	12.53^{ab}	12.56	12.50	11.73^{ab}	25619.85^{bc}
140 cm potato +3 row cabbage (T8)	12.4^{ab}	12.56	12.36	11.16^{b}	38392.85^{ab}
CV%	6.3	9.4	9.2	6.9	37
LSD(0.05)	0.97	1.41	1.41	0.95	14750.19
F-test	*	NS	NS	*	*
Interaction					
M1×T2	13.40^{ab}	13.46^{a}	11.73^{b}	11.20^{abc}	44614.30^{a}
M1×T3	13.73^{a}	12.67^{ab}	13.79^{a}	11.73^{ab}	32976.20^{abc}
M1×T4	11.66^{c}	11.40^{b}	12.26^{ab}	11.46^{abc}	16190.50^{bc}
M1×T6	13.40^{ab}	11.80^{ab}	12.53^{ab}	12.33^{a}	43115.10^{a}
M1×T7	12.67^{abc}	12.33^{ab}	12.73^{ab}	11.73^{ab}	24255.57^{abc}
M1×T8	12.47^{abc}	13.00^{ab}	12.45^{ab}	11.53^{abc}	41071.43^{a}
M2×T2	13.20^{ab}	11.46^{b}	12.13^{ab}	11.53^{abc}	40793.64^{a}
M2×T3	12.93^{abc}	13.53^{a}	12.33^{ab}	10.20^{c}	43571.43^{a}
M2×T4	12.53^{abc}	12.06^{ab}	11.73^{b}	11.40^{abc}	14444.43^{c}
M2×T6	12.87^{abc}	12.46^{ab}	13.46^{ab}	12.20^{a}	33432.53^{abc}
M2×T7	12.40^{abc}	12.80^{ab}	12.27^{ab}	11.73^{ab}	26984.13^{abc}
M2×T8	12.33^{bc}	12.13^{ab}	12.26^{ab}	10.80^{bc}	35714.27^{ab}
LSD(0.05)	1.37	1.99	1.95	1.35	20859.93
F-test	*	*	*	*	*

Note: NS represent statistically non-significant whereas * represent significant at 5% level of probability

Average leaf number of cabbage was recorded higher in plots with mustard broadcasting, but the result was found to be statistically non-significant throughout the crop period. Average leaf number was found statistically significant for subplot factor (different intercropping of cabbage and potato) at 30DAS and 75DAS; however, the result was found statistically non-significant at 45DAS and 60DAS. The larger number of cabbage leaf was observed in a single row (35cm) of cabbage within 70cm row spacing of potato (T6) at 30DAS and 75DAS; besides, more number of leaf was also found in 35cm row spacing cabbage (T2) and 70 cm row spacing cabbage (T3) at 30DAS. The impact of the interaction of the main plot factor (with or without mustard) with subplot factor (different intercropping of cabbage and mustard) on leaf number was found to be statistically significant. Higher leaf number was found in broadcasting of mustard in 70 cm inter-row cabbage (M1×T3) at 30DAS, broadcasting of mustard in 35cm inter-row cabbage (M1×T2) at 45DAS, broadcasting of mustard in 70 cm inter-row cabbage (M1×T3) at 60DAS and broadcasting of mustard in single inter-row cabbage within 70cm row spacing of potato (M1×T6) shown in table no.3.

Yield of cabbage (kg/ha) was found higher in mustard broadcasted plots than without mustard; however, the result was statistically non-significant. Yield of cabbage (kg/ha) was found statistically significant for subplot factor (different intercropping of cabbage and potato); higher (42703.97 kg/ha) being 35cm row to row spacing of cabbage (T2) and lower (15317.47 kg/ha) for 140 cm row spacing of potato and single row of cabbage (T4). The result of the interaction of main plot factor (with or without mustard broadcasting) with subplot factor (different intercropping of cabbage and mustard) on cabbage yield was found to be statistically significant at 5% level of probability. Statistically higher, and similar, result on cabbage yield was obtained in cabbage at 35cm row to row spacing with mustard broadcasting (M1×T2), mustard broadcasting on intercropping of 35cm cabbage within 70cm row to row spacing of potato (M1×T6), mustard broadcasting on intercropping of three rows of cabbage within 140 cm row to row spacing of potato (M1×T8), without mustard broadcasting on 35 cm row to row spacing of cabbage(M2×T2) and without mustard broadcasting on 70 cm row to row spacing of cabbage (M2×T2); however, cabbage yield was found higher, among statistically higher and similar, for 35cm row to row spacing with mustard broadcasting (M1×T2). Similarly, poor yield of cabbage was obtained on without mustard broadcasted plots with intercropping of a single row of cabbage within 140 cm row spacing of potato (M2×T4) shown in table no.3.

Table 4: Influence of mixed cropping of cabbage, mustard and potato in potato plant height and potato yield under weed dynamics

	Height of plant (cm)				
Treatments	30DAS	45DAS	60DAS	75DAS	yield(kg/ha)
Main plot factor					
mustard broadcasting(M1)	23.11	28.99	31.73^{a}	34.26^{a}	5206.75
without mustard(M2)	23.18	25.07	27.81^{b}	29.75^{b}	4269.84
CV%	10.10	11.60	8.20	6.00	25.20
LSD(0.05)	3.34	4.49	3.49	2.76	171343
F-test	NS	NS	*	*	NS
Sub-plot factor					
70cm potato (T1)	21.91^{c}	25.95^{bcd}	28.55^{b}	31.30^{abc}	8345.27^{a}
140 cm potato+ 1 row cabbage (T4)	21.23^{c}	25.05^{d}	28.06^{b}	30.90^{bc}	4208.33^{b}
140 cm potato (T5)	21.63^{c}	25.53^{cd}	30.53^{ab}	30.76^{c}	3309.53^{b}
70 cm potato+ 35cm cabbage (T6)	25.36^{a}	27.93^{ab}	30.10^{ab}	33.17^{a}	6809.52^{a}
140 cm potato+2 row cabbage (T7)	23.56^{b}	29.97^{a}	31.60^{a}	33.08^{ab}	2899.99^{b}
140 cm potato +3 row cabbage (T8)	25.20^{a}	27.73^{abc}	29.80^{ab}	32.83^{abc}	2857.14^{b}
CV%	10.5	7.00	7.00	5.7	29
LSD(0.05)	0.95	2.26	2.51	2.19	1655.71
F-test	*	*	*	*	*
Interaction					
M1×T1	22.16^{cd}	28.47abc	30.97abcd	31.16abc	8833.37^{a}
M1×T5	23.06^{c}	29.00abc	32.40ab	31.73cde	3690.48^{de}
M1×T4	22.13^{cd}	27.07^{bc}	29.53^{bcdef}	32.87^{bcd}	4845.23^{cd}
M1×T6	22.67^{b}	29.13^{abc}	32.07^{abc}	36.00^{a}	7190.47^{ab}
M1×T7	21.40^{def}	30.87^{a}	33.33^{a}	35.83^{ab}	3347.42^{de}
M1×T8	25.26^{ab}	29.80^{ab}	32.13^{abc}	34.97^{ab}	3333.34^{de}
M2×T1	21.67^{de}	23.43^{de}	26.13^{f}	28.43^{f}	7857.75^{ab}
M2×T5	20.20^{f}	22.07^{e}	28.66^{cdef}	29.80^{def}	2928.57^{de}
M2×T4	20.33^{ef}	23.03^{de}	26.60^{ef}	28.93^{ef}	3571.43^{de}
M2×T6	26.06^{a}	26.73^{bc}	28.13^{def}	30.33^{def}	6428.57^{bc}
M2×T7	25.73^{ab}	29.07^{abc}	29.87^{abcde}	30.33^{def}	2452.38^{e}
M2×T8	25.13$_{ab}$	26.07^{cd}	27.46^{def}	30.70^{def}	2380.95^{e}
LSD(0.05)	1.351	3.2	3.55	3.101	2341.52
F-test	*	*	*	*	*

Note: NS represent statistically non-significant whereas * represent significant at 5% level of probabiliy

Average plant height of potato was recorded higher in plots with mustard broadcasting, and the result was found to be statistically significant at 60DAS and 75DAS whereas, it was found non-significant at 30DAS and 45DAS. Average plant height of potato was found statistically significant for subplot factor (different intercropping of cabbage and potato) throughout the crop period. Statistically higher plant height was observed in intercropping of single row of cabbage (35cm row to row) within 70cm row to row spacing of potato (T6) at 30DAS and 30DAS and 75DAS, intercropping of double rows of cabbage within 140cm row to row spacing potato (T7) at 45DAS and 60DAS, and intercropping of triple rows of cabbage within 140cm row to row spacing of potato (T8) at 30DAS as mentioned in table no.4. The result of the interaction of main plot factor (with or without mustard broadcasting) with subplot factor (different intercropping of cabbage and mustard) on plant height of potato was found to be statistically significant at 5% level of probability. Higher plant height was obtained in plots without mustard and intercropping of single row of cabbage within 70 cm row to row spacing of potato (M2×T6) at 30DAS, mustard broadcasting on intercropping of double rows of cabbage within 140 cm row to row spacing of potato (M1×T7) at 45DAS and 60DAS and broadcasting of mustard with intercropping of single row of cabbage within 70cm row to row spacing of potato (M1×T6) at 75DAS as mentioned in the table no.4.

The yield of potato (kg/ha) was found to have higher in mustard broadcasted plots than without mustard; however, the result was statistically non-significant. The yield of potato (kg/ha) was found statistically significant for subplot factor (different intercropping of cabbage and potato) at 5% level of probability. The statistically higher yield of potato was found in row spacing of 70cm sole potato (T1) and intercropping of a single row of cabbage within 70com row to row spacing of potato(T6), the yield was 8345.27 kg/ha and 6809.52kg/ha respectively. Similarly, the result of interaction of main plot factor (with or

without mustard broadcasting) with subplot factor (different intercropping of cabbage and mustard) on yield of potato was found to be statistically significant at 5% level of probability; superior result was observed in broadcasting of mustard in 70cm row to row spacing of potato(M1×T1), shown in table no.4.

Table 5: Influence of mixed cropping of cabbage, mustard and potato in dry weight of broadleaf weed and productivity of potato

Treatments	30DAS	45DAS	60DAS	75DAS	potato(kg/ha)
Main plot factor					
mustard broadcasting(M1)	3.67	7.37^{b}	7.49^{b}	12.11^{b}	27324.75^{a}
without mustard(M2)	5.00	12.13^{a}	13.99^{a}	17.64^{a}	12340.22^{b}
CV%	65.40	36.30	47.30	11.70	30.00
LSD(0.05)	3.52	4.39	3.37	2.34	7397.63
F-test	NS	*	*	*	*
Sub-plot factor					
70cm potato (T1)	4.39^{ab}	10.09^{bcd}	12.41^{bc}	14.28^{bc}	14582.59^{de}
35cm cabbage (T2)	3.15^{b}	7.69^{cde}	6.14^{d}	10.15^{c}	23769.08^{b}
70cm cabbage (T3)	3.93^{ab}	11.96^{ab}	12.96^{ab}	14.34^{bc}	21920.67^{b}
140 cm potato+ 1 row cabbage (T4)	5.80^{a}	11.14^{abc}	13.91^{ab}	19.22^{b}	15399.67^{cd}
140 cm potato (T5)	5.18^{ab}	14.60^{a}	16.31^{a}	25.46^{a}	9630.05^{e}
70 cm potato+ 35cm cabbage (T6)	4.07^{ab}	6.17^{e}	6.97^{cd}	12.02^{c}	29728.20^{a}
140 cm potato+2 row cabbage (T7)	4.66^{ab}	9.61$_{bcde}$	7.79^{d}	12.22^{c}	19888.31^{bc}
140 cm potato +3 row cabbage (T8)	3.53^{b}	6.72^{de}	7.16^{d}	11.31^{c}	23741.31^{b}
CV%	42.4	33.6	26.5	31.5	22.6
LSD(0.05)	2.17	3.87	3.37	5.53	5295.46
F-test	*	*	*	*	*
Interaction					
M1×T1	4.01^{abcd}	7.22^{de}	8.24^{def}	9.52^{e}	21308.03^{cd}
M1×T2	2.89^{cd}	8.31^{cde}	4.61^{f}	8.82^{e}	32240.56^{b}
M1×T3	4.52^{abcd}	7.38^{de}	5.58^{def}	9.16^{e}	27502.03^{bc}
M1×T5	4.25^{abcd}	7.89^{cde}	11.12^{d}	20.25^{b}	16331.53^{def}
M1×T4	4.69^{abcd}	11.01^{cd}	9.47^{de}	18.84^{bcd}	21811.23^{cd}
M1×T6	3.30^{bcd}	4.95^{e}	6.31^{ef}	8.68^{e}	40490.60^{a}
M1×T7	3.71^{bcd}	7.71^{cde}	5.44^{ef}	10.51^{e}	27205.20^{bc}
M1×T8	2.093^{d}	4.46^{e}	5.93^{ef}	11.13^{de}	31708.83^{b}
M2×T1	4.78^{abcd}	12.95^{bc}	16.57^{bc}	19.04^{bc}	7857.15^{fg}
M2×T2	3.44^{bcd}	7.07^{de}	7.68^{def}	9.82^{e}	15297.61^{defg}
M2×T3	3.35^{bcd}	16.53$_{ab}$	17.07^{ab}	19.52^{b}	16339.30^{def}
M2×T5	6.12^{ab}	21.30^{a}	21.50^{a}	13.67^{a}	2928.57^{h}
M2×T4	6.90^{a}	11.27^{bcd}	18.35^{ab}	19.60^{b}	8988.11^{fgh}
M2×T6	6.84^{abcd}	7.39^{de}	12.23^{cd}	15.35^{bcde}	18965.80^{de}
M2×T7	5.60^{abc}	11.52^{bcd}	10.14^{de}	13.93^{bcde}	12571.42^{efg}
M2×T8	4.98^{abcd}	8.97^{cde}	8.39^{def}	11.49^{cde}	15773.80^{def}
LSD(0.05)	3.08	5.47	4.76	7.829	7488.92
F-test	*	*	*	*	*

Note: NS represent statistically non-significant whereas * represent significant at 5% level of probability

Normal distribution of the dry weight of weed was checked and it was found that data distributions of the dry weight of weed were not normal; therefore square root data transformation was done and the transformed data was iterated to ANOVA and mean comparison was done through LSD test. The average dry weight of broadleaf weed was recorded higher in plots without mustard broadcasting, and the result was found to be statistically significant throughout the crop period except at 30DAS. Similarly, Dry weight of broadleaf weed was found statistically significant for subplot factor (different intercropping of cabbage and potato) throughout the crop period. Statistically higher dry weight of weed was

obtained in intercropping of single row of cabbage within 140cm row spacing of potato (T4) at 30DAS, sole cropping of potato at 140 row to row spacing at 45DAS, 60DAS and 75DAS; similarly, lower dry weight of weed was obtained in sole cropping of cabbage at 70cm row to row spacing (T2) and intercropping of triple rows of cabbage within 140cm row spacing of potato (T8) at 30DAS, intercropping of single row of cabbage within 70cm row spacing of potato (T6) at 45DAS, and intercropping of single row of cabbage within 70cm row spacing of potato (T6), intercropping of double rows of cabbage within 140cm row spacing of potato (T7) and intercropping of triple rows of cabbage within 140cm row spacing of potato (T8) at 60DAS and 75DAS. The result of the interaction of main plot factor (with or without mustard broadcasting) with subplot factor (different intercropping of cabbage and mustard) on the dry weight of broadleaf weed was found to be statistically significant at 5% level of probability. Lower dry weight of weed was obtained in mustard broadcasted plots with intercropping of triple rows of cabbage within 140cm row to row spacing of potato (M1×T8) at 30DAS, broadcasting of mustard on intercropping of triple rows of cabbage within 140cm row to row spacing of potato (M1×T8) and broadcasting of mustard with intercropping of single row of cabbage within 70cm row to row spacing of potato (M1×T6) at 45DAS, broadcasting of mustard on 35 cm row to row spacing of cabbage (M1×T2)—statistically similar with and broadcasting of mustard with intercropping of single row of cabbage within 70cm row to row spacing of potato (M1×T6), broadcasting of mustard on intercropping of double rows of cabbage within 140cm row spacing of potato (M1×T7) and broadcasting of mustard on intercropping of triple rows of cabbage within 140cm row to row spacing of potato (M1×T8) at 60DAS—and broadcasting of mustard with intercropping of single row of cabbage within 70cm row to row spacing of potato (M1×T6), broadcasting of mustard on intercropping of double rows of cabbage within 140cm row to row spacing of potato (M1×T7), broadcasting of mustard on 35 cm row to row spacing of cabbage (M1×T2) and broadcasting of mustard on 70 cm row to row spacing of cabbage (M1×T3) at 75DAS.

Table 6: Influence of mixed cropping of cabbage, mustard and potato in dry weight of narrow-leaf weed

Treatments	30DAS	45DAS	60DAS	75DAS
Main plot factor				
mustard broadcasting(M1)	1.75	1.45	1.31	1.06
without mustard(M2)	2.21	1.71	1.56	1.8
CV%	49	30.8	40.1	75.2
LSD(0.05)	1.2	0.6	0.72	1.34
F-test	NS	NS	NS	NS
Sub-plot factor				
70cm potato (T1)	0.99^{b}	1.07^{c}	1.25^{b}	1.15^{ab}
35cm cabbage (T2)	2.38^{a}	1.68^{abc}	1.63^{ab}	1.55^{ab}
70cm cabbage (T3)	1.97^{ab}	1.91^{ab}	1.40^{ab}	1.69^{ab}
140 cm potato+ 1 row cabbage (T4)	2.49^{a}	1.26^{bc}	1.63^{ab}	2.12^{a}
140 cm potato (T5)	2.36^{ab}	1.98^{ab}	5.01^{a}	1.43^{ab}
70 cm potato+ 35cm cabbage (T6)	1.75^{ab}	1.48^{abc}	1.18^{b}	1.08^{b}
140 cm potato+2 row cabbage (T7)	1.58^{ab}	2.14^{a}	1.49^{ab}	0.98^{b}
140 cm potato +3 row cabbage (T8)	2.30^{ab}	1.084^{c}	1.24^{b}	1.48^{ab}
CV%	58.5	42.7	41.4	59.5
LSD(0.05)	1.37	0.79	0.7	1.01
F-test	*	*	*	*
Interaction				
M1×T1	1.09^{bc}	1.08^{bc}	1.094^{b}	1.25^{bc}
M1×T2	2.43^{abc}	1.79^{abc}	1.73^{ab}	1.28^{bc}
M1×T3	2.06^{abc}	1.65^{ac}	1.40^{ab}	1.33^{bc}
M1×T5	1.41^{abc}	1.99^{abc}	1.74^{ab}	1.10^{bc}
M1×T4	2.86^{ab}	0.88^{c}	1.31^{ab}	1.26^{bc}
M1×T6	1.46^{abc}	1.39^{bc}	1.12^{b}	0.87^{bc}
M1×T7	0.90^{c}	1.75^{abc}	1.14^{b}	0.70^{c}
M1×T8	1.74^{abc}	1.02^{bc}	1.00^{b}	0.70^{c}
M2×T1	0.90^{c}	1.06^{bc}	1.42^{ab}	1.04^{bc}
M2×T2	2.33^{abc}	1.57^{abc}	1.54^{ab}	1.83^{abc}
M2×T3	1.87^{abc}	2.17^{ab}	1.41^{ab}	2.05^{abc}
M2×T5	3.30^{a}	1.98^{abc}	2.27^{a}	1.75^{abc}
M2×T4	2.11^{abc}	1.62^{abc}	1.31^{ab}	2.98^{a}
M2×T6	2.03^{abc}	157^{abc}	1.24^{b}	1.28^{bc}
M2×T7	2.26^{abc}	2.55^{a}	1.85^{ab}	1.26^{bc}
M2×T8	2.85^{ab}	1.14^{bc}	1.48_{ab}	2.24^{ab}
LSD(0.05)	1.93	1.12	0.99	1.42
F-test	*	*	*	*

Note: NS represent statistically non-significant whereas * represent significant at 5% level of probability

Normal distribution of the dry weight of narrow-leaf weed was checked and it was found that data distributions of the dry weight of narrow weed were not normal; therefore square root data transformation was done and the transformed data were subjected to analysis of variance and mean comparison was done through LSD test. The average dry weight of narrow-leaf weed was recorded higher in pots without mustard broadcasting; but, the result was found to be statistically non- significant. But, dry weight of narrow-leaf weed was found statistically significant for subplot factor (different intercropping of cabbage and potato) at 5% level of probability. The lower dry weight of narrow-leaf weed was found in sole cropping of potato (row to row spacing of 70cm) while higher was found in intercropping of a single row of cabbage within 140cm row to row spacing of potato (T4). Similarly, the effect of the interaction of main plot factor (with or without mustard broadcasting) with subplot factor (different intercropping of cabbage and potato) on the dry weight of narrow-leaf weed was found to be statistically significant. Low dry weight of narrow-leaf weed was found in without mustard at 70cm row to row spacing of potato (M2×T1) at 30DAS, with broadcasting of mustard in intercropping of single row cabbage within 140cm row spacing of potato (M1×T4) at 45DAS,broadcasting of mustard with intercropping of single row of cabbage within 70cm row spacing of potato (M1×T6), broadcasting of mustard on intercropping of double rows of cabbage within 140cm row to row spacing of potato (M1×T7) and broadcasting of mustard on intercropping of triple rows of cabbage within 140cm row to row spacing of potato (M1×T8) at 60DAS and broadcasting of mustard on intercropping of double rows of cabbage within 140cm row to row spacing of potato (M1×T7) and broadcasting of mustard on intercropping of triple rows of cabbage within 140cm row to row spacing of potato (M1×T8) at 75DAS, shown in table no.6.

Table 7: Influence of the mixed cropping on number of narrow-leaf weed

treatments	30DAS	45DAS	60DAS	75DAS
Main plot factor				
mustard broadcasting(M1)	1.92	1.66	1.39	1.37
without mustard(M2)	1.97	1.64	1.16	1.30
CV%	20.3	40.2	59.9	21.5
LSD(0.05)	0.49	0.83	0.95	0.36
F-test	NS	NS	NS	NS
Sub-plot factor				
70cm potato (T1)	1.08^{c}	0.98^{b}	1.15	1.42^{ab}
35cm cabbage (T2)	2.73^{a}	2.05^{a}	1.44	1.33^{ab}
70cm cabbage (T3)	2.30^{ab}	1.75^{ab}	1.47	1.26^{ab}
140 cm potato+ 1 row cabbage (T4)	2.23^{ab}	1.33^{ab}	1.03	1.19^{b}
140 cm potato (T5)	1.45^{bc}	1.44^{ab}	1.26	1.33^{ab}
70 cm potato+ 35cm cabbage (T6)	1.86^{abc}	1.53^{ab}	1.11	1.25^{b}
140 cm potato+2 row cabbage (T7)	1.70^{bc}	2.26^{a}	1.43	1.57^{a}
140 cm potato +3 row cabbage (T8)	2.27^{ab}	1.89^{ab}	1.32	1.29^{ab}
CV%	44.20	49.30	40.4	19.9
LSD(0.05)	1.02	0.96	0.61	0.31
F-test	*	*	NS	NS
Interaction				
M1×T1	1.17^{cde}	1.095^{bc}	1.05^{ab}	1.32
M1×T2	2.87^{a}	2.22^{abc}	1.88^{a}	1.42
M1×T3	2.65^{ab}	1.85^{abc}	1.85^{ab}	1.33
M1×T5	1.22^{bcde}	1.44^{abc}	1.34^{ab}	1.29
M1×T4	2.47^{abcd}	1.09^{bc}	1.05^{ab}	1.23
M1×T6	2.06^{abcde}	1.35^{abc}	1.17^{ab}	1.27
M1×T7	1.09^{de}	1.84^{abc}	1.22_{ab}	1.58
M1×T8	1.83^{abcde}	2.39^{ab}	1.54^{ab}	1.43
M2×T1	0.99^{e}	0.87^{c}	1.25^{ab}	1.51
M2×T2	2.60^{abc}	1.88^{abc}	0.99^{b}	1.16
M2×T3	1.94^{abcde}	1.64^{abc}	1.09^{ab}	1.2
M2×T5	1.67^{abcde}	1.44^{abc}	1.17^{ab}	1.36
M2×T4	1.99^{abcde}	1.58^{abc}	0.99^{b}	1.16
M2×T6	1.67^{abcde}	1.70^{abc}	1.05^{ab}	1.22
M2×T7	2.32^{abcde}	2.67^{a}	1.64^{ab}	1.57
M2×T8	2.61^{ab}	1.38^{abc}	1.09^{ab}	1.16
LSD(0.05)	1.44	1.36	0.86	0.44
F-test	*	*	*	NS

Normal distribution of the number of narrow-leaf weed was measured and it was found that data distributions of the number of narrow weed were not symmetrical; therefore square root data transformation was done and the transformed data were subjected to analysis of variance and mean comparison was done through LSD test. The average number of narrow-leaf weed was found to be statistically non-significant. The number of narrow-leaf weeds was found statistically significant for the subplot factor (different intercropping of cabbage and potato) at 30DAS and 45DAS but the result was not significant at 60DAS and 75DAS shown in table no.7.

Statistically, a significant result was obtained in the interaction of main plot factor (with or without mustard broadcasting) with subplot factor (different intercropping of cabbage and potato) at 30DAS, 45DAS and 60DAS, but the result was not significant at 75DAS. The fewer number of narrow-leaf weed was found in without broadcasting of mustard at 70cm row to row spacing of potato (M2×T1) at 30DAS and 45DAS while it was found in without broadcasting of mustard in sole cropping of cabbage at 35 cm row to row spacing(M2×T2) at 60DAS, shown in table no.7.

Table 8: Influence of the mixed cropping in number of broadleaf weeds

treatments	30DAS	45DAS	60DAS	75DAS
Main plot factor				
mustard broadcasting(M1)	4.58	3.18	1.39	2.62
without mustard(M2)	4.52	3.44	1.16	2.66
CV%	28.4	64.5	59.9	17.8
LSD(0.05)	1.6	2.65	0.95	0.59
F-test	NS	NS	NS	NS
Sub-plot factor				
70cm potato (T1)	3.45^{c}	2.45^{b}	1.15	2.74^{ab}
35cm cabbage (T2)	6.12^{a}	3.46^{ab}	1.44	2.76^{ab}
70cm cabbage (T3)	5.96^{a}	3.84^{a}	1.48	3.45^{a}
140 cm potato+ 1 row cabbage (T4)	5.03^{ab}	3.28^{ab}	1.02	2.94^{ab}
140 cm potato (T5)	3.30^{c}	3.24^{ab}	1.26	2.94^{ab}
70 cm potato+ 35cm cabbage (T6)	4.11^{bc}	2.94^{ab}	1.11	2.15^{bc}
140 cm potato+2 row cabbage (T7)	4.41^{bc}	3.53^{a}	1.43	2.39^{bc}
140 cm potato +3 row cabbage (T8)	4.03^{bc}	3.71^{a}	1.31	1.78^{c}
CV%	22.30	21.70	40.00	28.3
LSD(0.05)	1.20	1.062	0.61	0.88
F-test	*	*	NS	NS
Interaction				
M1×T1	3.98^{cdef}	2.46^{b}	1.05^{ab}	2.92^{abcd}
M1×T2	5.60^{abc}	3.83^{ab}	1.88^{ab}	3.09^{abcd}
M1×T3	7.15^{a}	3.52^{ab}	1.86^{ab}	3.70^{a}
M1×T5	3.34^{efg}	2.78^{ab}	1.34^{ab}	2.22^{cde}
M1×T4	4.92^{cde}	3.10^{ab}	1.05^{ab}	2.73^{abcde}
M1×T6	4.64^{cdef}	3.14^{ab}	1.17^{ab}	2.11^{cde}
M1×T7	3.87_{defg}	3.29^{ab}	1.22^{ab}	2.31^{cde}
M1×T8	3.19^{fg}	3.29^{ab}	1.54^{ab}	1.90^{de}
M2×T1	2.92^{g}	2.48^{b}	1.25^{ab}	2.56^{abcde}
M2×T2	6.63^{ab}	3.09^{ab}	0.99^{b}	2.44^{bcde}
M2×T3	4.77^{cdef}	4.17^{a}	1.09^{ab}	3.19^{abc}
M2×T5	3.28^{egf}	3.70^{ab}	1.17^{ab}	3.65^{ab}
M2×T4	5.14^{bcd}	3.46^{ab}	0.99^{b}	3.11^{abcd}
M2×T6	3.58^{defg}	3.73^{ab}	1.05^{ab}	2.19^{cde}
M2×T7	4.95^{bcde}	3.77^{ab}	1.64^{ab}	2.47^{abcde}
M2×T8	4.77^{cdef}	4.18^{a}	1.09^{ab}	1.66^{e}
LSD(0.05)	1.7	1.5	0.86	1.25
F-test	*	*	*	*

Similarly, data transformation was done for the number of broadleaf weed and the data were subjected to analysis of variance and mean comparison result showed that no significant difference was observed in main plot factor (with or without mustard) on the number of broadleaf weed. Statistically, a significant difference was found in subplot factor (different intercropping of cabbage and potato) on the number of broadleaf weed at 30DAS and 45 DAS; but, the result was not significant at 60DAS and 75DAS as shown in table no.8. Statistically, a significant result was obtained in the interaction of the main plot factor (with or without mustard broadcasting) with subplot factor (different intercropping of cabbage and potato). Fewer number of broadleaf weed was found in without broadcasting of mustard at 70cm row to row spacing of potato (M2×T1) at 30DAS and 45DAS,

without broadcasting of mustard in sole cropping of cabbage at 35 cm row to row spacing (M2×T2) at 60DAS and without broadcasting of mustard on intercropping of triple rows of cabbage within 140cm row to row spacing of potato (M1×T8) at 75DAS, shown in table. no.8.

Table 9: Yield of the mustard leaf (kg/ha)

treatments	yield
70cm potato (T1)	19959.53[ab]
35cm cabbage (T2)	24816.30[ab]
70cm cabbage (T3)	24217.57[ab]
140 cm potato+ 1 row cabbage (T4)	17431.30[ab]
140 cm potato (T5)	20225.67[ab]
70 cm potato+ 35cm cabbage (T6)	27411.13[a]
140 cm potato+2 row cabbage (T7)	23618.77[ab]
140 cm potato +3 row cabbage (T8)	20757.87[ab]
CV%	25.20%
LSD(0.05)	9844
F-test	*

The difference in yield of mustard among various inter-row cropping of cabbage and potato was found statistically significant at 5% level of probability. The yield of mustard was found higher in intercropping of single row cabbage within 70cm row to row spacing of potato (T6); whereas poor yield was observed in a single row of cabbage within 140 cm row to row spacing of cabbage (T4) but the result was not statistically significant with other treatment except T6.

SN	Common name	Scientific name	English name
1	Kaligedi	*Solanum nigrum*	Black nightshade
2	Bethe	*Chenopodium album*	Goose foot
3	lude	*Amaranthus spp*	Pig weed
4	Kode jhar	*Elusine indica*	Cow foot grass
5	Gajar jhar	*Dacus carrota*	Carrot weed
6	Dubo	*Cynodon dactylon*	Dog grass
7	Rampate		
8	Rani jatta		

4. Discussion

Mustard broadcasted plots had higher cabbage height at 60DAS and 75DAS; however, the statistically non-significant result was observed at 30DAS and 45DAS. Similar results were observed for the height of potatoes. This can be attributed to the fact that mustard contains glucosinolate compounds that have allelopathic effects and contribute to weed suppression (Liebman and Davis, 2000). In addition to that, during initial growth phase mustard competes with cabbage and potato for nutrition in mustard broadcasted plots; at the same time, weed prevalence at without mustard plots compete with crops and result in poor vertical growth of the plant. As the time proceeds the mustard was harvested and the benefit of space and nutrition after removal of mustard was shared among crops, resulting in better plant growth. But, without mustard broadcasting, the weeds continue to compete for nutrients. A similar result of poor plant height due to weed competition was observed by Ronchi and Silva(2006) on young coffee plants, Hakim et al(2013) on rice under saline conditions and Fuksa et al(2004) on maize. Higher plant height, both cabbage and mustard, was found in the narrow spacing of mixed cropping. A plausible explanation to this statement is ascribed by the fact, plants with closer spacing tend to grow more vertically due to competition with light and space as comparatively less space is available for horizontal growth of plants (Singh and Aulakh, 2017). A similar result was observed by Das et al(2011) and Nargis et al(2004). Reddy et al, (1999), and Pendersen and Laucer, (2003) reported that the increase in plant height at narrow spacing is through stem elongation. But after a certain limit of closer spacing, the height of the plant starts to decline (Rahman and Hossain, 2011). The canopy of cabbage was found higher in mustard broadcasted plots. Mustard, being crucifers crop, have an allelopathic effect and contribute to weed suppression (Liebman and Davis, 2000), gives the advantage of space and nutrients to crops, and results in higher canopy length. Similarly, Sharif et al(2014) reported that weed-free conditions promote plant growth; besides, weed infestation gives comparatively less space for horizontal growth of canopy. During the initial stage of crop growth cabbage, the canopy was found higher for intercropping of cabbage at 70cm row to row spacing of potato—a narrow spacing, but as the growth of crop proceeds, it was found higher in wider inter-row spacing. Influence of mixed cropping had no significant effect on the leaf number of cabbage; a similar result on the number of leaves was observed by Fuksa et al(2004) on maize. Influence of mixed cropping of cabbage, mustard and potato had a statistically significant result on dry matter of broadleaf weed whereas the dry matter of narrow-leaf weed was found significant only in subplot factor (different intercropping of cabbage and potato) and interaction of main plot factor (with or without broadcasting of mustard) with subplot factor. But, the number of both narrow leaf weed and broadleaf weed was found statistically non-significant. Because of the vigorous growth of broadleaf weed, narrow leaf weed could not compete with them; thus, major weed recorded in the field was broadleaf. Dry matter of weed largely determines the growth of crops rather than the number of weeds, thus it is not serious if the number of weeds is non-significant. Dry matter of broadleaf weed was found lower in mustard broadcasted plots; as mustard contains glucosinolate compounds that have allelopathic effects and contribute in weed suppression (Liebman and Davis, 2000). Narrow spacing of mixed cropping have significant low dry weight of broadleaf weed: sole cropping of cabbage at 30DAS, intercropping of single row of cabbage within 70cm row to row spacing of potato (T6) at 45DAS, intercropping of double rows of cabbage within 140cm row to row spacing of potato (T7) and intercropping of triple rows of cabbage within 140cm row to row spacing of potato (T8) at 60DAS and 75DAS. Intercropping helps to utilize the space and nutrients. Mixed cropping helps to utilize the leftover space and nutrients of sole cropping; furthermore, they give no or very little space for weed growth. The reduction in weed density and biomass might be due to allelopathic and smothering effects of crops on associated weeds (Mohandoss et al., 2002). A similar result on reduced weed biomass and

density were reported by Silva et al(2009), Omovbude et al(2017), Mohandoss et al(2002) and Rajeshkumar(2017). Total production of the potato was recorded higher in mustard broadcasted plot than without mustard broadcasted plots, due to negative relation of mustard and weed infestation (Liebman and Davis, 2000). Highest productivity of potato was obtained in intercropping of single row of cabbage within 70cm row to row spacing of potato (T6), the result is in accordance with, Mohandos et al(2002) and Rajeshkumar et al(2017); however, poor result was observed in sole cropping of potato at inter-row spacing of 140cm. Similarly, the interaction of mustard broadcasting and intercropping of a single row of cabbage within 70cm row to row spacing of potato was found best in terms of net potato productivity. Similar results on higher productivity of crop were obtained by Ranganathan(1993) and Wahbi et al(2016).

5. Conclusion

Mustard broadcasting on intercropping of 35cm cabbage within 70cm row to row spacing of potato) was found superior in terms of yield of all the three crops and net productivity of potato; in addition, the same treatment had a lower dry weight of broadleaf. Thus, it would be better to suggest vegetable growing farmers, to adopt mixed cropping of cabbage, mustard and potato for higher return and better weed management.

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