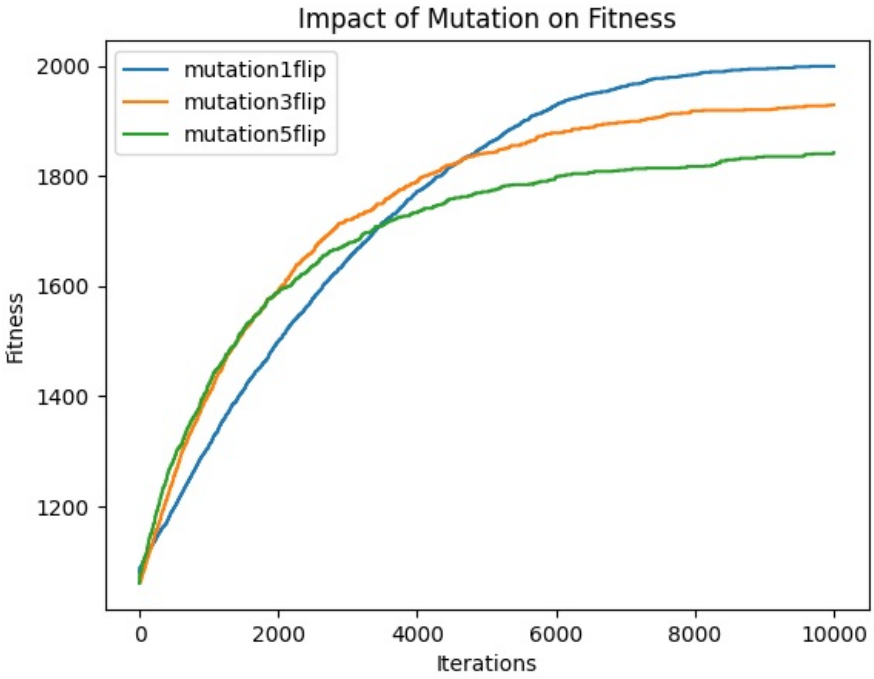
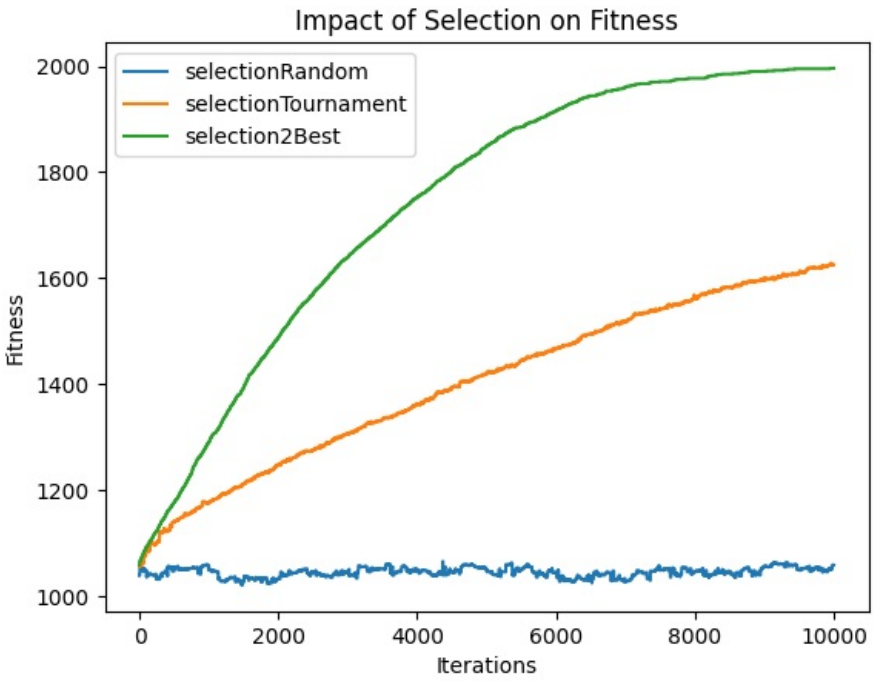
In [61]:
```python
from randomOneMax import RandomOneMax
from fitness import Fitness
import random
# plt
import matplotlib.pyplot as plt

TAILLE_VECTEUR = 2000
TAILLE_POPULATION = 100
MAX_ITER = 10000

def replace_random(population, individual, population_size=TAILLE_POPULATION):
    population[random.randint(0, population_size - 1)] = individual

def initialisationRandom(npop):
    population = []
    for i in range(npop):
        population.append(RandomOneMax(TAILLE_VECTEUR).getVector())
    return population

def selection2Best(population):
    population.sort(key=lambda x: Fitness(x).getFitness(), reverse=True)
    return population[:2]

def crossover(parent1, parent2):
    crossPoint = random.randint(0, TAILLE_VECTEUR - 1)
    child1 = parent1[:crossPoint] + parent2[crossPoint:]
    child2 = parent2[:crossPoint] + parent1[crossPoint:]
    return child1, child2
```

In [62]:
```python
def mutation1flip(individual):
    mutationPoint = random.randint(0, TAILLE_VECTEUR - 1)
    if individual[mutationPoint] == 0:
        individual[mutationPoint] = 1
    else:
        individual[mutationPoint] = 0
    return individual

def mutation3flip(individual):
    for i in range(3):
        mutation1flip(individual)

def mutation5flip(individual):
    for i in range(5):
        mutation1flip(individual)

def evolution_with_mutation_test(mutation_type):
    population = initialisationRandom(TAILLE_POPULATION)
    i = 0
    fitness_history = []

    while i < MAX_ITER and Fitness(selection2Best(population)[0]).getFitness() < TAILLE_VECTEUR:
        parents = selection2Best(population)
        children = crossover(parents[0], parents[1])

        # Appliquer la mutation choisie
        for pop in population:
            if random.random() < 0.1:
                mutation_type(pop)

        for j in range(2):
            replace_random(population, children[j])
        i += 1
        fitness_history.append([i, Fitness(selection2Best(population)[0]).getFitness()])

    return fitness_history

for mutation_fn in [mutation1flip, mutation3flip, mutation5flip]:
        history = evolution_with_mutation_test(mutation_fn)
        x = [i[0] for i in history]
        y = [i[1] for i in history]
        plt.plot(x, y, label=mutation_fn.__name__)
plt.xlabel('Iterations')
plt.ylabel('Fitness')
plt.title('Impact of Mutation on Fitness')
plt.legend()
plt.show()
```



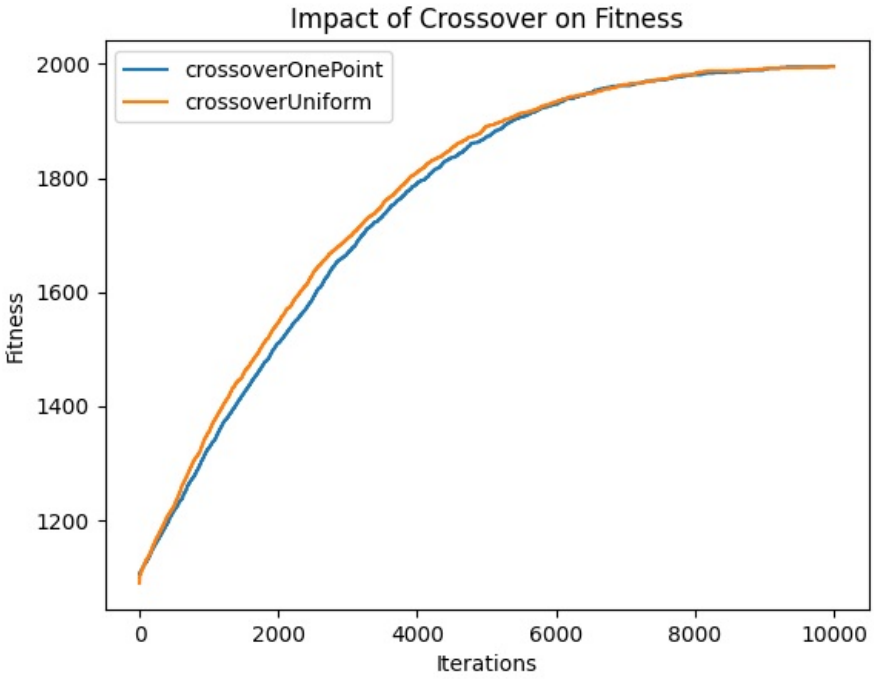
In [63]:

```python
def selectionRandom(population):
    return random.sample(population, 2)

def selectionTournament(population):
    tournament = random.sample(population, 5)
    tournament.sort(key=lambda x: Fitness(x).getFitness(), reverse=True)
    return tournament[:2]

def evolution_with_selection_test(selection_type):
    population = initialisationRandom(TAILLE_POPULATION)
    i = 0
    fitness_history = []

    while i < MAX_ITER and Fitness(selection2Best(population)[0]).getFitness() < TAILLE_VECTEUR:
        parents = selection_type(population)
        children = crossover(parents[0], parents[1])

        # Appliquer la mutation choisie
        for pop in population:
            if random.random() < 0.1:
                mutation1flip(pop)

        for j in range(2):
            replace_random(population, children[j])
        i += 1
        fitness_history.append([i, Fitness(selection2Best(population)[0]).getFitness()])

    return fitness_history

for selection_fn in [selectionRandom, selectionTournament, selection2Best]:
    history = evolution_with_selection_test(selection_fn)
    x = [i[0] for i in history]
    y = [i[1] for i in history]
    plt.plot(x, y, label=selection_fn.__name__)

plt.xlabel('Iterations')
plt.ylabel('Fitness')
plt.title('Impact of Selection on Fitness')
plt.legend()
plt.show()
```



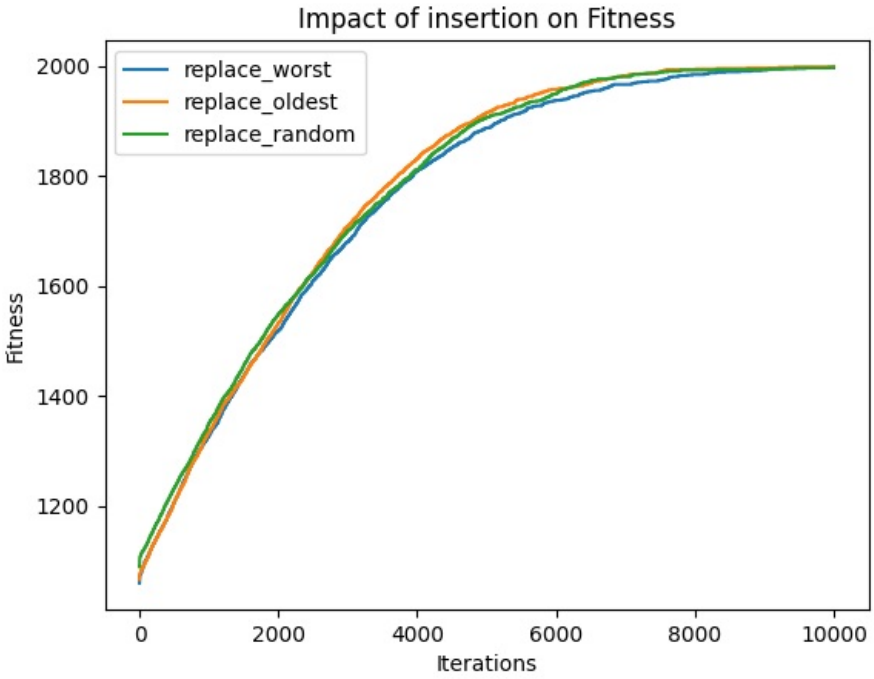
In [64]:

```python
def crossoverUniform(parent1, parent2):
    child1 = []
    child2 = []
    for i in range(TAILLE_VECTEUR):
        if random.random() < 0.5:
            child1.append(parent1[i])
            child2.append(parent2[i])
        else:
            child1.append(parent2[i])
            child2.append(parent1[i])
    return child1, child2

def crossoverOnePoint(parent1, parent2):
    crossPoint = random.randint(0, TAILLE_VECTEUR - 1)
    child1 = parent1[:crossPoint] + parent2[crossPoint:]
    child2 = parent2[:crossPoint] + parent1[crossPoint:]
    return child1, child2

def evolution_with_crossover_test(crossover_type):
    population = initialisationRandom(TAILLE_VECTEUR)
    i = 0
    fitness_history = []

    while i < MAX_ITER and Fitness(selection2Best(population)[0]).getFitness() < TAILLE_VECTEUR:
        parents = selection2Best(population)
        children = crossover_type(parents[0], parents[1])

        # Appliquer la mutation choisie
        for pop in population:
            if random.random() < 0.1:
                mutation1flip(pop)

        for j in range(2):
            replace_random(population, children[j])
        i += 1
        # sort population by fitness
        population.sort(key=lambda x: Fitness(x).getFitness(), reverse=True)
        fitness_history.append([i, Fitness(selection2Best(population)[0]).getFitness()])

    return fitness_history

for crossover_fn in [crossoverOnePoint, crossoverUniform]:
    history = evolution_with_crossover_test(crossover_fn)
    x = [i[0] for i in history]
    y = [i[1] for i in history]
    plt.plot(x, y, label=crossover_fn.__name__)

plt.xlabel('Iterations')
plt.ylabel('Fitness')
plt.title('Impact of Crossover on Fitness')
plt.legend()
plt.show()
```



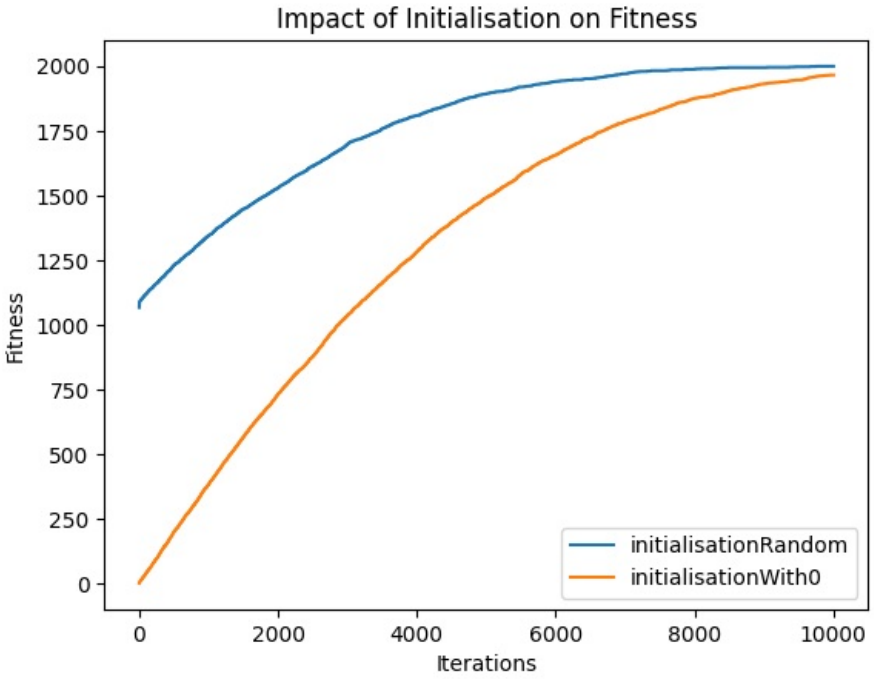
In [65]:

```python
def replace_worst(population, individual):
    # Remplace l'individu avec la pire fitness
    population.sort(key=lambda x: Fitness(x[0]).getFitness())
    population[0] = individual

def replace_oldest(population, individual):
    # Remplace l'individu le plus ancien
    population.sort(key=lambda x: x[1])  # Trier par âge
    population[0] = individual

def evolution_with_insertion_test(replace_type):
    # Initialiser la population avec des âges
    population = [(individual, 0) for individual in initialisationRandom(TAILLE_POPULATION)]
    i = 0
    fitness_history = []

    while i < MAX_ITER and Fitness(selection2Best([ind for ind, age in population])[0]).getFitness() < TAILLE_VE
        # Sélectionner les parents
        parents = selection2Best([ind for ind, age in population])
        children = crossoverUniform(parents[0], parents[1])

        # Assigner l'âge actuel aux enfants
        children = [(child, i) for child in children]

        # Appliquer la mutation sur toute la population avec probabilité 0.1
        population = [
            (mutation1flip(ind) if random.random() < 0.1 else ind, i if random.random() < 0.1 else age)
            for ind, age in population
        ]

        # Remplacer les individus dans la population
        for child in children:
            replace_type(population, child)

        # Calculer la fitness du meilleur individu
        best_fitness = Fitness(selection2Best([ind for ind, age in population])[0]).getFitness()
        fitness_history.append([i, best_fitness])
        i += 1

    return fitness_history

# Tester avec différents types de remplacement
for replace_fn in [replace_worst, replace_oldest, replace_random]:
    history = evolution_with_insertion_test(replace_fn)
    x = [i[0] for i in history]
    y = [i[1] for i in history]
    plt.plot(x, y, label=replace_fn.__name__)

plt.xlabel('Iterations')
plt.ylabel('Fitness')
plt.title('Impact of insertion on Fitness')
plt.legend()
plt.show()
```



In [66]:

```python
def initialisationWith0(npop):
    population = []
    for i in range(npop):
        individual = [0 for i in range(TAILLE_VECTEUR)]
        population.append(individual)
    return population

def evolution_with_initialisation_test(initialisation_type):
    population = initialisation_type(TAILLE_POPULATION)
    i = 0
    fitness_history = []

    while i < MAX_ITER and Fitness(selection2Best(population)[0]).getFitness() < TAILLE_VECTEUR:
        parents = selection2Best(population)
        children = crossoverUniform(parents[0], parents[1])

        # Appliquer la mutation choisie
        for pop in population:
            if random.random() < 0.1:
                mutation1flip(pop)

        for j in range(2):
            replace_random(population, children[j])
        i += 1
        fitness_history.append([i, Fitness(selection2Best(population)[0]).getFitness()])

    return fitness_history

for initialisation_fn in [initialisationRandom, initialisationWith0]:
    history = evolution_with_initialisation_test(initialisation_fn)
    x = [i[0] for i in history]
    y = [i[1] for i in history]
    plt.plot(x, y, label=initialisation_fn.__name__)

plt.xlabel('Iterations')
plt.ylabel('Fitness')
plt.title('Impact of Initialisation on Fitness')
plt.legend()
plt.show()
```



In [67]:

```python
# test en faisan varier la taille de la population
def evolution_with_population_size_test(population_size):
    population = initialisationRandom(population_size)
    i = 0
    fitness_history = []

    while i < MAX_ITER and Fitness(selection2Best(population)[0]).getFitness() < TAILLE_VECTEUR:
        parents = selection2Best(population)
        children = crossoverUniform(parents[0], parents[1])

        # Appliquer la mutation choisie
        for pop in population:
            if random.random() < 0.1:
                mutation1flip(pop)

        for j in range(2):
            replace_random(population, children[j], population_size=population_size)
        i += 1
        fitness_history.append([i, Fitness(selection2Best(population)[0]).getFitness()])

    return fitness_history

for population_size in [10, 50, 100, 200, 350, 500]:
    history = evolution_with_population_size_test(population_size)
    x = [i[0] for i in history]
    y = [i[1] for i in history]
    plt.plot(x, y, label=population_size)

plt.xlabel('Iterations')
plt.ylabel('Fitness')
plt.title('Impact of Population Size on Fitness')
plt.legend()
plt.show()
```