THE EFFECT OF VOLUNTEER VETCH IN BARLEY ON TOTAL YIELD AND OTHER CHARACTERISTICS

by

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Volunteer Vetch in Barley

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ABSTRACT

A two-year study was conducted at the Agricultural Research and Education Center of the American University of Beirut, Lebanon to evaluate the effect of volunteer vetch in barley on the total yields and other characteristics of barley crop. The treatments were barley-vetch grown in mixture and barley grown separately. The crops were harvested twice, first for forage yields and second for seed yields.

During the two years, barley-vetch mixture produced more forage and seed yields than pure barley stands. These mixtures contained higher protein percentages and thus produced more total protein yields as compared to barley grown alone. In contrast, the two years average protein yields of barley-vetch forage and seed mixtures (including straw) were almost similar.

Vetch was growing in competition with the associated barley and reduced its individual yields, protein percentages, and protein yields as compared to pure stands. It decreased average spike length, number of grains per spike, and average weight of 1000 grains, as compared to barley grown separately. In general, vetch had more beneficial than harmful effects because the total yields of forage, seed, protein and the percentage of protein of the mixture was higher than pure stand of barley.

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INTRODUCTION

Barley has been cultivated by the ancients, long before some of the other cereals were known. It is one of the extensively grown cereals, with world-wide distribution and adaptation. It grows in arid climates of Sahara, the high plateaus of Tibet, and the tropical plains of India. It is one of the most dependable cereals under extreme conditions of alkali, frost or drought. With regard to area and production, it occupies fifth position in the world after wheat, rice, corn and sorghum (Anonymous 1955) and second position in some of the Middle Eastern countries like Iraq, Jordan, Lebanon and Syria. Lebanon alone produces annually about 16,000 tons of barley (Sayegh 1962) and imports about 22,000 tons from the neighbouring countries to meet its requirements.

Barley is used mainly as a cattle feed and has a feeding value of 95 percent of that of corn. In the United States 65-70 million bushels of barley are used annually for malting purposes and preparation of alcoholic beverages (Martin and Leonard 1959). In many of the Asiatic countries it is used as human food. Barley flour can be easily substituted up to five percent with wheat flour without detriment to the quality of bread. For hot breads, where baking powder is used, 80 percent of the barley flour may be substituted.

Vetch is also an important leguminous crop as a winter annual not only in Lebanon, but everywhere in the world. About 3,000 tons of vetch seed is annually required in Lebanon for different feeding purposes, half of which is produced locally and the remaining half is imported (Sayegh 1962). Vetch is used for green manuring, hay making, some as a

green fodder, pasturing, and as a cover crop. The early supply of green fodder as pasture by vetch crop in the spring is of great value to livestock men due to non-availability of any other legume fodder during this period of scarcity.

The climatic conditions of the Mediterranean regions, particularly of Beqa'a plain are suitable for successful barley and vetch production. The annual precipitation of this area is limited (300-600 mm. annually and is received in winter), therefore, crops like barley and vetch, having comparatively short growing period become of increasing importance under these dry farming conditions. The two crops efficiently utilize the winter rains as they start growth early in spring, and by the time the soil moisture is exhausted, they are usually mature and ready for harvest.

Barley and vetch crops fit well in a dry land rotation. The vetch crop in a rotation may be used for green manuring to increase soil fertility, may be harvested as green fodder for livestock, or for seed. In seed production, the problem of shattered seed is often experienced by the growers. At the time of harvest, usually some seeds shatter on the soil. When the same piece of land is sown with barley, which generally follows vetch in a rotation, a great number of volunteer vetch plants also come up along with the barley seedings. These volunteer plants compete directly with the main crop, mature along with it, and reinfest the soil when the barley crop is harvested for grain yield.

The present study was undertaken to investigate the effect of volunteer vetch on the total yield and other characteristics of barley crop. The study was conducted at the Agricultural Research and Education Center at the American University of Beirut, located in the north central Beqa'a, Lebanon, during the two years, 1962-63 and 1963-64.

REVIEW OF LITERATURE

Forage Yield

Andrew and Gieger (1938) working with Austrian winter peas and rye grown in pure stands and in mixture in a green house found that: (1) The forage yield of Austrian winter peas was slightly reduced when grown in association with rye, whereas that of rye in mixture was almost equal to rye grown alone; (2) The combined yield of rye-pea mixture was considerably higher than that of peas grown alone.

Madhok (1940) using sand culture and pot experiments at Lyallpur, West Pakistan studied the effect of association of legumes with non legumes. He reported an injurious effect on the growth of legumes when they were in association with non legumes. From the experiments it was inferred that in certain combinations the non legumes did benefit from the associated legumes, while in others they did not. Chickpeas (Cicer arietinum) suffered a loss of 35-40 percent in size and 14-20 percent in weight from the associated wheat, while senji (Melilotus parviflora) lost 88 percent in dry weight from oats association. Chari (Andropogon sorghum), on the other hand, showed considerable gain in plant weight as a result of its association with guara (Cyamopsis psoraloides).

Roberts and Olson (1942) studied six legumes and two grasses grown in all possible combinations of one legume with one grass, and in pure stands. The results showed that both the legumes and the grasses were neither benefited nor injured by the associated growth as compared to pure stands. In general, when one component of a mixture produced more dry weight than in pure stand, the other component produced less in the

mixture than in pure stand. In several grass-legume mixtures, greater yields of dry matter were obtained from mixtures than from pure stands of grasses and legumes.

Harper (1946) working with row spacing planted small grains in rows of 7 inches and 14 inches apart with legumes planted between the rows of the grains. He found that yields of the leguminous crops, sweet clover and korean lespedeza, were more when the oat companion crop was planted in wider rows than in narrow rows.

Hughes (1951) reported that vetch-oat combination was a recommended mixture for short term pastures in Georgia. Similarly common vetch with oats and purple vetch with oats were reported to be good forage mixtures for hay and pasture in the states of Oregon and California, respectively. Ahlgren (1951) reported from Wisconsin Agricultural Station that soybean-oat mixture was considered best in Wisconsin for temporary or supplementary hay or grass silage.

Willard (1951) reported from Ohio the results of experiments conducted on various grasses and legumes sown with and without cereal companion crops. The hay yield obtained from both the companion crop and forage crop together was more than the hay yield produced by the forage crop sown alone.

Barley is the quickest to give a hay crop in the early spring. Hendry (1951) reported that under California conditions barley required almost 175 days from planting to soft dough stage of maturity. Rye, wheat, and oats required about 187, 193, and 205 days, respectively, to reach the same stage of maturity.

Pendelton and Dungan (1953) in a 3 year experiment at Urbana,

Illinois studied the effect of oat companion crop sown at different spacings on red clover. They concluded from their work that stand, growth, and hay yields of red clover increased proportionately as the row width of oat companion crop was increased in dry season. Population, early growth, and hay yield of red clover sown alone were always better than red clover sown with oat companion crop. Similar studies were conducted by Blackmon and Snell (1954) on the effect of different row spacings of wheat companion crop with red clover. They found no significant difference in the average number of red clover plants growing in a nine square foot area. Hay yields were slightly better but not significant at wider spacing.

Ahlgren et al. (1954) showed that the greatest dry matter yield of barley alone or with winter vetch was obtained when harvests were made during the dough stage. Vetch as a companion crop with winter barley did not increase dry matter yield as compared to barley grown alone. A similar experiment was conducted by Henderson and Davies (1955) while working with cereal-legume mixtures. They got highest average dry matter yield from oat-pea-bean mixture and least from the bean crop grown alone.

Masefield (1955) reported the findings of Wilson who found that interplanted cereals and legumes gave higher yield when both the crops were planted in the same row than in alternate rows.

Langford (1956) compared several legumes for early spring forage production in Alabama and found that crimson clover and hairy vetch were the highest yielding winter legumes.

Hodgson (1956) reported that oat-pea and oat-pea-vetch mixtures were most important forage mixtures grown on daify farms in Alaska. He

worked on different seeding rates and stages of harvest of these mixtures and found that highest dry matter yields were obtained when harvests were made at late milk to early dough stage and when the mixtures contained one-half to two-thirds of the legume seed.

Donnely and Langford (1959) compared the dry forage yield of bermuda grass and bahia grass grown alone and in mixture with vetch, crimson clover and no fertilizer and with 160 lbs. of nitrogenous fertilizer per acre. Highest forage yields were obtained from vetch in mixture with both the grasses. When grasses were grown alone and applied 160 lbs. of nitrogenous fertilizer per acre, they yielded similar to grass-vetch mixture with no fertilizer.

Robinson (1960) conducted several trials on crop mixtures and rates of sowing at St. Francis, Rosemount, and several other experiment stations in Minnesota. The mixtures studied were oat-vetch, oat-pea, oats alone and oats + 100 lbs. of ammonium nitrate fertilizer per acre. When results of forage yield of oats alone and oat-legume mixtures were compared on sandy soils at St. Francis, all mixtures yielded considerably higher forage yield than oats alone. On heavier soils at Rosemount and south western Minnesota, the highest yielding mixtures did not produce more forage than oats alone. As an average of all trials, forage yields of mixtures and pure stands did not differ significantly.

Kilcher and Heinrichs (1960) studied the effect of small grain companion crops on the establishment of a perennial forage crop mixture as compared to no companion crop at Saskatchewan, Canada. The results showed that: (1) The first year crop cover of alfalfa and grass component was usually significantly less when established with small grain companion

crop as compared to no companion crop; (2) The cover of the forage component was most reduced when the companion crop was mowed for hay as compared to harvesting for grain; (3) Reduced forage yields were obtained when cereal companion crops were used. In the first crop year, mean yields of forage were reduced by 25-55 percent when seeded with companion crops. The amount of yield reduction was higher when the companion crop was mowed for hay as compared to harvesting for grain.

Manghirmalani (1961) in 1960-1961 studied oats, vetch, and Austrian winter peas seeded alone and in mixtures for forage yield in Beqa'a, Lebanon. He got high forage yield from oats alone as compared to oat -vetch or oat-Austrian winter pea mixtures. Oat-vetch mixture produced one and a half times more forage yield than vetch alone.

Peters (1961) investigated the establishment of legumes as related to the presence or absence of an oat companion crop. He found that alfalfa + oat as a silage yielded the greatest amount of dry matter. The legume component was very much depressed by the presence of an oat companion crop and yielded only one-tenth of the yield of plots where there was no oat companion crop.

Hoveland et al. (1961) at Auburn, Alabama, working with small grains, grasses, and legumes planted on Dalis grass-white clover sod from 1958-1960, showed that vetch-rye mixture gave 7 percent higher forage yield than vetch alone. Oat-pea mixture gave 19 percent higher yield than peas alone. Forage yield of rye-pea mixture was 20 percent higher than rye alone and 28 percent higher than peas alone. Nel et al. (1962) reported similar results from cereal-legume mixtures. More forage yield was obtained from oats and barley in combination with lupine than in pure stands. A

higher total production of roots was given by the lupine-cereal mixture than by either of the components grown alone at the same total density.

Wedin (1962) tested oats and rye in pure stands and in combination with peas and rape at Rosemount, Minnesota. Oat-pea-rape mixture and oats alone produced more forage yield than peas alone and oat-pea in combination. A similar study was carried out by Beg (1963) with oats, rye, and vetch grown alone and in mixture at the Agricultural Research and Education Center of the American University of Beirut, Lebanon, for two years. He obtained high forage yield from oat-vetch and rye-vetch mixtures as compared to the forage yield obtained from oats alone.

Protein Percentage in Forage

Andrew and Gieger (1938) obtained a higher percentage of nitrogen in a forage mixture of Austrian winter peas and rye grown together as compared to rye grown alone and slightly lower nitrogen percentage as compared to peas grown in pure stand. The percent nitrogen content of rye forage was increased from 0.94 percent to 1.35 percent when it was grown in association with peas. Similar results were reported by Ahlgren and his co-workers (1954) from New Jersey, Robinson (1960) and Wedin (1962) from Minnesota, and Manghirmalani (1961) and Beg (1963) from Lebanon. All of these workers studied different cereal and legume mixtures and found that the forage yield obtained from different cereals, cereal-legume mixtures, and leguminous crops alone, differed with regard to their protein percentages, but in general, the protein content of the forage of cereal-legume mixture was always higher than the protein content of the cereal forage alone and lower than the protein percentage of the forage obtained from the leguminous crop grown separately.

Madhok (1940) found that oats and wheat did not show any increase in the nitrogen content of the above ground parts by their association with leguminous crops. In nitrogen deficient medium, the legumes used to fix more nitrogen by their association with non legumes, as compared to nitrogen rich medium. The relative efficiency of nitrogen fixation was greatest when the ratio of chickpeas to wheat was 1 : 2.

Hodgson (1956) studying several oat-pea mixtures in Alaska found that: (1) Protein content of forage was proportional to the amount of peas in the mixture; (2) Although the protein content of the mixtures varied considerably from year to year, those mixtures containing only a small proportion of peas were always lower in protein content; (3) Mixtures containing at least half peas maintained comparatively a high level of protein percentage at late harvests.

Hawkins and Autery (1957) studied the milk production from dairy cows fed on alfalfa hay alone, half alfalfa hay + half young oats forage, and young oats forage alone. The results showed that cows produced more milk when they were fed oats green forage alone or half oats forage and half alfalfa hay than alfalfa hay alone.

Chapman (1943) in a pot culture study with nitrogen starved citrus seedlings, reported that the yellow citrus seedlings did not change colour by growing in association with inoculated vetch and he concluded from the experiment that no significant excretion of nitrogen occured from the vetch nodules.

Protein Yield of Forage

Ahlgren et al. (1954) experimented with barley seeded alone and with winter vetch and came to the conclusion that the total protein yield

was highest when barley planted with vetch was harvested for hay during the milk and dough stages of growth. Henderson and Davies (1955) reported highest average protein yield from peas forage alone and lowest from oats forage alone. The protein yield obtained from the oat-pea-bean mixture and beans forage alone were similar.

Hodgson (1956) showed that oat-pea forage mixture with a high proportion of peas gave significantly higher total protein yield than those having a small proportion of peas in their forage. Forage mixture which contained at least half peas maintained a high level of protein percentage at later harvests and therefore gave a high return of total protein yield. Robinson (1960) observed similar results from oat-pea and oat-vetch forage mixtures as compared to oats forage alone. Average protein yield of oat-pea forage mixture was 20 percent higher than that of oat-vetch forage mixture and about 16 percent more than oats alone.

Peterson (1961) compared the total protein yield of alfalfa forage obtained from plots having oats as a companion crop and plots having no oats companion crop. His results showed little difference between the total protein yield of the forage from the two plots.

Manghirmalani (1961) reported highest total protein yield per dunum from oat forage alone as compared to oat-vetch and oat-Austrian winter pea forage mixture. His results showed that the total protein yield obtained from one dunum of vetch forage mixture was slightly more than the combined yield of half dunum of vetch and half dunum of oats grown in pure stand. On the other hand, Beg (1963) reported more than double protein yield per dunum from oat-vetch forage mixture as compared to oats alone, but some what less total protein yield per dunum as compared to vetch crop grown separately. The protein yield obtained from rye-vetch forage mixture

was about five times the protein yield obtained from pure stand of rye forage. The protein yield of rye-vetch forage was almost equal to protein yield of vetch forage grown alone.

Grain Yield

Godel (1935) reported 34.8 percent reduction in grain yield of wheat from the associated severe weed competition. Robinson (1949) in a similar experiment studied the effect of annual weeds on the grain yield of oats, wheat, and flax. He found that moderate infestation of weeds in 1944 significantly reduced the grain yield of these crops, where as in 1945 when the weed infestation was light, no significant decrease in the grain yield occured.

Madhok (1940) reported that the beneficial effect of chickpeas on wheat grain formation was not marked or constant, but in general, the grain formation in wheat crop was maximum when the wheat-chickpeas populations were in the ratio of 1:2.

Papadakis (1941) working in Greece with small grains and winter legumes grown singly and in mixtures for several years reported 21 percent higher total grain yield from the cereal-legume mixtures than the average grain yield of the two crops grown alone over the same unit area. Moreover, the grain yield of mixtures were less variable than pure stands and at the same time weeds were suppressed more efficiently.

Harper (1946) observed that planting small grain companion crop in 14 inch rows as compared to 7 inch rows provided more favourable conditions for survival of legume seedlings during normal drought periods, but the average grain and straw yields were slightly lower when drill rows were 14 inches apart. Winter barley suffered a greater reduction in yield (about three bushels per acre) when planted in wider rows.

Pendeleton and Dungan (1953) concluded from their work that oats seeded alone and clean cultivated produced 190 bushels of grain yield for each bushel planted, as compared to a 42-bushels return from a regular seeded 8 inches row spacing interseeded with clover. Reduction in oat yield due to the presence of red clover increased as oat row width increased. Yields were reduced by 7 percent, 10 percent, 14 percent, and 18 percent, respectively, for 8 inch , 16 inch , 24 inch , and 32 inch , row spacings.

Henderson and Davies (1955) reported that mixtures of oat-pea and bean yielded almost the same amount of total grain per acre as compared to oats seeded alone. The grain yield of peas and beans seeded alone, however, were significantly low as compared to the mixture.

Kilcher and Heinrichs(1960) obtained slightly lower grain yield from small grain companion crops when they were seeded in the same rows along with the forage mixture as compared to plots where the small grains were seeded cross-wise to forage rows.

Robinson (1960) working with oats, peas, and vetch seeded alone and in mixtures, got high seed yields from oat-legume mixtures as compared to oats alone on sandy soils, where as oats alone gave high seed yield on heavy soils.

In an unpublished data, Khan (1964) got almost similar grain yields from wheat grown alone and berseem-wheat grown together. He showed that on an acre basis, berseem grown in between the wheat rows reduced the wheat grain yield by about 205 lbs. as compared to check, but returned about 328 lbs. to 410 lbs. of berseem seed, which was more valuable, thus more return per acre was obtained.

Protein Percentage and Protein Yield of Grain

Henderson and Davies (1955) obtained more protein yield (in straw + grain) from an oat-pea-bean mixture as compared to oats alone, and almost equal protein yield as compared to combined protein yield of oats, peas, and beans each grown in pure stand on one third of an acre of land.

Robinson (1960) reported 21 percent more total protein yield (obtained from oat + pea seeds) produced by mixture of the two crops as compared to protein yield obtained from oat grain produced by oats grown separately. The protein percentage in oats grains was increased from 13.5 percent to 13.9 percent by the associated peas. The percent protein content of the pea seeds was almost double as compared to that of oat grains.

Plant Height, Number of Tillers, Length of Spike, Weight of 1000 Grains, and Other Agronomic Characteristics

Godel (1935) reported that under conditions of heavy infestations of annual weeds in wheat fields, the weed competition reduced the wheat spike length by 17.3 percent, tiller number by 10 percent, and seed weight by 3.1 percent. He further stated that heavy seeding rates (1.75 bushels against 1.25 bushels per acre) of wheat crop on clean land also reduced the spike length (9.3 percent), seed weight (2.2 percent), and tiller number (6.3 percent).

Madhok (1940) observed that out of the several cereal and legume mixtures that he tested, only chari (Andropogon sorghum) showed gain in height as a result of its association with guara (Cyamopsis psoraloides). Other cereals showed little, if any, gain in height as a result of their association with legumes.

Flanagan and Washko (1950) found significant differences in stem numbers and height of plants at maturity, while studying the value of spring

grains (barley and oats) characteristics which affect their value as companion crops for legumes. They observed that when the tiller number of the grains were less then there were more red clover plants per unit area and similarly when the small grain heights were less, then the red clover populationswere more.

Robinson (1960) observed that on the basis of actual number of viable seeds sown per acre, mortality average of oats alone was 5 to 14 percent, oat-pea mixture 17 to 25 percent and oat-vetch mixture 18-26 percent. For peas alone mortality was 12 to 21 percent. In general, mortality tended to be higher for species in mixture than when grown alone.

Nel et al. (1962) reported that when cereal plants were associated with lupines (Lupinus spp.), they produced more culms and grew taller than when these were grown alone.

MATERIALS AND METHODS

The present study was conducted for the two cropping seasons of 1962-63, and 1963-64, at the Agricultural Research and Education Center located 80 kilometers east of Beirut, under dry farming conditions.

Plots that contained volunteer vetch plants in the barley crop were obtained from a rotation experiment that was already in progress at the Agricultural Center in which a permanent treatment of vetch-barley sequence was present. Eight such plots were available where barley was planted in the fall on plots containing shattered vetch seed in the soil.

All of the plots were fertilized with four kilograms of each of P_2O_5 and nitrogen per dunum applied in the form of superphosphate and ammonium sulfo-nitrate. The fertilizers were thoroughly incorporated into the soil by disking before sowing. The seed bed was prepared by ploughing, disking, and harrowing. The barley variety, Athinais, was sown on November 6, in the year 1962-63, and November 8, in the year 1963-64, with a grain drill using eight kilograms of barley seed per dunum. In October, 1963 an early rain was received resulting in the germination of the volunteer vetch seed in the experimental plots before the seed bed was prepared. All of the germinated seedlings were destroyed during the seed bed preparation process and to compensate for this loss and establish vetch plants in the barley crop, inoculated vetch seed was drilled on 14th of January, 1964 at the rate of 6 kilograms per dunum between the barley rows by means of Planet Junior hand drill.

The plots were laid out as a randomized complete block experiment

with two treatments and eight replications. The treatments consisted of barley alone and barley plus volunteer vetch. Each block was 27 meters long and 5 meters wide. One treatment was alloted to each half of the block resulting in a plot size of 13.5 x 5 square meters.

In the treatment, where only barley was desired, the volunteer vetch seedlings were killed by the application of 2, 4-D. The herbicide was applied at the concentration of two pounds of active ingredient per acre when the vetch seedlings were three to five centimeters tall.

Two harvests of the barley and vetch crops were made. One harvest was made for forage yield when the vetch crop was in the late bloom stage and the barley crop in the early milk stage. The second harvest was at the time of maturity for seed yields.

For forage yield, three individual one-square meters plots were harvested, and for grain yield, five individual one-square meters areas were harvested. For both forage and grain yield, harvests were made with a hand clipper from the central rows of the experimental plots to avoid border effects. The forage samples were air dried in cloth sacks for a period of forty days, after which moisture determination of the samples were made and dry forage yields were calculated on 12.5 percent moisture basis. The samples containing mixtures of vetch and barley plants for grain yield were hand separated into vetch and barley bundles and dried separately for about four weeks. After drying (about 8 percent moisture), the samples were threshed with a nursery thresher. Grain and straw yields of both vetch and barley were recorded. Representative samples were taken for protein determination from barley forage, barley-vetch forage mixture, barley grain from vetch infested plots, barley grain from pure barley plots, and vetch seed. Protein analyses were made according to the modified

Kjeldahl's method, as specified in the Official Methods of Analysis of Association of Official Agricultural Chemists (Horwitz 1960).

Plant population data both for the barley and the vetch crops were recorded after the germination was completed. Data were also collected on the agronomic characters such as, height of the plant at maturity, length of the spike, number of grains per spike and weight of 1000 grains. Records for characters of the vetch crop included, height at maturity, number of pods per plant, number of seeds per pod, and weight of 1000 seeds taken on random representative samples.

Statistical analyses of the data were carried out according to the procedure described by Le Clerg, Leonard and Clark for the paired samples (Le Clerg, Leonard and Clark 1962).

RESULTS AND DISCUSSION

This experiment was conducted to evaluate the effect of volunteer vetch in barley on: total forage yield, grain yield, protein percentage of forage and grain, total protein yield of forage and grain, and other agronomic characteristics of barley crop. The results obtained are reported in tables 1 to 9.

Forage Yield

The first year of the experiment, 1962-63 was a comparatively more favourable year during which good timely rains were received (total precipitation for the year 526 mm.) and therefore, forage and other yields obtained during this year were much better as compared to the second year of the experiment i.e. 1963-64. The dry forage yields of barley vetch forage mixture and pure stand of barley are shown in table 1. Barley-vetch forage mixture yielded about 17 percent and 56 percent more dry forage per dunum, in the first and second year respectively, as compared to barley alone. However, the differences between the dry forage yields of barley-vetch mixture and pure barley stand were non-significant during the first year and highly significant during the second year. These differences in the results could be attributed to the differences of the vetch stand in barley during the two cropping seasons. In the first year, the vetch stand (av. population = 89625 plants per dunum) in barley crop was not uniform throughout the different replications (because it was volunteer and not seeded), therefore, it resulted in greater variation between the different replications and hence greater experimental error which masked the real differences between the two treatments. On the other hand, the vetch stand (avg. population = 147,142 plants per dunum) in barley crop during the second year of the

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experiment was almost uniform and as a result there was less variation between the replications. When comparison was made between the forage yields contributed by vetch component toward the total forage yield of barley-vetch mixture during the two years, it was found that vetch contributed about 43 percent of the total dry forage during the first year and about 21 percent of the total dry forage during the second year. It may be mentioned here that vetch crop during the first year was much more vigorous and the plants branched profusely due to the favourable season and timely germination, whereas, in the second year it was seeded later and did not branch well and had a poor growth.

The second year's results are in agreement with the findings of Andrew and Gieger (1938), Roberts and Olson (1942), Willard (1951), Henderson and Davies (1955), Hodgson, Donnely and Langford (1959), Peters and Hoveland et al. (1961), Nel et al., Wedin (1962), and Beg (1963). The first year's results agree with the work of Ahlgren (1954) and Robinson (1960).

Protein Percentage of Forage

The protein percentage results of the barley-vetch forage mixture and barley alone are given in table 2. Barley-vetch forage mixture contained 17 percent and 13 percent higher percentages of protein than the percentage protein of barley alone during the two years. The difference between mean protein percentages of barley-vetch mixture and that of barley alone were highly significant during the first year and non significant during the second year. As already mentioned, the dry forage obtained from the mixture in the first year, contained a high proportion of vetch forage as compared to the second year. Vetch forage, being a leguminous crop,

Table 1. Dry forage yield (kgs; per dunum) of barley-vetch mixture and pure stand of barley.+

	Barley and vetch mixture			Pure barley
Year	Barley	Vetch	Barley + Vetch	
1962-63	236.49	159.92	396.41	337.03
1963-64	220.54	58.89	279.43**	178.98
Average	228.51	109.40	337.92	258.00

Table 2. Protein percentage of barley-vetch forage mixture and pure-barley forage.+

	Barley and vetch mixture			Pure barley
Year	Barley	Vetch	Barley + Vetch	
1962-63	5.58	14.75	9.11**	7.76
1963-64	7.65	13.23	8.93	7.88
Average	6.61	13.99	9.02	7.82

Table 3. Protein yield (kgs; per dunum) of barley-vetch forage mixture and barley forage alone.+

	Barley and vetch mixture			Pure barley
Year	Barley	Vetch	Barley + Vetch	
1962-63	12.62	23.61	36.23**	26.18
1963-64	16.50	8.02	24.52**	13.74
Average	14.56	15.81	30.37	19.96

+ Figures are averages of eight replications.

** Differences between means significant at 1 percent level.

possessed about twice as much protein percentage as barley forage, and therefore, forage mixture containing a greater proportion of vetch was high in protein percentage as compared to the one with less quantity of vetch. It may also be noticed in table 2 that the protein percentage of barley component in barley-vetch forage mixture has been lowered during both years (average decrease 1.20 percent) as compared to protein percentage obtained from barley forage grown separately. This shows that barley and vetch crops, while in mixture, grew in a sort of competition, and this competition was particularly more pronounced in the first year, when vetch crop had more luxuriant growth and offered more competition.

The results of the protein percentages are in conformity with those of Andrew and Gieger (1938), Ahlgren et al. (1954), Robinson (1960), Manghirmalani (1961), Wedin (1962) and Beg (1963). All of these workers concluded from their work that cereal-legume forage mixtures contained higher percentages of protein than cereals grown alone and lower percentages of protein than the leguminous crops grown separately.

Protein Yield of the Forage

The data for the total protein yield obtained from barley-vetch forage mixture and pure stand of barley forage are presented in table 3. In both years, the barley-vetch forage mixtures gave significantly higher total protein yield than barley alone. In the first year the total protein yield of the barley-vetch forage mixture was about 38 percent higher than barley alone and that of the second year was about 78 percent higher than pure barley stand. Though the second year of the experiment was an unfavourable one, still the mixture did quite well as far as the forage yields and the total protein yields of the forage were concerned as com-

pared to pure barley stand.

These results are in line with the work of Ahlgren (1954), Hodgson (1956), Henderson and Davies (1955), and Beg (1963) who reported higher total protein yields from cereal-legume mixtures than cereal crops grown separately. The results of this experiment, however, do not agree with the work of Manghirmalani (1961) who reported highest protein yield from oats grown alone than oat-legume mixtures. This might be due to the extremely low rains that were received during the years of his experiment (Annual precipitation in 1959-60 and 1960-61 being 219 mm. and 285 mm., respectively) as compared to the rainfall during the present study (526mm. in 1962-63 and 471 mm. in 1963-64).

Grain Yield

As shown in table 4, the total average seed yield of barley-vetch mixture was about 9 percent more than that of barley alone, but the difference was statistically non significant. It may be pointed out that due to the late sowing of the vetch seed in the second year, the vetch crop produced negligible number of pods which resulted in few shrivelled seeds. Thus, the seed yield of vetch component was extremely low during the second year and contributed very little towards the total seed yield of the mixture. When the effect of vetch on barley seed yield in the barley-vetch mixture was considered, it was found that in the first year, when the vetch crop was more vigorous, right from the beginning of the plant growth up to the maturity stage, it reduced the barley seed yield by about 40 percent as compared to barley seed yield obtained from pure stand. In contrast to this in the second year, vetch did not reduce the seed yield of the barley component in barley-vetch mixture as compared to the seed yield of barley

grown separately. This was due to the fact that less competition was provided by vetch crop during the second year as a result of its poor growth. In the first year, the grain yield reduction of barley by vetch competition was very similar to the results obtained by Godel (1935) from moderate weed infestation of wheat fields. He reported about 34.8 percent reduction in wheat grain yield from weed infestation. The results also agree with those of Henderson and Davies (1955) and Khan (1964). They got almost the same amount of total seed yields from cereal-legume mixtures as compared to pure stands of cereal crops.

Protein Percentage of Grain

The protein percentages of barley-vetch seed mixture and barley grain alone are reported in table 5. In the first year the protein percentage of barley-vetch seed mixture was 1.94 percent higher than protein percentage of barley grain obtained from pure stand and this difference was significant (5% level). On the other hand, the protein percentage of barley-vetch seed mixture during the second year was slightly lower (1.16 percent) than protein content of barley grain alone, but the difference was statistically non significant. These differences being due to the higher proportion of the vetch seeds in the barley-vetch mixture, 77.67 kilogfams in the first year as compared to 4.25 kilograms in the second year. As the vetch seed contained more than double the protein percentage of barley grain, the greater the proportion of vetch seed in the mixture, the higher was the protein percentage of the mixture. When the effect of vetch association was considered on barley grain in the mixture as compared to pure stand of barley, it was observed that the protein content of the barley grain obtained from the mixture was always lower than protein content of

the barley grain grown separately. This indicated that the two crops were actually growing in competition with each other.

In general, the results of protein percentages of the barley-vetch seed mixture and pure barley grains agree with the work of Robinson (1960) who also got a higher percentage of protein from the cereal-legume seed mixture than cereal grains alone. On the other hand, the results partially disagree with his findings in the sense that he got an increase in the protein percentage of the cereal grain from the associated growth with the legume. This difference in the results may not be due to several factors i.e. climate, and soil. Robinson (1960) also reported that Bacher was of the opinion that factors controlling the balance of cereals to legumes in the mixture is complex, and instead of showing complementary growth, the cereal and the legume constituents appear to grow in competition with one another.

Protein Yield of Grain

The total protein yields secured from barley-vetch seed mixture and barley grains alone are given in table 6. In the first year, seed mixture of barley-vetch combination produced 5.78 kilograms (about 26 percent) more total protein yield as compared to barley grown in pure stand and in the second year the barley-vetch seed mixture and barley alone yielded similar protein yields per dunum. This difference in the two years data in protein yields can be clearly understood from the vetch seed contribution (given in table 4) towards the total seed yield and ultimately total protein yield during the two years. In the first year vetch seed contributed 16.86 kgs. of protein yield per dunum and in the second year only a negligible amount (0.96 kgm. per dunum). Statistical analyses of

Table 4. Grain yield (kgs; per dunum) of barley-vetch seed mixture and pure barley grain.+

	Barley and vetch mixture			Pure barley
Year	Barley	Vetch	Barley + veteh	
1962-63	155.98	77.67	233.65	219.85
1963-64	214.03	4.25	218.28	191.51
Average	185.00	40.96	225.96	205.68

Table 5. Protein percentage of barley-vetch seed mixture and pure barley grain.+

	Barley and vetch mixture			Pure barley
Year	Barley	Vetch	Barley + vetch	
1962-63	7.22	22.36	11.84*	9.90
1963-64	10.50	22.44	10.76	11.92
Average	8.86	22.40	11.30	10.91

Table 6. Protein yield of barley-vetch seed mixture and pure barley grain.+

	Barley and vetch mixture			Pure barley
Year	Barley	Vetch	Barley + vetch	
1962-63	11.35	16.86	28.21	22.43
1963-64	22.74	0.96	23.70	23.09
Average	17.04	8.91	25.95	22.76

+ Figures are averages of eight replications.

* Differences between means significant at 5 percent level.

the data showed that the differences in protein yields of the seed mixtures and pure seeds during the two years were non significant.

The results agree with those reported by Henderson and Davies (1955) and Robinson (1960) who got more protein yields from cereal-legume seed mixtures than pure stand of cereal crops.

Straw Yield

The straw yields of barley-vetch mixture and barley alone are presented in table 7. On the basis of the two years average barley-vetch mixture gave 261.21 kilograms of straw yield per dunum as compared to 200.33 kilograms of straw yield given by barley alone i.e. barley-vetch mixture gave about 30 percent more straw yield per dunum than barley alone. During both years barley-vetch mixture produced significantly higher straw yields than barley alone. When the straw yields contributed by vetch towards total straw yields of the mixtures were considered, it was noticed that vetch contributed almost 50 percent of the total straw yield in the first year and only about 12 percent of the total straw yield during the second year. It is to be mentioned here that though vetch contributed only a small amount of seed towards the total seed yield, it contributed a relatively large quantity of straw towards total straw yield during the second year. It was due to the fact that although very little seed formation occured in the vetch plants, the plants had enough growth to add towards the straw yield.

Comparison of Protein Yield of Barley-vetch Forage Mixture and Protein Yield of Barley-vetch Seed Mixture

The results of protein yield of barley-vetch forage mixture and

protein yield of barley-vetch seed mixture are reproduced in table 8. Barley-vetch forage mixture gave on the average 30.37 kilograms of total protein yield and barley-vetch seed mixture produced 25.95 kilograms of average protein yield i.e. barley-vetch forage mixture produced about 17 percent more total protein yield per dunum than barley-vetch seed mixture. However, when the straw yield obtained from barley-vetch seed mixture was also taken into account, then possibly the protein yield produced by barley-vetch seed mixture + protein yield of barley-vetch straw yield would equal or exceed the total protein yield of barley-vetch forage mixture.

Henderson and Davies (1955) reported about a third of the protein percentage of the oat-pea-bean forage mixture in the straw mixture of the same crops. If the same relationship is supposed to hold true then barley-vetch straw mixture would contain about 3 percent protein as compared 9.02 percent average protein content of the forage. In this way barley-vetch straw yield (261.21 kilograms) would add about 7.83 kilograms of protein to the total protein yield of barley-vetch seed mixture. Thus the total protein yield of barley-vetch seed mixture + total protein yield of barley-vetch straw yield (25.95 kilograms + 7.83 kilograms) would become slightly more (3.41 kilograms) than the protein yield obtained from barley-vetch forage mixture. It is to be pointed out here that the nutritive value of the crude protein obtained from barley-vetch straw mixture would be low because of high amount of fiber content, so the actual contribution of straw towards total protein yield of the barley-vetch seed mixture would be quite low. Therefore, there seems little evidence, which could support the superiority of barley-vetch seed mix-

Table 7. Straw yield (kgs; per dunum) of barley-vetch mixture and pure barley.+

	Barley and vetch mixture			Pure barley
Year	Barley	Vetch	Barley + vetch	
1962-63	161.70	139.40	201.10*	232.95
1963-64	195.61	25.72	221.33**	167.72
Average	178.65	82.56	261.21	200.33

Table 8. Protein yield (kgs; per dunum) of barley-vetch forage mixture and protein yield (kgs; per dunum, of barley-vetch seed and straw mixture.+

Year	Barley-vetch forage mixture	Barley-vetch seed mixture	Barley-vetch straw mixture	Barley-vetch seed + straw mixture
1962-63	36.23	28.21	9.03	37.24
1963-64	24.52	23.70	6.63	30.33
Average	30.37	25.95	7.83	33.78

+ Figures are averages of eight replications.

* Differences between means significant at 5 percent level.

** Differences between means significant at 1 percent level.

ture over the barley-vetch forage mixture.

Effect of Vetch on Barley Height

The average heights of barley plants both from vetch infested plots and pure barley stand are given in table 9. During both years of the experiment the average heights of barley plants were increased by vetch association as compared to pure stand of barley. Over the two years period vetch increased the average height of barley plants by 2.6 centimeters. This may be due to the lateral space competition provided by the vetch plants, resulting in the more upward growth of barley plants. The differences in heights from vetch infested plots and pure barley stand, however, were non significant. The results agree with the work of Madhok (1940) and Nel et al. (1962) who observed that cereal plants were taller when these were in association with legumes.

Effect of Vetch on Length of Barley Spike

Results of average length of barley spike from barley-vetch mixture and barley gfown separately are shown in table 9. The average length of the barley spike was reduced by vetch competition about 9 percent. This reduction of barley spike length was quite high (21 percent) in the first year, when the vetch crop was more vigorous as compared to the second year's average spike length reduction which was quite low (about 3 percent), due to the poor vetch crop. The first year's results are quite similar to those of Godel (1935) who reported a reduction of 17.3 percent in wheat spike length from moderate weed infestation.

Effect of Vetch on Number of Grains Per Spike

As shown in table 9 the average number of grains per spike of

Table 9. Average height, spike length, number of grains per ear, and weight of 1000 grains of barley from barley-vetch mixture and pure stand of barley.+

Year	Height of barley in cms.		Length of barley spike in cms.		Number of grains per spike		Weight of 1000 grains (in gms.)	
	Barley-vetch mixture	Pure stand	Barley-vetch mixture	Pure stand	Barley-vetch mixture	Pure stand	Barley-vetch mixture	Pure stand
1962-63	56.2	52.9	2.3	2.8	22.1	25.1	45.0**	49.0
1963-64	50.6	48.8	4.4	4.5	37.8	40.2	46.4	46.9
Average	53.4	50.8	3.3	3.6	29.9	32.6	45.7	47.9

+ Observations taken on small representative samples.

** Differences between means significant at 1 percent level.

barley plants from vetch infested plots was about 9 percent less as compared to the check. The reduction in number of grains per spike during the first year was more than double (13 percent) as compared to the second year (6 percent). This was expected because of the differential amounts of vetch competitions during the two years. From statistics stand point, the results were non significant during both years.

Effect of Vetch on the Average Weight of 1000 Grains of Barley

The average weight of 1000 grains of barley from the barley-vetch mixture and pure barley stands are shown in table 9. It can be seen from the results that vetch association considerably reduced (about 9 percent) the weight of the associated barley grains as compared to check in the first year. This reduction in weight of barley grains was highly significant. The results obtained during the second year were just opposite to the first year. During this year, the weight of 1000 grains of barley from vetch infested plots and pure barley stand were similar. The reason for variation in the two years data again was the same i.e. the relatively less competition which was offered by vetch crop during the second year lower as compared to first year. These results resemble the findings of Godel (1935) who got a reduction of 3.1 percent in seed weight of wheat from annual weed competition.

SUMMARY AND CONCLUSIONS

This study was conducted to investigate the effect of volunteer vetch in barley on total yield and other characteristics of barley crop. The treatments studied were barley-vetch in mixture and pure barley stands. In the first year vetch plants, in the barley crop, were volunteer as a result of usual shattering in the normal harvesting operations and in the second year, vetch was seeded in between the barley rows. Two harvests from the plots were taken, the first for forage yields and the second for seed yields.

In both years, barley-vetch forage mixture produced more forage yield, contained a higher protein percentage and ultimately returned more total protein yield per dunum as compared to pure barley stand. Similarly, the seed mixture gave, on the average, more seed with higher percentage of protein and thus produced an increased amount of average total protein as compared to barley alone.

The vetch component had a depressing effect on the associated barley crop. Vetch reduced the average forage and seed yields, protein percentages, total protein yields, and average straw yields of barley. Likewise, vetch decreased the average length of the associated barley spike, number of grains per spike, and average weight of 1000 grains as compared to the pure stand. Only the average height of barley plants was increased by the vetch association.

The average total protein yield of barley-vetch seed mixture (including straw) was statistically similar to the average total protein yield of barley-vetch forage mixture. Therefore, a mixture which is har-

vested for forage will return an almost equal amount of total protein per unit area as compared to the mixture harvested for seed. This practice will also save the farmer from the exfra labor that would be required for the separation of the seed mixture, if each component is to be marketed separately and would vacate the land, almost a month earlier and the farmer could grow a crop like melon in the summer.

While utilizing the barley-vetch mixture for forage, it is suggested that a few pounds (4 to 6 pounds) of vetch seed be sown in the fields containing shattered vetch seed at the time of barley seeding. This would insure sufficient vetch stand throughout the barley field and thus good yield of high quality forage would be obtained.

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APPENDIX

Table 10. Observed "t" for dry forage yields (kgs., per dunum) of barley-vetch mixture and pure stand of barley.

Year	Observed "t"	D.F.	P value
1962-63	1.761	7	0.1 - 0.2
1963-64	4.107	7	0.001 - 0.01**

** Significant at 1 percent level.

Table 11. Observed "t" for protein percentage of barley-vetch forage mixture and pure barley forage.

Year	Observed "t"	D.F.	P value
1962-63	4.269	7	0.001 - 0.01**
1963-64	1.944	7	0.05 - 0.1

** Significant at 1 percent level.

Table 12. Observed "t" for protein yield (kgs., per dunum) of barley-vetch forage mixture and barley forage alone.

Year	Observed "t"	D.F.	P value
1962-63	3.772	7	0.001 - 0.01**
1963-64	7.124	7	$\angle$ 0.001**

** Significant at 1 percent level.

Table 13. Observed "t" for grain yield (kgs. per dunum) of barley-vetch seed mixture and pure barley grain.

Year	Observed "t"	D.F.	P value
1962-63	0.347	7	0.7 - 0.8
1963-64	2.338	7	0.05 - 0.1

Table 14. Observed "t" for protein percentage of barley-vetch seed mixture and pure barley grain.

Year	Observed "t"	D.F.	P value
1962-63	3.259	7	0.01 - 0.02*
1963-64	1.031	7	0.3 - 0.4

* Significant at 5 percent level.

Table 15. Observed "t" for protein yield of barley-vetch seed mixture and pure barley grain.

Year	Observed "t"	D.F.	P value
1962-63	1.318	7	0.2 - 0.3
1963-64	0.357	7	0.7 - 0.8

Table 16. Observed "t" for straw yield (kgs; per dunum) of barley-vetch mixture and pure barley.

Year	Observed "t"	D.F.	P value
1962-63	2.975	7	0.02 - 0.05*
1963-64	6.608	7	< 0.001**

* Significant at 5 percent level.
** Significant at 1 percent level.

Table 17. Observed "t" for protein yield (kgs; per dunum) of barley-vetch forage mixture and protein yield (kgs; per dunum) of barley-vetch seed and straw mixture.

Year	Observed "t"	D.F.	P value
1962-63	0.169	7	0.8 - 0.9
1963-64	1.654	7	0.1 - 0.2

Table 18. Observed "t" for average height of barley plants from barley-vetch mixture and pure stand of barley.

Year	Observed "t"	D.F.	P value
1962-63	1.883	7	0.1 - 0.2
1963-64	1.524	7	0.1 - 0.2

Table 19. Observed "t" for average spike length of barley plants from barley-vetch mixture and pure stand of barley.

Year	Observed "t"	D.F.	P value
1962-63	0.841	7	0.4 - 0.5
1963-64	1.390	7	0.2 - 0.3

Table 20. Observed "t" for average number of grains per spike from barley-vetch mixture and pure stand of barley.

Year	Observed "t"	D.F.	P value
1962-63	1.181	7	0.2 - 0.3
1963-64	1.081	7	0.3 - 0.4

Table 21. Observed "t" for average weight of 1000 grains of barley from barley-vetch mixture and pure stand of barley.

Year	Observed "t"	D.F.	P value
1962-63	5.820	7	$<0.001^{**}$
1963-64	0.640	7	0.5 - 0.6

** Significant at 1 percent level.